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Designing a Visible City for Visually Impaired Users:

Breaking the Barriers of Disabling Architecture

By

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Author's Declaration

This thesis is the result of the author's original research. It has been composed by the author and has not been previously submitted for examination which has led to the award of a degree.

Signed: Date:

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Abstract

This thesis investigates the barriers inherent to the design of urban environments for individuals with different types and degree of visual field loss. According to the Royal National Institute for the Blind (RNIB), there are an estimated 2.3 million visually impaired individuals living in the United Kingdom. This figure is expected to increase to 4 million by 2030, due to the effects of an ageing population and the obesity epidemic. It is therefore essential to invest in the design of safe and accessible environments, which are sympathetic to the needs of the visually impaired user. Currently the urban landscape resembles an obstacle course. This results from a distinct lack of mandatory regulations available to designers and planners, which specifically address the navigational needs of the visually impaired pedestrian beyond the curtilage of a building.

This work embarks from the hypothesis that commonalities exist in the manner that individuals with different types and degree of visual field loss experience barriers in the built environment. Furthermore, it is hypothesised that the nature of these commonalities can be measured and incorporated into the – presently insufficient – existing building regulations. The question that arises is: *How can design regulations integrate the specifications to collectively accommodate the varying needs of different visual impairments for seamless navigation in urban streetscapes?* This question is explored through a nationwide survey targeted at visually impaired users of the built environment. The survey is followed by an access audit, which aims to quantify the number and type of hazards present within a typical city centre. The research is complemented by a series of user-based navigational experiments, which situate the problem through comparison of experiences between visually impaired and fully sighted cases.

The collected data have been used to inform the creation of an evaluation tool, which measures both the adequacy of mandatory regulations and the degree that best practice guidelines are embraced by local authorities. When applied to the audited city centre, the tool reveals deficiencies in both the content of the regulations and in the adoption of the guidelines. In order to procure a solution, enhanced guidelines are presented that incorporate the findings of the research results. The overall conclusion is that visually impaired people are not disabled by personal factors but by the design and physical influence of features within the built environment. The thesis contributes to an understanding that designing urban environments should be less about architectural fashion trends and more about creating practical spaces that cater for the needs of all users.

Chapter 1: Introduction

My darkness has been filled with the light of intelligence, and behold, the outer day-lit world was stumbling and groping in social blindness.

(Helen Adams Keller)

1.1. Motivation and Problem Statement

This thesis investigates the barriers inherent to the design of urban environments for individuals with different types and degree of visual field loss. One of the main motivating factors for tackling the research topic stems from the personal experiences of the author, who in 2003 was diagnosed with a degenerative eye disease leading to a loss of central vision and colour blindness. Since that point onwards a world of choice, freedom and independence was transformed into a hostile landscape imposing restrictions, social exclusion, isolation and entrapment. There was a realisation that architecture is by nature, a profession which primarily caters for the requirements of the fully, able-bodied person with an inadequate regard for the design requirements of all other users. In addition to personal factors, the research is further motivated from two integral issues relating to visual impairment and urban design. One is the recognition that the number of visually impaired individuals within the UK is expected to double within the next twenty years due to the adverse effects of the increasingly ageing population and the ramifications of the obesity epidemic (Charles, 2006). The other is the distinct lack of mandatory regulations available to designers and planners, which specifically address the needs of the visually impaired pedestrian beyond the curtilage of a building.

The present state of urban environments reflects at best an inadequate understanding of the needs of the visually impaired population for seamless navigation. Indicative of this situation is the observation in the British Standards BS: 8300 that “less is known about [...] external environments than internal environments, *but the same principles as for the internal environment* *are thought to apply*" (BSI, 2009, p. 29; emphasis added). The statement provides a glimpse of current perceptions in designing urban spaces, further reinforcing Golledge's standpoint that "[m]ost people have not experienced the frustration of having to undertake laborious time-consuming trips through built environments" (Golledge, 1993, p. 64). In the twenty years since Passini & Proulx (1988, p. 288) commented that "our architectural and urban environments have not been thought out with the needs of the visually impaired in mind", little has changed. Although the severity and cause of decreased vision inevitably varies, people with visual impairments still face the challenges that the built environment poses to them enjoying the same level of street navigation as the fully sighted population. In response to this statement, the following question has been set:

> How can design regulations integrate the specifications to collectively accommodate the varying needs of different visual impairments for seamless navigation in urban streetscapes?

Building on the identified problems and derived research question, this thesis hypothesises that commonalities exist in the manner that individuals with different types and degree of visual field loss experience barriers in the built environment. Furthermore, it is argued that the nature of these commonalities can be measured and incorporated into the – presently insufficient – existing building regulations. The key roles of the architect and designer can then be established as creators of inclusive environments, absent from barriers and potential hazards.

1.2. Research Objectives

This thesis explores a number of interdependent approaches to designing urban environments for visually impaired people, which are intrinsic to the problem statement. As this study takes place within the architectural domain, emphasis is placed on developing solutions to overcome barriers inherent within the design of streets and public spaces, as opposed to relying upon technology to facilitate "seamless" navigation within the urban environment.

This approach further reinforces the benefits of inclusive architecture where environments can be used by all without the need to segregate a particular sector of society through the forced use of technological aids. Emphasis is initially placed in investigating how the built environment can be redesigned to alleviate discomfort and danger for the visually impaired pedestrian. Firstly, visual impairment is not viewed as a generic condition, but as discrete types of functional vision loss, with each type potentially generating contrasting needs in navigation and unobstructed access. Instead of focusing on a singular case, this research aims to specify design guidance which incorporates the areas in which navigational requirements for different types of vision loss converge. Secondly, there is an evident relationship between the content of building regulations and the level of accessibility in the built environment. However, the influence of partial adoption or even disregard of regulations and accessibility guidelines by local authorities is also considered in this work. Thirdly, preliminary feedback to this research is provided by a review of documented experiences and existing accessibility guidelines and legislation taking into account published material up until March 2010. Although current provisions to facilitate the navigation of visually impaired individuals in urban environments are either absent or based on diverse specifications, there may be established conventions that require further investigation and readjustment. Finally, the involvement of visually impaired users of urban spaces should be paramount in the identification of a solution to the research problem. Building on the recognised need for user-oriented visual impairment studies (Duckett & Pratt, 2001), this work is guided by the researched views and experiences of visually impaired participants. If urban environments are envisioned as inclusive, non-discriminatory spaces that promote participation in social life for everyone, a solution should be designed and implemented that is devoid of the problematic consequences of current building regulations and tepid approaches to create all-encompassing environments. In order to achieve this ambition, the following objectives for this research are detailed below:

- To identify the disabling & enabling features within a modern city centre that apply beyond the curtilage of a building. A range of features need to be considered, including pavement characteristics, the design and zoning of street furniture and the provision of accessible crossing points.

- To investigate physical and psychological barriers to access, experienced by the visually impaired population. In doing so, preferences of the visually impaired population regarding the specifications of urban design features are determined.

- To compare the navigational experience between visually impaired and fully sighted individuals within an urban context.

- To complement research on the behavioural patterns of the blind and visually impaired population, both in terms of their cognitive processes and their way finding behaviour when presented with the challenges of interacting within real architectural environments.

- To explore the points of convergence in the difficulties experienced among individuals with different types and degree of visual field loss.

- To present a mechanism for calculating and quantifying the difficulties experienced and the degree to which urban environments introduce hazards to the visually impaired population.

- To scrutinise the specifications of current building regulations and guidelines with regards to creating accessible, inclusive environments and thereafter build on this analysis, to provide an enhanced set of design guidelines for the urban environment, specifically catering for the needs of the visually impaired pedestrian.

1.3. Methodology

In order to address the research problem and reach the objectives, a methodology has been devised that consists of the following components:

- A literature review of existing research and theories on visual impairment and navigation in urban environments. The review further includes introductory concepts on the nature and consequences of varying types of vision loss. It is complemented by an overview and critique of current building regulations and accessibility guidelines.

- A nationwide survey targeted at visually impaired users of the built environment. The survey addresses all types of vision loss and enquires about the current status of town and city centres and the related provisions for unobstructed navigation.

- An access audit, which aims to quantify the number and type of hazards present within a typical city centre. The access audit identifies the quantity and variety of obstacles and misconducts, thus providing a comprehensive view of the current conditions that visually impaired individuals face when navigating through an urban environment.

- A series of user-based navigational experiments, which situate the problem through comparison of experiences between visually impaired and fully sighted cases.

The information collected from the above instruments is used to inform the creation of a tool to evaluate the hazardousness of urban streetscapes and measure the existence of inaccessible features within the city context. At the conclusive phase of the research, the complete body of evidence is translated into an enhanced set of design guidelines. These extend current regulations and best practice guidelines so that augmented provisions to aid navigation may become available to architects, designers and therefore the visually impaired population. The enhanced guidelines are considered as outputs based on informed decision, since they incorporate the pragmatic views of users with vision loss.

1.4. Contributions

This thesis makes a contribution to the design of accessible urban environments specifically for visually impaired individuals and to the wider domain of architecture. In more detail:

- The thesis contributes to a profound understanding of the needs that visually impaired individuals have with regards to navigation in urban environments. These needs are contextualised within the analysis of findings from the access audit in a typical city centre and can therefore be extrapolated to cases beyond the studied environment.

- Building on the review of the current theoretical underpinning, the thesis presents a firsthand investigation in the adoption levels of existing regulations and guidelines by local authorities. A high-level conclusion is that the results of the access audit and survey reveal insufficient coverage of accessibility features at best or complete disregard at worst.

- By introducing a user-centric approach in the collection of evidence through the survey and navigational experiments, the thesis highlights the fundamental role of involving visually impaired users of the built environment in the identification of current inadequacies and the definition of further requirements to augment their navigational experience.

- The work introduces the first effort to quantify and measure the degree that urban environments present hazardous features to the visually impaired user through a comprehensive evaluation tool for a wide spectrum of visual impairments. The hazard rating tool integrates the evidence collected via the methodological instruments and encapsulates them into a meaningful and functional mechanism that can support decision-making processes in the design and renovation of urban environments. The design of the tool is further informed by a review of previous exploratory research in the disciplines of geography, environmental psychology and sociology.

- The proposed enhanced guidelines emphasise on the lack of extensive specifications in existing building regulations to accommodate unobstructed street navigation by the visually impaired population. This work sets the groundwork to actively demonstrate the necessity for these guidelines to be mandatory in their implementation.

1.5. Chapter Plan

The remainder of this thesis is organised in nine chapters as follows:

- Chapter 2, *Disability Legislation & Guidance*, provides the background necessary to understand the context of disability within theoretical approaches and current regulatory forces. The chapter commences with a discussion on the general awareness of disability within society, as evidenced in relevant literature. Two established models of disability are examined, the Individual (Medical) Model and the Social model, which formalise the range of perceptions on disability within society. An analytical review of existing legislation regarding disability, building regulations and best practice guidance documents is then presented as a means to establish the approaches to disability and accessibility within legal frameworks in the UK.

- In Chapter 3, *The Eye & Visual Impairment*, a literature review on the nature and consequences of different types of vision loss is conducted, so as to facilitate the reader's understanding of the research problem. The review is complemented by illustrative figures of streetscapes as viewed by individuals with central, peripheral and mixed vision loss. The focus then shifts to situating the research area within statistical evidence regarding current visual impairment prevalence and future projections. The chapter presents the findings regarding the effects of the ageing population and obesity epidemic on the rising numbers of the visually impaired population in the UK.

- Chapter 4*, The Spatio-cognitive Abilities of the Visually Impaired Population,* focuses on the way finding techniques, cognitive processes and abilities adopted by the visually impaired population when navigating within the built environment. This review of the literature aims to identify and critique some of the important aspects of previous studies undertaken regarding the cognitive abilities and spatial awareness of the blind and visually impaired population. Furthermore the chapter focuses on the environmental settings in which previous studies have been undertaken and categorises each study under the headings of internal – artificial, internal – real and external. The analysis of previous user-centred research undertaken with visually impaired individuals highlights the lack of extensive studies on the subject, thus reinforcing the significance of this work in the domain of focus.

- Chapter 5, *The Disabling Nature of the City – a survey* documents the design and results of a nationwide survey with visually impaired participants, which aims to gauge the disabling nature of the city via a user-oriented approach. The survey identifies the features within the built environment which present the most difficulties to the visually impaired population. The results reveal both the physical and psychological barriers to access within UK town and city centres, as well as preferred colour and contrast combinations for a range of scenarios. A review of previous work helps to contextualise and compare the findings among other studies in this domain.

- Chapter 6, *The Disabling Nature of the City – an access audit* continues with the investigation of the disabling nature of the city through an access audit of a typical city centre. The audit extends the issues explored in the survey and situates them within evidence of the real-life conditions faced by the visually impaired pedestrian when navigating in urban environments. The access audit scrutinises the state of three main sections, namely pavement characteristics, street furniture and pedestrian crossings. The methods used to record specific features are detailed throughout the Chapter, with accompanying photography and annotated diagrams to illustrate enabling and disabling features.

- Chapter 7, *The Disabling Nature of the City – a navigational experiment,* investigates the manner that the hazardous features identified in the survey and access audit impede the independent navigational behaviour of visually impaired pedestrians within the boundaries of a modern city centre. This is achieved through a navigational experiment with visually impaired individuals and a control group with fully sighted participants. The experiment complements the results of the survey and access audit. This navigational task is used as a qualitative data collection instrument and is not representative of the general population. However, the findings provide fine-grained information on the manner that visually impaired individuals navigate the city. By conducting post-task interviews, further light is shed on the problematic consequences of uninformed design in urban environments through the everyday life experiences of visually impaired and blind users.

- In Chapter 8, *Street Hazard Rating*, the results from the survey, access audit and navigational experiment are integrated in the creation of an evaluation tool to represent the overall accessibility of individual streets located within the boundary of the study area. The street hazard rating calculation is used as a basis for assessing the suitability and current provision of existing mandatory regulations featured in the Scottish Building Regulations. The city centre investigated in the access audit is subjected to evaluation though the rating tool which quantifies the accessibility of each individual street and presents this information on a colour-coded map. The chapter documents the results of this process, focusing in particular on the most and least accessible streets within the study area. The chapter concludes that a major contributor to the disabling nature of the built environment is the distinct lack of mandatory regulations available to designers, planners and local authorities for creating spaces that are sympathetic to the needs of the visually impaired user.

- Chapter 9*, Design guidelines* builds on the preceding analysis to address many of the problematic elements identified in the survey, access audit, navigational experiments and post task discussions, through a critique and comparison of existing mandatory regulations and best practice guidelines. This information is used to facilitate the creation of an enhanced set of design guidelines focusing specifically on characteristics associated with the design of pavements, level changes, street furniture and pedestrian crossings. Through a comparative review of the specifications of existing building regulations, standards and design guidelines, the need for enhanced guidelines is revealed and the extent to which amendments are necessary to improve access within the built environment for visually impaired pedestrians is documented.

- Chapter 10 concludes this work with a summary of research aims and major findings, as well as contributions to the research area and future research directions.

Chapter 2: Disability Legislation & Guidance

2.1. Introduction

This chapter is based on the topic of disability within the United Kingdom (UK), where disability is defined as a:

> "physical or mental impairment which has a substantial and long-term - adverse effect on a person's ability to carry out normal day-to-day activities".
>
> (DDA, 1995; Part 1)

A disability or long-term illness covers a broad spectrum of categories. These include: visual impairments, mobility impairments, hearing impairments, mental health problems, learning difficulties, multiple sclerosis, heart conditions, diabetes, cancer, and physical disfigurements (DDA, 2005). Although this thesis is primarily concerned with visual impairment (see Chapter 1), it is necessary to disambiguate the context of disability in general, within societal structures and legislative frameworks. These regulatory forces – legal or otherwise – influence the public perceptions towards disability and form the main sources of information currently available for designing accessible urban environments. This chapter argues that understanding the needs of the disabled population for access to public spaces means understanding the impact of these regulations and perceptions in shaping the urban environment.

To this end, this chapter starts with a critique on general awareness of disability issues which is based on relevant literature. The attention then shifts to discussing existing models of disability, which attempt to formally define the perceptions towards disability and interaction with society. Lastly, a comprehensive review of current legislation and non-legislative guidance documents is presented. The review aims to highlight the benefits and limitations of these regulations and guidance in promoting equality, protecting against discrimination when accessing goods, facilities and services, and offering specifications for designing accessible city spaces.

2.2. Awareness of Disability within Society

The level of awareness regarding the access needs of the disabled population as a whole is unevenly distributed. Certain impairments receive more attention, publicity and research investments while others remain less visible in the public eye. For instance, the access requirements for individuals with mobility impairment are more prominent – and therefore more acknowledged – within society and urban spaces. This situation can be attributed to two reasons. First, the introduction of the Disability Discrimination Act 1995 (see Section 2.3.1) - and specifically Part 3 of the Act - has resulted in a mass modification programme aimed at transforming non-compliant buildings into services and facilities that can accommodate a person in a wheelchair. The Act specifies that this is achieved either through level access door entry, larger toilets, and reduced height counters, handles or light switches.

Second, the most common form of illustrating provisions for disabled users is at present the International Symbol of Access (ISA). The symbol (illustrated in Figure 2.1) consists of a dark blue square with an abstract image of a person in a wheelchair. The symbol has many uses including marking a vehicular space intended for use by disabled people, marking an accessible entrance to a building, identifying accessible toilet facilities with space for wheelchair users, and in more general terms marking the removal of environmental barriers to access, such as an accessible entrance to a public building. Since its introduction, the symbol has gained international recognition. However, there has been criticism over its design and emphasis on mobility impairments, mainly because it promotes the wheelchair as the main representation of the concept of disability. A complete account of the criticism and alternatives to the ISA is provided in Ben-Moshe & Powell (2007). Although the establishment of the ISA is a significant step in clearly marking accessibility requirements, the connotations of its graphical representation constrain public awareness on mobility impairments.

Figure 2.1: International Symbol of Access (ISA)

The limitations imposed by other impairments are less understood within society. Regarding visually impaired individuals, Passini *et al.* (1990) argue that it is architectural elements that impede their way-finding abilities so much so that they can be "*just as impassable as stairs are for wheelchair users*". It is suggested that the problems encountered by visually impaired people when navigating within the built environment originate from the lack of knowledge that professionals have with regards to their needs and way-finding abilities (Passini & Proulx, 1988). Furthermore these problems may be exacerbated due to the lack of awareness with regards to visual impairment or blindness among members of the general public, resulting in greater risks for the visually impaired pedestrian (Corcoran *et al.*, 2005; Pey *et al.*, 2007). The next section provides more insight on the perceptions of disability within society through the review of two established models of disability.

2.3. Models of Disability

The way in which disabled people have been portrayed within society has evolved and altered significantly over recent years. In particular two main models of disability have been identified and rigorously debated with regards to the distinction between impairment and disability and the way in which disabled people interact with the built environment. The two models, known as the Individual (medical) Model and the Social Model originally stem from discussions held at a meeting between the Union of the Physically Impaired Against Segregation and the Disability Alliance regarding the Fundamental Principles of Disability (UPIAS, 1976). Both models present radically different views on the role of disability within society and are reviewed in more detail in section 2.2.1(Individual model) and section 2.2.2 (Social model).

2.3.1. Individual (Medical) Model

The Individual Model of disability also referred to as the medical model, was widely followed up until the 1980's and embraced by the majority within the professional world as the correct view for outlining the position of disability within society. The model supports the view that the problems experienced by disabled people when carrying out day to day activities are caused as a direct result from the effects of their specific disability. It is believed that in order to overcome these problems, adjustments need to be made to the individual rather than to social practices and physical environments (Oliver, 1981; Oliver, 1983). The model supports the view that a disabled individual must undergo a series of personal adjustments in the form of physical rehabilitation, designed to convert the individual to "as near normal as possible"; and psychological adjustments, aimed at assisting the individual to come to terms with their limitations (Oliver, 1981; Oliver, 1983). The individual model assumes that persons with a disability have been subjected to a significant loss generally leading to poor mental health and depression; thus, in order to come to terms with this loss it is necessary to undergo a process of grieving and mourning similar to that when a loved one or close friend loses a life. Fitzgerald (1970) released a four stage approach for the processes in which newly diagnosed patients with blindness go through in order to come to terms with their disability, which are, disbelief, protest, depression and recovery.

The individual model has been criticised on a number of levels with regards to the methods of physical rehabilitation and psychological adjustments enforced on a disabled individual in order to make them adapt to the challenges presented within society. In particular, there are concerns over the assumption that the mental health of a disabled person must also be affected as a consequence of any physical or sensory impairment (Oliver, 1981; Oliver, 1983). The model proposes that a person with a disability must have a psychological problem. If the individual protests against that statement, then they are seen as being in denial, which is a recognised psychological problem (Trieschmann, 1980). The model has been seen by many as being “politically convenient” as it diverts all responsibility away from society and solely onto the disabled individual. In other words, society is not to blame for the many challenges faced by disabled people. In order for improvements to be made, the disabled person must adapt to the functional restrictions and psychological losses resulting from their disability (Oliver, 1996). Finally, there has been much criticism from the disabled community who feel victimised about the way in which professions theorise about the effects of disability as opposed to basing their views on factual information (Trieschmann, 1980). Some have argued that the model has been based on “psychological imagination” due to many of the theories emerging from individuals imagining what it would be like to be disabled and assuming that it would be a tragedy which would require psychological methods of adjustment (Oliver, 1981).

2.3.2. Social Model

The Social Model of disability presents opposing views and values compared to those reported in the Individual Model. Unlike the Individual Model, which primarily stems from non-disabled professional imagination (Oliver, 1981; Oliver, 1983) the Social Model was created by disabled people and disability related organisations. Instead of focusing on the physical and psychological limitations of particular individuals, the social model is based on the way in which physical and social environments impose limitations on specific groups or segments of the population, taking into account common barriers and experiences (Oliver, 1981; Oliver, 1983). The model is based on the premise that society is responsible for disabling physically impaired individuals. Hence, disability is something inflicted in addition to a person's impairment, which leads to frequent isolation and exclusion from full participation in society (UPIAS, 1976). The Fundamental Principles document elaborates further by specifically outlining the differences between impairment and disability. Impairment is classified as (i) *"lack of all or part of a limb*" or (ii) *"defective limb, organism or mechanism"* (UPIAS, 1976). The term disability is outlined as the:

> "disadvantage or restriction of activity caused by a set of contemporary social organization which takes no or little account of people who have physical impairments and thus excludes them in the mainstream of social activities"
>
> (UPIAS, 1976, p. 14)

The classifications of impairment and disability further emphasise the view that disability manifests itself as a result of the actions imposed by society (Leaman, 1981). In order for social oppression and disabling environments to be eliminated, society is required to adjust its patterns and expectations to include members with impairments by removing the unnecessary barriers that disable rather than enable independence and inclusion (Shearer, 1981). The principles of the social model have significant implications on the way in which disability is viewed, as it no longer identifies disabled people as having "something wrong with them" (Oliver, 1981). In cases where a disabled individual is unable to perform a specific task or access a facility or service, the reasons for this are seen to be due to poor design or unrealistic expectations from other parties.

By adopting the principles of the social model, it is the responsibility of society to change and not that of the disabled individual (Oliver, 1981; Oliver, 1983). The social model is not however without criticism; it has been stated that a denial that disablement is nothing to do with the body is biased and neglects the fact that impairment is a contributing factor to limitations in functionality (Oliver, 1996). Despite this criticism, the social model is now, (since the 1990's) internationally recognised and adopted by professional bodies and organisations as the most accurate way of representing disability within society.

The recognition of the fundamental principles outlined within the model has led to the introduction of non-discriminatory legislation aimed at protecting the interests of the disabled population. Furthermore, it has motivated the creation of design guidelines for safe and accessible built environments. The next section provides an overview of these regulations and guidelines, while their specifications are analysed in detail in Chapters 6 and 8.

2.4. Legislation & Guidelines

The current legislative framework with regards to disability and accessible environments consists of a number of documents for which the application is either compulsory or advisory. At the highest level, the Disability Discrimination Act dictates civil rights specifically targeted to the disabled population within the UK. In parallel, building regulations are in place to provide architects and designers with mandatory minimum standards for the design of elements within domestic and non-domestic buildings. The building regulations comprise legal statures that enforce their exercise when designing built environments. Designers are encouraged to integrate inclusive design methods throughout the design process and involve the views and experiences of potential user groups rather than implement changes afterwards in an attempt to adhere to Building Regulations (SBSA, 2009). Within the UK it is the responsibility of each region to publish their own set of building regulations, resulting in separate guidance for Scotland, Northern Ireland and England/Wales. Each set of regulations has a dedicated section for advice on the access, usability and design of safe environments in order to address the needs of disabled users. The regulations among these regional documents converge. This information can be sourced from Part 4 (Safety) of the Building (Scotland) Regulations (SBSA, 2009), Part R (Access to and Use of buildings) of the Building (Northern Ireland) Regulations (Dept. for Transport, 2006) and Part M (Access to and Use of buildings) of the Building Regulations for England and Wales (Dept. for Transport, 2004). As this thesis takes its research inputs from a Scottish urban environment, the analysis will focus exclusively on the Building Regulations for Scotland (see Section 2.3.2). However, the research outputs can be extrapolated to inform the design and accessibility of built environments throughout the UK and beyond.

The building regulations only contain the minimum standards of good practice. It is therefore necessary to rely on additional information from alternative sources in order to obtain more detailed guidance on accessibility issues and inclusive design methods. Further guidance is available from governmental departments and advisory panels, whose application is advisable but not compulsory. These guidance documents include:

- British Standards Design of buildings and their approaches to meet the needs of disabled people – Code of Practice (BSI, 2009)

- Inclusive Mobility: A guide to best practice on access to pedestrian and transport infrastructure (Dept. for Transport, 2005a)

- Guidance on the use of tactile paving surfaces (Dept. for Transport, 2002)

Although all relevant legislation will be explored in more detail in Chapters 6 and 8 of this thesis – with a critique of content, relevance and usability – the next sections offer an introduction to their fundamental principles, aims and audiences.

2.4.1. Disability Discrimination Act

The Disability Discrimination Act (DDA) is an Act of Parliament of the UK which was first introduced in 1995 and later amended and extended in 2005. The main aim of the Act is to promote civil rights and prevent against discrimination. The Act makes it unlawful to discriminate against an individual or group due to their disability. Since its introduction, close to eleven million people with a disability or long term-illness now have legal rights with regards to employment (Part 2), the provision of goods and services (Part 3), education (Part 4) and public transport (Part 5) (DDA, 2005). The legislation requires that public bodies actively promote equality of opportunity for disabled people even if the treatment is in the form of positive discrimination. As such, it is unlawful for service providers to treat people less favourably for reasons relating to their disability. Service providers are required to make reasonable adjustments to the way in which they offer services and provide additional assistance in order to accommodate the needs of disabled people. In addition, when a physical feature means that it is impossible to, or unreasonably difficult for a disabled person to make use of a service, a service provider is required to take reasonable measures to:

> "remove the feature; or alter it so that it no longer has that effect; or provide a reasonable means of avoiding it or provide a reasonable alternative method of making the service available".
>
> (DDA, 2005; Part 3)

Both the original and amended version of the Disability Discrimination Act have been subject to criticism with regards to a number of different issues. The first criticism is the stance taken by the act on the definition of disability, in which it defines disability as the impairment of an individual, adopting the definition given within the Individual Model (Barnes, 2000; Corker, 2000). The DDA has also been criticised for its use of terminology. Phrases such as "*reasonable adjustment*" and "*unreasonably difficult*" have been referred to as being "*dangerously vague*" terms (Gooding, 1996) as the Act fails to provide an adequate definition of the meaning behind the terms (Disability Rights Commission, 2002). Instead it is up to the employer, service provider or educational establishment to determine the adjustments necessary on a case by case basis. For example an adjustment which may be deemed "*reasonable*" for a large company may not be "*reasonable*" for a small company to undertake. Factors used to determine "*reasonableness*" include the type of service provided, the size and resources available to the provider and the financial implications of making the adjustment, including any disruption caused to the service. Guidance on determining what may be "*unreasonably difficult*" for a disabled person is covered by the Disability Rights Commission (Disability Rights Commission, 2002) – as of 2007 replaced by the Equality and Human Rights Commission (EHRC). Disability Rights Commission advises the service provider to take account of the issues faced by disabled people when using their service, such as additional time, effort, inconvenience, discomfort and loss of dignity and to consider whether persons without an impairment would find such difficulties reasonable or not. Part 3 of the Act (Access to goods, facilities and services), has significant implications on the design of new and existing elements within the built environment, as architects and designers are required by law to adopt a new standard of practice when considering the needs of all users of a building. The Act however only focuses on access to and from buildings and fails to specifically mention the rights of a disabled person when travelling between buildings, for example on a pavement or pedestrian precinct. Furthermore, the Act has been referred to as being "confusing, contorted and unsatisfactory" (Gooding, 1996). This confusion is also reflected and enhanced when practitioners attempt to comply with the Act. In order to assist architects further during the design stage, more detailed information on issues relating to accessibility can be sourced from the building regulations and other advisory guidelines, which are reviewed in the following sections.

2.4.2. Building Regulations (Scotland)

The Building Standards Regulations for Scotland are produced by the Scottish Building Standards Agency (SBSA) and are administered and enforced by local authorities within Scotland. The purpose of the regulations is to protect the public interest by outlining essential standards. These standards must be adhered to during the design, construction and conversion of both domestic and non domestic buildings (SBSA, 2009). The regulations ensure that any new build project, conversion or demolition is compliant in terms of “health, safety, welfare, convenience, conservation of fuel and power, and sustainable development” (SBSA, 2009). As such, the regulations are categorised into six main sections providing mandatory requirements for (i) structure, (ii) fire, (iii) environment, (iv) safety, (v) noise and (vi) energy.

The regulations responsible for ensuring the accessibility and usability of a building are provided in section 4, *Safety*, of the Building Regulations for Scotland. The standards within this section aim to limit the risk levels to users of buildings and reduce the number of accidents particularly in the case of the elderly and disabled populations. In particular, the regulations relevant to accessibility in the external built environment address the following issues:

- Accessible car parking spaces for individuals with mobility impairment.

- Setting-down points to facilitate alighting of mobility impaired individuals from vehicles.

- Provisions for accessible routes to the entrance of a building and indications for length, width and surface materials of accessible routes.

- Accessible entrances, powered doors and thresholds.

- Protective barriers in and around buildings to prevent accidental fall at an unguarded level change.

From the above, it becomes evident that the Building Regulations place a strong emphasis on mobility impairments. The remaining regulations predominantly focus on issues relating to health and safety *within* buildings. Design standards for external environments are limited to the design of access routes between a road and the principle building entrance; and access routes between any accessible car parking provided within the curtilage of the building. The regulations fail to provide any mandatory standards for the design of spaces and routes between buildings in the built environment on a wider scale. For this reason designers are required to source additional information from guidance documents, details of which are provided below.

2.4.3. British Standards BS: 8300

British Standards BS: 8300, *'Design of buildings and their approaches to meet the needs of disabled people' – code of practice* (BSI, 2009) is a guidance document concerned with the design of new buildings and their approaches in order to cater for the needs of the disabled population. It should be noted that as a code of practice offering guidance and recommendations, the standards contained within BS 8300 are not enforceable by law. The guidance applies to accessible car parking provision, access routes to and around all buildings and the entrances and interiors of new buildings. The recommendations also incorporate guidance regarding accessible routes to facilities associated with and in the immediate vicinity of buildings (BSI, 2009). The recommendations in the guidance document augment the specifications of the Building Standards (see Section 2.3.2), by extending guidance outside the curtilage of the building to include access routes that connect buildings to public transport terminals (BSI, 2009,

p. 16). However, similarly to the Building Regulations, the remit of the Building Standards fails to provide comprehensive guidance regarding the design of exterior public spaces located beyond the immediate proximity of buildings and public transport nodes. Furthermore, the main focus is again on mobility impairment with little reference to the needs of the visually impaired. These issues are more extensively documented in the *Inclusive Mobility* guidelines reviewed in the following section.

2.4.4. Inclusive Mobility

The “Inclusive Mobility” guidelines (Dept. for Transport, 2005a) were published by the Department of Transport in 2002 and later updated in 2005. The guidelines build on the specifications of the DDA and BS: 8300 in order to cover omissions and supply updated, accurate and comprehensive guidance for designing accessible urban environments (Dept. for Transport, 2005a, p. 2). The overall objective of the guide is to “provide inclusive design and through that achieve social inclusion” (Dept. for Transport, 2005a, p. 2). To this end, *Inclusive Mobility* is the only document in this review to specifically address access issues for both mobility- and visually-impaired people. The recommendations cover a wide spectrum of features, ranging from pedestrian and street environments to public transport buildings and infrastructure. The *Inclusive Mobility* guidelines are widely acknowledged as “the most authoritative reference for *inclusive design* of *pedestrian architecture* and for *transport-related buildings* such as bus and coach stations, railway stations, air terminal and transport interchanges” (Vandenberg, 2008, p. 6; emphasis in the original). For this reason, the guidelines are examined in detail in Chapter 6, where the specifications are cross-analysed and compared with the findings of an access audit in the city centre of Glasgow. This analysis aims to determine the extent to which these guidelines are taken into account and employed for informed decisions in designing accessible public spaces.

2.4.5. Guidance for the use of tactile paving

In 2002 The Department for Transport published a set of guidelines for the use of tactile paving surfaces in streetscapes for aiding the independent navigation of the visually impaired pedestrian (Dept. for Transport, 2002). The guidance document commences with a recognition of the increasing numbers in the visually impaired population outlined in the *Introduction* of this thesis. A number of mobility techniques are identified to reach the conclusion that tactile paving offers discrete indicators for navigation in the built environment and a “compensation” for the absence of other features to signify changes in street design (Dept. for Transport, 2002, p. 3). The guidelines provide specifications for seven types of tactile paving, namely:

- Blister surfaces for pedestrian crossings
- Corduroy hazard warning surfaces for level changes
- Platform edge (off-street) warning surfaces
- Platform edge (on-street) warning surfaces
- Segregated Shared Cycle Track/Footway Surface and Central Delineator Strips
- Guidance path surfaces to compensate for the lack of traditional cues (e.g. kerb edge)
- Information surfaces to aid in locating amenities (e.g. telephone boxes or ticket offices)

The above specifications focus not only on the texture of the paving, but also its layout, colour and maintenance. The research behind the guidelines indicated that “visually impaired people can reliably detect, distinguish and remember a limited number of different tactile paving surfaces and the distinct meanings assigned to them." (Dept. for Transport, 2002, p. 5) The necessity for tactile paving is so evident that visually impaired pedestrians nowadays "actively seek and make use of tactile information underfoot, particularly detectable contrasts in surface texture." (Dept. for Transport, 2002, p. 4) Precisely because these specifications are exclusively applicable to navigation needs of visually impaired individuals, their formulation has consulted the needs of other users of pedestrian architecture to ensure unobtrusive access for all users. For this reason, the rules for correct use are very precise and designers are instructed to consult both documents for *Guidance for the use of tactile paving* and *Inclusive Mobility* (Vandenberg, 2008, p. 61). To this end, a detailed analysis of tactile paving specifications is included in Chapter 6, in conjunction with the guidance outlined in Section 2.3.4.

2.5. Conclusion

This chapter has clarified the context surrounding Disability, with particular reference to the UK. The analysis commenced with a definition of disability and the role of existing documentation in influencing the awareness over disability issues within society. It has been exhibited that evidence in the evolution of accessibility decision-making has created a cognitive culture whereby mobility impairments have attracted more attention than other forms of disability. However, literature findings suggest that discussion on perceptions of disability have historically created two strands with opposing views. This is prominent in the fundamental principles of the Individual and Social models of disability. The former draws a clear distinction between able-bodied and disabled people, who consequently have special needs. These needs are perceived as the aftermath of their own condition rather than of the limitations that the built environment imposes on free access. In contrast, the Social Model identifies the organisational structures of society as the restricting factors of opportunities for disabled individuals.

Although the ideas behind the Social Model of Disability are simple, they challenged previous perceptions and influenced the social and legal world on many levels. The essential contribution of the Social Model was in paving the way for building regulations to specifically address accessibility issues; and for government bodies to create guidance documents with accessibility recommendations. This legal and advisory framework is represented here in the reviews of the Disability Discrimination Act, the Building Regulations (Scotland), as well as three fundamental guidance documents: British Standards BS: 8300, Inclusive Mobility and Guidance for the use of tactile paving. The nature of the guidance documents is advisory and therefore does not have legal stature. Nevertheless, they augment the – rather limited - specifications set out in the Building Regulations. Conformity with their recommendations further reinforces the requirements of the Disability Discrimination Act for equal opportunities within the community of disabled people for access in the built environment.

The purpose of this chapter was not to provide an extensive analysis of the above issues but rather to establish an insight in the study background that is essential for contextualising the methods and approaches employed in this thesis. In doing so, the chapter sets out the groundwork for understanding that the findings of this work are part of a continuum in identifying accessibility needs and interpreting them into functional requirements for urban environments.

In order for architects and designers, as well as members of the general public, to further understand the access requirements of the visually impaired population, it is also necessary to explore the nature of visual impairment. The next chapter focuses specifically on visual impairment; highlighting the anatomy of the eye and types of vision loss an individual may experience. An outline of current prevalence statistics and future predictions highlights the relationship between changing demographics and future increase in the visually impaired population and reinforces the need for more detailed research to be conducted in order to accommodate the needs of the changing population living in a world with low vision.

Chapter 3: The Eye & Visual Impairment

3.1. Introduction

This chapter describes the anatomy and physiology of the eye as a foundation for understanding the issues explored in this thesis, illustrating some of the numerous medical conditions that may occur and their effects on vision. The broad range of visual impairments is detailed and categorised according to type of vision loss, specifically central loss, peripheral loss, mixed loss and blindness. This is followed by an explanation of the registration process whereby an individual can voluntarily register as either sight impaired or severely sight impaired, provided that they meet eligibility criteria.

Thereafter an overview of current statistics and future predictions regarding the prevalence of visual impairments in the UK will be detailed. Furthermore the links between unhealthy lifestyle and changing demographics are also highlighted as critical factors for the significant increase in cases of visual impairment. The statistics presented within this chapter provide a clear justification for further research to be conducted in order to investigate the requirements of this changing population.

3.2. The Eye

The human eye is a complex organ, which plays a vital role in providing the necessary information required for spatial awareness and navigational activities. The eye is made up of a number of different components and successful vision requires that all of these parts work together simultaneously in an integrated fashion; from the window of the eye, the cornea through to the optic nerve at the back of the eye. The cross-sectional anatomy of the eye is shown in Figure 3.1 (Kimber & Leavell, 1966). The explanation given below regarding the structure and function of the eye is based on the descriptions provided by the Encyclopedia of Blindness and Vision Impairment (Sardegna *et al.*, 2002).

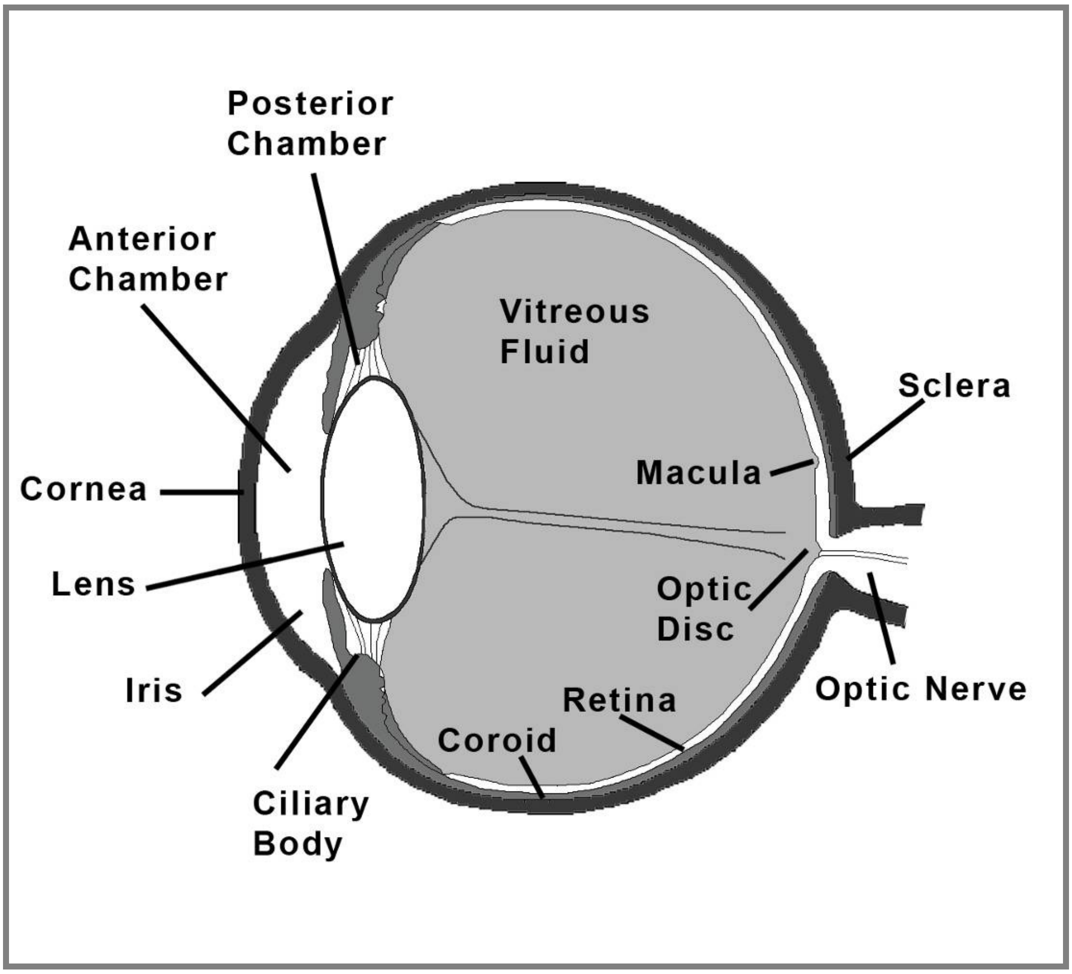


Figure 3.1: Cross-section of the eye, (Kimber & Leavell, 1966)

The anterior segment is composed of the cornea, iris, ciliary body and lens. Its main function is to focus light on to the photosensitive retina at the back of the eye. The majority of the focusing power comes from the cornea with fine adjustments provided by the lens under the control of the ciliary muscles. The amount of light reaching the retina is regulated by the iris, which controls the size of the pupil through the sphincter and dilator papillae muscles. In dark conditions the pupil dilates in order to allow the maximum possible amount of light to pass, whereas in bright conditions the opposite occurs and the pupil contracts in order to screen out excess light.

The inner two-thirds of the eye is known as the posterior segment. It is composed of the retina, underlying choroid and optic nerve. The retina is a complex multi-layered structure containing the photosensitive cells (rods and cones) which transform light into chemical messages that are ultimately processed into the visual image. Located near the centre of the retina is the macula, within which lies the fovea - a pit with a high concentration of cone photoreceptor cells. The cone cells are responsible for central vision, colour perception and focusing on fine sharp details. Rod cells react to dim light, movement and shape and are responsible for peripheral and night vision. The retina collects information from the cone and rod receptor cells and transfers this information to the brain as electrical impulses via the optic nerve. The brain then converts these signals into images.

3.3. Types of Vision Loss

Vision can be compromised by damage to any of the structures that make up the eye or transmit the visual image to the brain. The spectrum of impairment is therefore wide but as a general rule these conditions can be divided into three groups relating to the type of vision loss; these are: Central Vision Loss, Peripheral Vision Loss and Mixed Vision Loss. The explanations given below discuss the different types of vision loss, their aetiology and the effect this has on the visual field. This discussion is based on the definitions given in the Encyclopedia of Blindness and Vision Impairment (Sardegna *et al.*, 2002).

3.3.1. No Vision Loss

No vision loss refers to individuals with no eye disorders affecting either their field of vision or visual acuity. In this thesis, individuals within this group are referred to as being fully sighted. For comparison purposes, a typical streetscape as would be viewed by a fully sighted individual is presented in Figure 3.2.

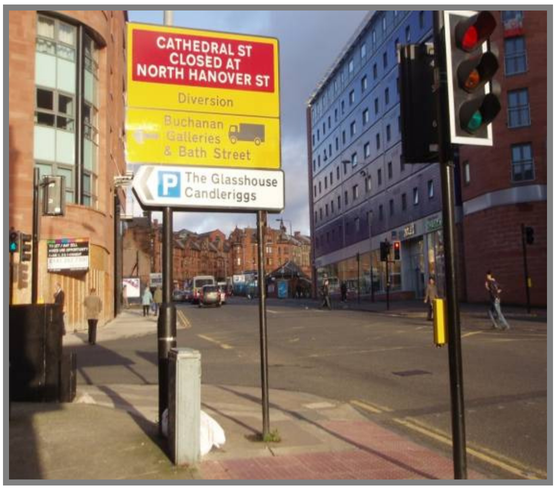


Figure 3.2: Streetscape as viewed by a person with no vision loss

3.3.2. Central Vision Loss

Central vision is affected as a result of damage to the macula, fovea or optic nerve. The most common form of central vision loss is caused by age related macular degeneration (AMD). The condition can either be dry or wet. Dry AMD is the result of degeneration of the retinal pigment and underlying photoreceptor cells and usually progresses fairly slowly; however 10% of those affected will experience severe vision loss resulting in disruption to most daily activities (RNIB, 2006b). Wet AMD accounts for 10% of AMD cases and usually develops more rapidly. It is caused by an abnormal growth of blood vessels under the retina which form in order to improve the blood supply to the oxygen deprived retinal tissue. The delicate blood vessels begin to leak fluid and form scar tissue, affecting the function of the cones and rods within the macula. AMD is largely influenced by age and appears mainly in the over 60 population although it can occur from age 40 onwards (Sardegna *et al.*, 2002).

Central vision can also be lost through macular dystrophy, a group of rare inherited diseases, usually diagnosed before the age of 20 (Sardegna *et al.*, 2002). The macula contains a high concentration of cone cells in the fovea, therefore any damage in this area results in vision with a blurred central field (Figure 3.3) and in certain cases colour blindness. Central vision loss can also lead to photophobia, causing an individual to have a low tolerance to bright light and experience problems with glare. Degeneration of the macula is a progressive condition, however it rarely leads to total blindness as some residual peripheral vision remains active.

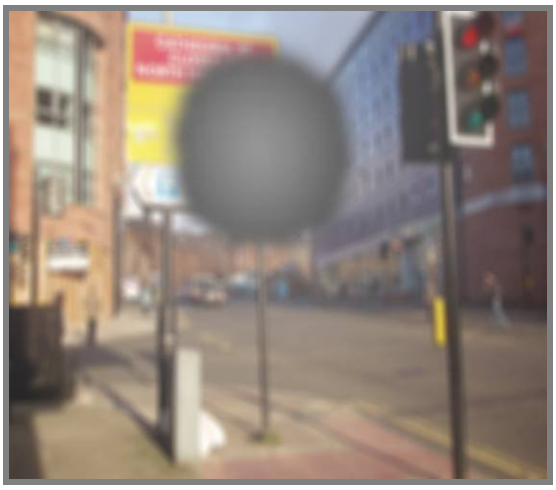


Figure 3.3: Streetscape as viewed by a person with central vision loss

3.3.3. Peripheral Vision Loss

Peripheral vision loss is caused by damage to the periphery of the retina. Two of the most common causes of peripheral vision loss are Glaucoma and Retinitis Pigmentosa. Glaucoma occurs when there is increased pressure within the anterior chamber as the aqueous fluid cannot drain normally. This increased pressure is transmitted to the retina and the optic nerve (Figure 3.1) which results in damage to the sensitive nerve cells of the retina. Glaucoma progressively reduces peripheral vision resulting in tunnel vision (Figure 3.4). Retinitis Pigmentosa is a disease which leads to degeneration of the cones and rods of the retina and is predominantly a genetic disorder. Initially the rods are affected resulting in poor vision under dim lighting conditions (commonly known as night blindness) and a reduction in peripheral vision. As the disease progresses, an individual may develop central vision loss as well and in some severe cases the disease may progress to a stage of total vision loss, although this is uncommon.

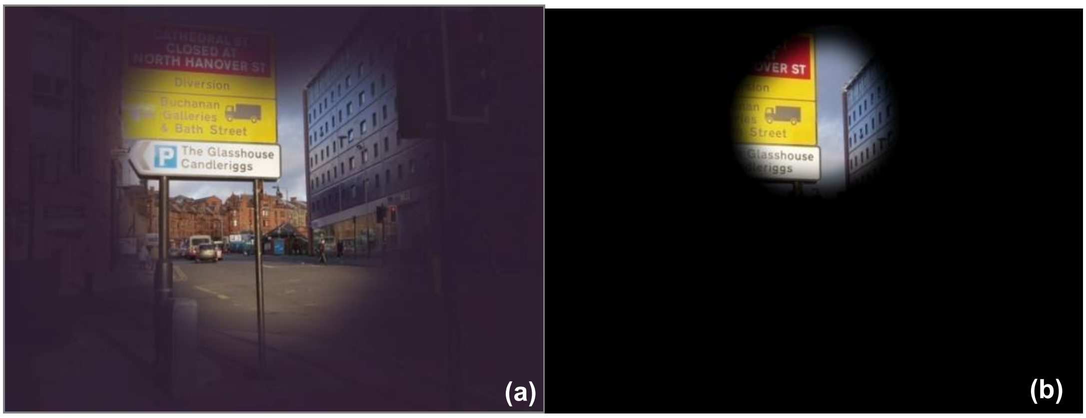


Figure 3.4: Streetscapes as viewed by a person with (a) a mild form and (b) a severe form of peripheral vision loss

3.3.4. Mixed Vision Loss

Mixed vision loss occurs when a combination of cones and rods are damaged affecting both the peripheral and central visual fields. The most common cause of this pattern is Diabetic Retinopathy. Diabetic Retinopathy is a micro-vascular complication of diabetes; the small blood vessels are damaged leading to loss of blood supply to areas of the retina. In response, the retina produces a growth factor that stimulates the production of new vessels which form in a disorganised fashion and are easily damaged. Diabetic Retinopathy results in sporadic patches of vision loss in both the peripheral and central visual fields (Figure 3.5a). In severe cases the retina can become detached leading to a total loss of vision. Treatment with laser therapy kills the damaged areas of the retina and prevents growth of these new blood vessels; however in most cases this will only stop the progression of the disease and not recover any lost vision.

Although not a condition affecting the cones and rods, cataracts are also responsible for mixed vision loss. A cataract is the clouding of the crystalline lens of the eye resulting in dim or blurred vision, (Figure 3.5b) and may occur in one or both eyes. Other effects include problems with glare or the presence of a halo when in brightly lit environments; it is also possible for colour perception to change. The older generation are particularly susceptible to cataracts (senile cataracts) however this is not exclusively the case as birth defects (congenital cataracts), exposure to UV light, steroid use and the presence of diabetes can also influence their formation. Unlike most other eye conditions, it is possible for cataracts to be treated through an operation by replacing the cloudy, opaque, lens with a synthetic lens.

Within the experimental stages of this thesis those individuals who have more than one type of vision loss have been classified as belonging to the mixed vision loss group, (e.g. an individual with glaucoma and congenital cataracts).

Figure 3.5: Streetscape as viewed by a person with (a) diabetic retinopathy and (b) cataracts

3.3.5. Blindness

Visual impairment is the end result of many different processes and can vary dramatically in severity, e.g. two individuals could both have retinitis pigmentosa, however one may have a mild visual impairment reducing their peripheral vision and the other may have no remaining useful vision (blind). Aside from being the most severe stage of progression of some of the aforementioned eye conditions, blindness may also be caused by trauma, premature birth or congenital defects. Examples of conditions which can lead to blindness include: retinoblastoma, toxoplasmosis, sarcoid uveitis, choroiditis and mitochondrial disorders such as Leber's hereditary optic neuropathy.

In this thesis the term “blind” refers to circumstances where an individual has no useful remaining vision, as opposed to “visually impaired” which should refer to those individuals with some useful remaining vision, however little that amount may be. It is important to note here however, that for registration purposes, the severely sight impaired category (formerly known as blind) includes those individuals with useful remaining vision (see Section 3.4).

3.3.6. Other

The category ‘Other’ refers to conditions affecting a person’s visual acuity rather than any significant visual field loss. Conditions may include myopia (short sightedness), hypermetropia (long sightedness), nystagmus, albinism and colour blindness. Individuals, with a myopia or hypermetropia, who wear lenses or glasses, which correct their vision, are not classified in this research as being visually impaired. Nystagmus is a condition which involves involuntary movements of the eyes. These movements cause difficulties in focussing and result in blurring of the vision. Nystagmus may be congenital or the result of another disease.

3.4. Visual impairment Classification

Registration is a joint process involving an ophthalmologist and the social service department of each local authority. Individuals with a visual impairment and who are eligible for registration are encouraged to do so in order to receive the support and benefits that they are entitled to, including concessionary travel and disability living allowance. In order for an individual to be eligible for registration they must be diagnosed with a visual impairment which cannot be cured. Therefore treatable conditions such as cataracts and refractive error are exempt from the registration process even though vision can be seriously impaired. For all other non curable conditions, a person can either be registered as sight impaired (formerly known as partially sighted) or as severely sight impaired (formerly known as blind) (Dept. of Health, 2007). Classification is based on the measurement of a person’s visual acuity (VA) compared to that of a fully sighted person when reading letters displayed on a Snellen eye chart from a specified distance. A fully sighted person is just able to view the top letter of the eye chart from a distance of 60 metres (Galloway *et al.*, 2006). Therefore if an individual is only able to view the top line of the chart from a maximum distance of 3 metres, they would be awarded a VA of 3/60.

An individual can be registered as sight impaired if they have poor visual acuity and or a reduction in visual field as defined in Table 3.1. Individuals who are registered as sight impaired are likely to experience sight problems that are disruptive to most daily activities such as reading print, watching television, driving and recognising faces, even at close distances. An individual can be registered as severely sight impaired if they have a severe or very severe reduction in visual acuity and / or a severe reduction in visual field (Table 3.1). Within this category a number of different visual abilities exist, ranging from some useful remaining vision - no light perception - total blindness. Individuals within the severely sight impaired category may face serious difficulty in carrying out daily tasks, especially when it comes to leading an independent lifestyle.

Table 3.1: Classifications for registration as sight impaired or severely sight impaired in the UK (Dept. of Health, 2007)

Sight impaired classification	Severely sight impaired classification
3/60 < VA < 6/60	VA < 3/60
A moderate reduction in visual field & 6/60 < VA < 6/24	A severe reduction in visual field & 3/60 < VA < 6/60
A large reduction in visual field & 6/24 < VA < 6/18	A very severe reduction in visual field & VA > 6/60

*** VA = Visual Acuity**

3.5. Visual Impairment Prevalence

Worldwide it is estimated that more than 314 million people are visually impaired; 269 million have low vision (sight impaired) and 45 million are blind (severely sight impaired), (WHO, 2009). Cataracts are the leading cause of blindness worldwide followed by glaucoma and AMD. AMD is the leading cause of blindness in developed countries due to growing ageing populations (WHO, 2009). It should be noted that the figure of 314 million does not include cases of refractive error; if this category was to be included then the figure would be substantially higher.

In the UK, statistics regarding the size of the visually impaired population are based on the numbers of those legally registered as sight impaired or severely sight impaired. Table 3.2 presents the numbers of those registered in Scotland, England and Wales in 2008. Equivalent data for visually impaired individuals in Northern Ireland is not available. It is estimated that 82% of the entire visually impaired population have some residual vision; 14% have some light perception and only 4% see nothing at all (Bright *et al.*, 2004).

Table 3.2: Number of people registered in the UK as sight impaired & severely sight impaired in 2008 (National Statistics, 2008, 2009; NHS, 2008)

Country	Sight Impaired	Severely sight Impaired	Total
Scotland	15,957	19,959	35,916
England	156,300	153,000	309,300
Wales	8,925	8,889	17,814
UK	**181,182**	**181,848**	**363,030**

Registration is a voluntary process and there is some uncertainty as to the actual size of the visually impaired population within the UK. It has been suggested that only between one quarter and one third of the visually impaired population are actually registered (Bruce *et al.*, 1991). Tate *et al.*, (2005) however suggest that the number of individuals eligible for registration could be 20% higher than existing figures. Furthermore these figures do not account for individuals with cataracts or refractive error. Charles (2006) estimate that there could be as many as 2.3 million visually impaired individuals in the UK, representing 3.6% of the total UK population. The total can be divided into three main categories, namely children aged 16 years and younger; adults aged 17 to 64 and the elderly aged 65 years and over (see Table 3.3 for details).

Table 3.3: Estimated UK visually impaired population by age group (Charles, 2006)

Age Group	Visually Impaired Population
Children (0 – 16)	7 000 – 30 000
Adults (16 – 64)	47 000
Elderly (65+)	1 600 000 – 2 200 000

3.6. Future Predictions

Visual impairment prevalence in the UK is expected to double from 2.3 million to around 4 million by the year 2030 (RNIB, 2006a). This would suggest that over 5.5% of the UK population would be visually impaired by 2030, taking into account the increase in the overall UK population. The substantial estimated expansion in the visually impaired population has strong links to the changing demographics of the UK population in addition to increasingly unhealthy lifestyle choices. The links between ageing population, obesity and visual impairment are explored further in section 3.6.1 and section 3.6.2.

3.6.1. Ageing Population

The latest population statistics for the UK are estimated to be close to 61.4 million (ONS, 2009). This figure is expected to increase to 65.6 million in 2018 and reach 71.6 million by 2033 (ONS, 2010). The low birth rate and increasing life expectancy mean that this growth in population size is not accompanied by a proportionate change of numbers in different age groups. This is particularly evident for those aged 60 years and over; it is expected that this age group will increase significantly from 12.9 million (21.3% of UK population) in 2006 to 20 million (28.2% of UK population) in 2031, representing a 6.8% increase within the total UK population (ONS, 2009). Although these projections are based on a number of assumptions, it is anticipated that the population will continue to age with the proportion of the over 60 group rising under different scenarios (Smith *et al.*, 2005).

As people age, they are increasingly likely to suffer from health problems (Tomassini, 2005) including complications with their vision. In fact, an estimated 97% of the visually impaired population is aged 65 years and over (Charles, 2006). It is estimated that between 964,000 and 1,155,000 of the elderly population suffer from a mild visual impairment and between 676,000 and 1,036,000 are affected by moderate to severe vision loss (Charles, 2006). Approximately half of all cases of vision loss are caused by untreated cataracts or refractive error and the other half by untreatable conditions such as AMD. Table 3.4 presents the most common types of visual impairment diagnosed in individuals aged 75 years and over. The number of cases of AMD is likely to increase as the population grows older and unless any advances in the treatment of AMD arise, it is anticipated that there will be an additional 20,000 – 24,000 more cases of registerable AMD among those aged 70 years and over by the year 2020 (Charles, 2006).

Table 3.4: Visual impairment prevalence in the population aged 75 years and over (Charles, 2006)

Visual impairment	Population affected
Age Related Macular Degeneration	180,000 - 216,000
Refractive error	155,000 - 190,000
Cataracts	119,000 - 147,000
Glaucoma	34,000 - 52,000
Vascular occlusions	10,000 - 21,000
Diabetic eye disease	8,000 – 17,000

The probability of becoming visually impaired substantially increases in old age. This is particularly evident among those aged 85 years and over; estimates show that over a quarter (26.8%) have either a moderate or severe visual impairment (Charles, 2006). This figure compares to 8.5% of those aged between 75 and 84 and 5.6% of those aged between 65 and 74 (Charles, 2006), see Figure 3.6.

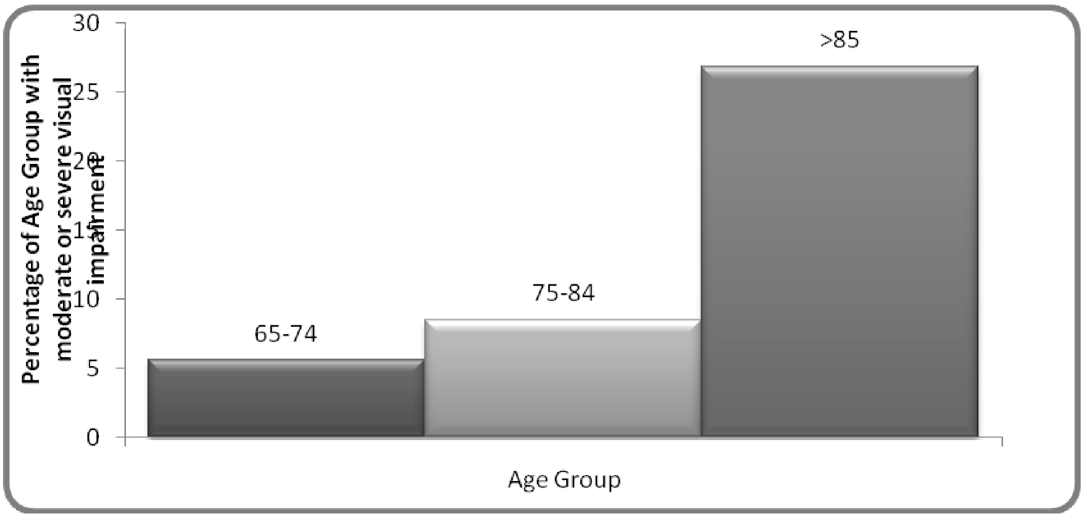


Figure 3.6: The estimated ranges for the number of people in the UK aged 65 years and over with vision impairment (Charles, 2006)

3.6.2. Obesity Epidemic

A person is classified as being obese when their Body Mass Index (BMI) exceeds 30 kg/m^2 (WHO, 2000). BMI is calculated by dividing body weight in kilograms by the square of a person's height. The World Health Organisation has published the classifications for BMI illustrating the range of categories from a figure of <18.5 (underweight) to a measurement of >40 (class III obesity) see Table 3.5, (WHO, 2000).

Table 3.5: BMI Classification (WHO, 2000)

BMI (kg/m^2)	Classification
<18.5	Underweight
18.5 – 24.9	Normal weight
25.0 – 29.9	Overweight
30.0 – 34.9	Class I Obesity
35.0 – 39.9	Class II Obesity
> 40.0	Class III Obesity

Data regarding levels of obesity in England, Wales, Scotland and Northern Ireland is collected by the respective devolved administrations. As a result, it is difficult to obtain UK-wide statistics. In England approximately 25% of adults and 10% of children are obese (Dept. of Health, 2004). Similar figures have been recorded in Scotland, with 22% of men and 24% of women classified as obese (Dept. of Health, 2003). The UK Government's Foresight programme published extrapolations for the whole of the UK, based on data from the Health Survey for England (Dept. of Health, 2004). It is anticipated that by 2025, 40% of the UK population will be obese and will increase further to more than 50% by 2050 (Butland *et al.*, 2007). Figure 3.7 details the predicted increase in obesity levels among the male and female population from 2004 to 2050. In 2050 it is estimated that 60% of men, 50% of women and 25% of children will be obese (Butland *et al.*, 2007).

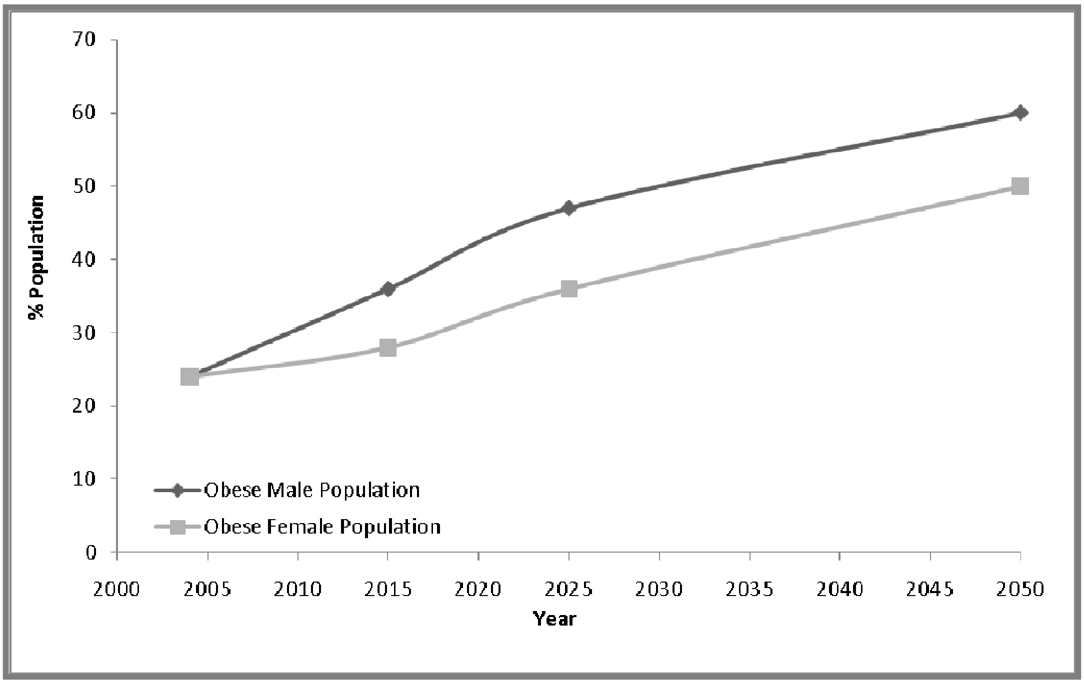


Figure 3.7: Obesity Predictions 2004-2050 (Butland, 2007)

These findings will have major consequences on the future size of the visually impaired population as obesity is associated with a number of different eye conditions, including AMD, diabetic retinopathy, cataracts, glaucoma and diseases of the eye caused by cardiovascular disease. The links between obesity and each of these eye conditions is explored here in more detail.

3.6.2.1. AMD

Research has shown that obesity may increase the risk of developing both dry and wet forms of AMD. Individuals with a BMI of over 25 have a 1.5 fold increased risk of developing dry AMD, whereas those with a BMI of over 30 are twice as likely to develop dry AMD compared to a person of normal weight (RNIB, 2006b). Perhaps more significant is the way in which obesity affects the progression of wet AMD. It is thought that individuals with a BMI of over 25 are at twice the risk of developing a rapid progression of wet AMD whereby sight loss can deteriorate significantly over a three month period leading to legal blindness (RNIB, 2006b). Individuals with a family history of

AMD, who are known to have a genetic predisposition for developing the disease should take extra care to maintain a healthy body weight as their risk of developing the disease will rise from four times with a normal body weight to an eleven times increase when obese (RNIB, 2006b).

3.6.2.2. Cardiovascular Disease

Individuals who are obese have a significant increased risk of developing cardiovascular disease which can manifest as stroke or heart attack (RNIB, 2006b). Cardiovascular disease can be particularly damaging to the blood vessels within the retina and is responsible for two retinal disorders: hypertensive retinopathy and retinal vein occlusion (RNIB, 2006b). Hypertensive retinopathy occurs in patients with high blood pressure and leads to damage of the delicate blood vessels within the retina. If left untreated the blood vessels can leak and cause swelling of the optic nerve, resulting in loss of vision. Research has shown that obesity increases the risk of developing retinal vein occlusion by up to four times (RNIB, 2006b).

3.6.2.3. Diabetic Retinopathy

Obesity significantly increases the risk of developing type II diabetes, an illness whereby the body is unable to regulate blood sugar levels due to a relative underproduction of insulin or insulin resistance. Individuals with a BMI of over 30 are ten times more likely to develop diabetes than someone with a normal body weight (RNIB, 2006b). A person who has lived with a BMI of 35 or greater for more than ten years is 80 times more likely to develop diabetes than a person with a BMI of less than 22 (RNIB, 2006b). It is anticipated that the obesity epidemic will lead to a diabetes epidemic, which will in turn see a significant increase in cases of diabetic retinopathy, as 60% of individuals with type II diabetes will eventually develop the disease (RNIB, 2006b).

3.6.2.4. Cataract / Glaucoma

There is a strong link between obesity and the prevalence of cataracts. Individuals with a BMI over 30 are twice as likely to develop cataracts compared to someone with a normal body weight (RNIB, 2006b). Although cataracts are treatable, the increase in cases places a large strain on the NHS due to the high costs of treatment. There have also been suggestions that obesity can trigger the onset of Glaucoma. The findings from a major Japanese study (Mori *et al.*, 2000) have indicated that a significant link exists. The results show that obesity has a direct link to a rise in intra-ocular pressure, which if left untreated can lead to the development of glaucoma.

3.7. Conclusion

This chapter has focused on the structure and function of the eye, illustrating some of the numerous medical conditions that may occur and their effects on vision. An explanation has been given as to the registration process whereby an individual can voluntarily register as either sight impaired or severely sight impaired. This has been followed by an overview of current statistics and future predictions regarding the prevalence of visual impairments in the UK. The links between an unhealthy lifestyle and changing demographics have also been highlighted as critical factors for this substantial increase. As the population grows older the prevalence of visual impairment will also increase.

The statistics presented within this chapter provide a clear justification for further research to be conducted in order to investigate the requirements of this changing population. In particular, the design and layout of the external built environment will be analysed in order to identify the main barriers to access for the visually impaired population and in doing so, identify potential areas for improved design strategies. Prior to this stage it is first necessary to investigate possible human factors associated with visual impairment and subsequent limitations that this may pose on unobstructed navigation within the built environment, details of which are presented in Chapter 4: Spatio-cognitive Abilities of the Visually Impaired Population.

Chapter 4: Spatio-Cognitive Abilities of the Visually Impaired Population

4.1. Introduction

This chapter primarily focuses on the wayfinding techniques and cognitive processes and abilities adopted by the visually impaired population when navigating within the built environment. By focusing on their abilities and not their impairment, it may be possible to gain a broader understanding of how environments can be designed in a way which eliminates as far as possible, discomfort and unnecessary stress and fear for the visually impaired population.

Concerns have been raised regarding the lack of understanding among the general population with regards to the problems encountered by blind and visually impaired people during navigational tasks (Brambring, 1982; Golledge, 1993). It is even suggested that the problems encountered by visually impaired people when navigating within the built environment originate from the lack of knowledge that professionals have regarding their needs and wayfinding abilities (Passini & Proulx, 1988). The key role of the architect and designer should be to create an inclusive environment, absent from barriers and potential hazards, however without a comprehensive understanding of the navigational behaviour of this population this is not possible. An increased awareness among design professionals could lead to more memorable and enjoyable environments (Kitchin & Jacobson, 1997).

This review of the literature aims to identify and critique some of the important aspects of previous studies undertaken regarding the spatio-cognitive abilities of the blind and visually impaired population. The chapter then focuses on the environmental settings in which previous studies have been undertaken and categorises each study under the headings of internal – artificial, internal – real and external. The subject groups involved within previous studies are outlined and the lack of research undertaken involving visually impaired individuals with a range of impairments and differing severities of visual field loss is highlighted. Furthermore, the question is raised as to the effects if any, that the time of onset of blindness has on a person's ability to construct a visual representation of the environment and in particular, if the type of visual field loss is responsible for differences in performance levels. Finally, the environmental features and cues used by fully sighted and visually impaired subjects during navigational tasks are identified and analysed. The importance and lack of non visual environmental cues for the purpose of assisting visually impaired people during wayfinding tasks is highlighted with recommendations for future research regarding the implementation of additional tactile and other sensory cues within the built environment.

4.2. Theory

4.2.1. History

Theories regarding the spatio-cognitive skills of blind and visually impaired people have been a topic of conversation extending as far back as the late 17th Century. In 1688 the English philosopher John Locke attempted to answer a question put forward by his friend, Irish scientist and politician, William Molyneux (Ungar, 2000).

> "Suppose a man born blind, and now adult, and taught by his touch to distinguish between a cube and a sphere of the same metal, and nighly of the same bigness, so as to tell, when he felt one and the other, which is the cube, which the sphere. Suppose then the cube and sphere placed on a Table, and the blind man be made to see: quaere, whether by his sight, before he touched them, he could now distinguish and tell which is the globe, which the cube?"
>
> (Ungar, 2000, p. 1)

This question evoked great interest among philosophers and scientists and led to the creation of several theories, often opposing in nature as to the importance that visual experience has on a person's ability to construct a spatial understanding of their surroundings. Prior to Molyneux's question, Descartes (1965) theorised that all humans have an inherent ability to construct a visual representation of objects and space without prior experience of vision. This statement was later opposed by Berkeley (1965) who hypothesised that visual distance perception results from past visual experiences.

Prior to the 1970's the definition of wayfinding was concerned with the static relationship between a human and their surrounding environment (Levine *et al.*, 1982). However during the 1970's a changing attitude among researchers led to more emphasis being placed on discovering how adults interpret, construe, interact and retain information about space (Levine *et al.*, 1982). The definition of wayfinding later evolved to focus on purposeful dynamic movement between a user and their environment, (Passini, 1984). This changing attitude in conjunction with the demand for technological solutions to overcome wayfinding and navigational barriers has resulted in an increased interest among researchers and designers as to the spatio-cognitive abilities of both the blind and fully sighted population. Increasingly, robotics, artificial intelligence, virtual reality, human computer interaction (HCI) and Global Positioning Systems (GPS) are becoming an integrated part of society (Bradley & Dunlop, 2003; Golledge *et al.*, 1999). Although advances in technology can assist a blind or visually impaired person during a navigational task, the planned route may be inaccessible due to one or a sequence of architectural barriers within the urban landscape. Therefore it is important not to place too much emphasis on the use of technological aids as a means of overcoming every aspect of wayfinding problems. Instead, more emphasis should be placed on researching ways to better improve the quality of the built environment. This issue was highlighted by Passini and Proulx (1988) who favoured more emphasis being placed on environmental forms of navigation instead of technological solutions to wayfinding problems.

4.2.2. Spatio-Cognitive Theories

In order to design an environment that better suits the needs of the visually impaired population, it is important that we fully understand how capable this population is at processing spatial information. During the 1980's, three main theories emerged: Deficiency Theory, Inefficiency Theory and Quantitative Difference Theory. Fletcher (1980) proposed two theories relating to the spatio-cognitive abilities of the congenitally blind population (blind from birth). The first, the deficiency theory proposes that in all circumstances the blind are unable to perform the full range of spatio-cognitive tasks required in order to gain even a basic understanding of environmental features and spatial compositions. The second opposing theory, the quantitative difference theory proposes that visually impaired people are able to process the information in the same way as the fully sighted but are not able to execute their decisions to the same degree due to a lack of past independent travel, heightened stress levels and inaccessibility to information (Passini & Proulx, 1988). A third theory was introduced by Andrews (1983), the inefficiency theory states that the spatial abilities and cognitive processes of individuals with a visual impairment are similar to but are not necessarily less efficient than, those of sighted people (Ungar, 2000).

A number of studies have supported or opposed each of these theories. The work of von Senden (1960), who strongly believed that prior visual experience is crucial if a human is to have even a basic concept of their spatial surroundings, lends support to the deficiency theory. He also stated that spatial concepts are impossible for the congenitally blind to code and decipher. Attitudes however began to change, as an increasing number of scientists and researchers started to favour the principles of the quantitative difference theory. Ungar (2000) stated that it is often difficult to decipher the difference between the inefficiency theory and the quantitative difference theory, as frequently the results from research prove difficult to categorise into a specific theory. Research conducted by Millar (1995) however strongly opposed the inefficiency theory and remarked that individuals lacking visual perception do not produce lower cognitive efficiency.

Passini and Proulx (1988) analysed the wayfinding capabilities of the congenitally blind and fully sighted within an educational building. The findings from their experiment gave evidence to support the quantitative difference theory. The results indicated that even the congenitally blind were capable of representing a previously traversed complex route and their performance in the task was similar to the sighted control group (Passini & Proulx, 1988). Further research carried out by Passini *et al.* (1990) provided significant evidence to reject the spatio-cognitive deficiency theory. The performance levels of the congenitally blind group in this study revealed that neither vision nor prior experience is necessary to use spatio-cognitive skills effectively. The findings also support Descartes' theory (1965) that visual experience is not a necessitating factor when coding spatial information. Golledge *et al.* (1999) gave further evidence to support the quantitative difference theory. Research conducted using a mixed ability group of fully sighted, visually impaired and blind adults revealed that the participants with a severe visual impairment were capable of spatially coding a journey through a complex urban setting. The performance levels between the sighted and blind groups indicated significant similarities, with the blind group reaching the same level of environmental awareness in a quick and efficient manner. This strongly contradicts a number of studies, which support the idea that blind people are less efficient during wayfinding and navigational tasks than sighted individuals (Bigelow, 1991; Bigelow, 1996; Byrne & Salter, 1983; Herman *et al.*, 1983; Rieser *et al.*, 1980). Passini *et al.* (1990) highlighted the fact that the majority of research undertaken to examine the spatio-cognitive abilities of the blind have demonstrated that they are able to understand their spatial surroundings. Further studies supporting the principles of the quantitative difference theory include Rosencranz & Suslick (1976); Casey (1978); Fletcher (1980, 1981a, 1981b); Landau *et al.* (1981); Dodds *et al.* (1982); Byrne and Salter (1983); Hollyfield & Foulke (1983);

Herman *et al.* (1983) and Kerr (1983). However the studies indicate an overall limitation in the way in which spatial tasks and decisions are executed. It is possible that the inferior performances demonstrated by the blind subjects are as a direct response to the architectural and environmental barriers inherent within the design of the built environment. The link between reduced performance levels and inaccessible architecture emphasises the need for improved awareness surrounding the issue of inclusive design. It also reinforces the need for further research on the way in which we can improve performance (assuming cognitive abilities are the same) to reach a level which is either approximate to or equivalent to that of the sighted population.

4.2.3. Cognitive Mapping

The cognitive map was first introduced by Tolman (1948) where the term was used as a means of identifying when the subject has constructed an overall mental image of the environment. Cognitive mapping was later defined as:

> "a process composed of a series of psychological transformations by which an individual acquires, stores, recalls, and decodes information about the relative locations and attributes of the phenomena in his everyday spatial environment"
>
> (Downs & Stea, 1973, p. 7)

Levine *et al.* (1982) suggested that the cognitive map may vary from strong to weak. Where the cognitive map is strong, the individual has formed a picture like image of the environment whereas in the weak form, the cognitive map does not have a specified form and knowledge just exists. Golledge & Timmermans (1990) refer to cognitive maps as a collection of "knowledge structures" which continuously develop with age and education. As a result the amount of information stored, continually updates and expands. The information held within the cognitive map specific to navigational tasks may take the form of a variety of different types of knowledge such as landmark, route or configurational knowledge.

Landmark knowledge is the most basic form of spatial information whereby an individual identifies a location using distant or near reference points. Route knowledge has been referred to as route learning or associationism and has been used to describe the strategy adopted when subjects memorise specified segments along a route (Levine *et al.*, 1982). The definition given by Hirtle & Hudson (1991) referred to route knowledge as the process of remembering sequential locations without the awareness of general interrelationships between points, giving rise to the conclusion that blind and visually impaired people are unable to perform shortcuts along a specified or previously remembered route. Configurational knowledge is the term used to describe when an individual has formed a complex understanding of a geographical area and is therefore able to perform shortcuts while traversing along a previously learned or unfamiliar route.

It is generally believed that route knowledge is a more reliable strategy for blind and visually impaired people to adopt when coding their spatial surroundings. Brambring (1982) found that blind subjects tended to use "person-oriented descriptions" supporting the idea of egocentric coding. Some scientists believe this to be an immature and inefficient form of spatial coding (Piaget *et al.*, 1960). However Millar (1986) believed that the sequential coding strategy adopted by the blind is simply a natural and inherent way for those with reduced vision to experience the world.

There is much debate regarding the order in which route and configurational knowledge are acquired. It has been suggested that the type of knowledge acquired when learning a new route (i.e. route or configurational knowledge) is dependent upon the way in which the route is learned, either by navigation or by using a map (Thorndyke & Hayes-Roth, 1982). However Golledge *et al.* (1985) believed that the process of acquiring spatial knowledge occurs in a sequential manner, beginning with landmark knowledge, followed by route knowledge and then configurational knowledge. This theory is also supported by Hirtle and Hudson (1991) who suggest that route knowledge and configurational knowledge are not separate entities but are instead, a continuum.

Hatwell (1966) believed that those who are congenitally totally blind were unable to accurately represent space. However studies such as Jones (1975), Casey (1978), Fletcher (1980, 1981a, 1981b), Hollyfield (1981), Rieser *et al.* (1982) and Byrne and Salter (1983) all concluded that individuals with a visual impairment are able to represent to some extent, an environment using cognitive mapping abilities. This was further demonstrated by research carried out by Passini and Proulx (1988) who found that the congenitally blind were capable of reproducing a journey and the surrounding environment using a series of building blocks. The question has also arisen as to the effects that the age of onset of blindness has on the way in which a person decodes their surroundings. Thinus-Blanc & Gaunet (1997) believed that those who develop blindness at an early age will more often use route knowledge as a cognitive strategy for navigational purposes. This can be attributed to the nature of how they have learned about spatial relationships from an early age, as they primarily employ body-centred egocentric cues. Individuals who develop blindness later in life will more often use configurational knowledge in a map-like form. However Thinus-Blanc & Gaunet (1997) also point out that those who are congenitally blind are still capable of forming a spatial representation in a map-like form, but in doing so they require more cognitive effort due to a lack of visual information.

Equipped with this information and with the knowledge that blind and visually impaired people are capable of using both route knowledge and configurational knowledge as a means of processing spatial information, it may be possible to design our urban environments in a way that either embraces the principles of sequential route coding and / or the more global map-like strategy of configurational knowledge. As route knowledge is the easiest navigational strategy to adopt, requiring less cognitive effort, it may be possible for the urban landscape to be designed in a way that takes advantage of this coding technique and therefore integrate egocentric cues at strategic locations within the environment. It may also be possible to do this in conjunction with the principles outlined using configurational knowledge. As it has been demonstrated that the blind and visually impaired population are capable of employing configurational knowledge in a map-like form, albeit with more cognitive effort, it could therefore be possible to design a built environment that reduces the cognitive effort required prior to and during a journey by eliminating barriers and introducing assistive cues and reference points. Indeed, Kitchin and Jacobson (1997) argue that future research regarding cognitive mapping could identify the necessary types of spatial information needed and in what contexts, in order to assist the movement of blind and visually impaired individuals within the built environment. The configurational knowledge design strategy therefore reduces the repetitive nature of following the same route even if it is longer and less direct than available alternatives. Golledge (1993) indicated that although blind and visually impaired people may be able to use mental geometry or trigonometry to explore and navigate through an unfamiliar environment and perform shortcuts, their ability to do so, may be severely restricted due to a lack of knowledge and uncertainty of the location and presence of obstacles and barriers within such an unfamiliar territory.

> "For the blind and vision impaired, movement habits often are limited to selected learned routes between known places. Departures from these routes can easily result in disorientation and chaos, accompanied by the fear and panic associated with being lost."
>
> (Golledge, 1993, p. 69)

The potential is there to give the blind and visually impaired population more freedom and independence to travel around the city, to make shortcuts where appropriate and not just be restricted to a few key familiar routes. This is especially important in a practical sense if a previously learned preferred route is made unavailable at short notice, due to temporary construction or maintenance works; and therefore would give the option of traversing along an alternative route with the aim of arriving at the planned destination in a safe and stress free manner. This would therefore ensure that the visually impaired traveller would not be stranded without an alternative coping strategy and would be able to lead a more active and less captive lifestyle.

4.3. Research Environments

The varied nature of previous research conducted with the aim of proving or disproving the theories relating to the cognitive processing and coding strategies of the blind and visually impaired population have incorporated a wide and diverse assortment of methodologies. These range from recording and comparing wayfinding decisions and utterances made during a journey by blind and sighted test groups to the analysis of spatial information retrieved during and after the completion of a journey or task. The test conditions also contrast in nature. The main differing conditions relate to experiments undertaken within an internal and often artificial setting opposed to those undertaken in an external and often real – life environment. For the purpose of this review, the analysis of previous research will be outlined under two main categories, those conducted within internal environments opposed to externally based experiments.

4.3.1. Internal- Artificial Environments

An artificial environment is a controlled environment and therefore allows the possibility for potential variables that may influence and inform the visual, olfactory and auditory senses to be set and closely monitored. This is particularly relevant in relation to environmental factors such as varying weather conditions (producing a variation in lighting levels, shadows and ground appearance) as well as the detection of distinguishing smells or sounds that may conflict with the methodology and distort the outcome of a particular piece of research.

Initial research with the aim of proving or disproving the presence of the cognitive map and subsequent wayfinding skills of blind and visually impaired people was predominantly conducted within artificial man-made internal environments. An example of such research includes work carried out by

Levine *et al.* (1982) who conducted a number of experiments using a large sample of sighted, blindfolded college students. Tasks included navigating around predetermined routes marked on the floor in an indoor setting as well as retracing previously navigated routes using their index finger on a sheet of paper. The aim of the study was to increase the understanding regarding the validity of the cognitive map, therefore the methodology employed, involved controlling the movement of participants within an artificial environment absent from barriers or obstacles and subsequent environmental cues. In another study conducted by Passini *et al.*, (1990), participants were required to navigate through a labyrinthine testing area with controlled lighting, the experiment was conducted in such a way that eliminated the possibility for distant cues, reference points and familiarity which potentially could influence the wayfinding decisions and subsequent results of the trial. Loomis *et al.* (1993) carried out a combination of tabletop retracing tasks and navigation tasks which were carried out in a darkened room. Participants were required to wear blindfolds and headphones at all times to attenuate light and noise levels. Participants were additionally equipped with light bulbs allowing the experimenters to accurately trace their coordinates and analyse their movements using video recording equipment.

The experiments conducted by Levine *et al.*, (1982), Passini *et al.*, (1990) and Loomis *et al.*, (1993) were carried out in this manner, filtering and controlling variables in order to gain an understanding of the core cognitive processes involved prior to and during a task. The experimental procedures were successful in demonstrating the existence of the cognitive map however they do not provide an accurate representation of an everyday scenario experienced by a visually impaired or blind individual as they have eliminated all environmental features and cues.

4.3.2. Internal-Real Environments

Studies conducted within internal real environments generally establish a different strategy to those undertaken within artificial internal environments.

The methodology and subsequent outcome are structured in a way that incorporates and makes use of features and cues located within the internal setting to assess and monitor the influence that such features may have on the wayfinding abilities of the blind and visually impaired population.

One of the most cited studies conducted within an internal real life environment was carried out by Passini and Proulx, (1988); they performed an experiment within a building (formerly an old convent) at the University of Montreal. The site was chosen due to its complex layout and unfamiliarity among members of the general public. The route contained a series of level changes as well as large open spaces and narrow corridors. At the time of the research, studies exploring the navigational abilities of the blind and visually impaired pedestrian were limited to small scale environments and routes; therefore this research was an important advance in the movement towards gaining a better understanding of how visually impaired people navigate through a large scale complex internal environment. The participants included totally congenitally blind and sighted, blindfolded sample groups. The aim of the experiment was to provide and suggest new innovative design solutions to aid the visually impaired community during navigational tasks.

Previous studies by Passini, (1984) and Butler *et al.*, (1993) were also conducted within internal real environments; however both studies involved only sighted participants and were designed primarily to facilitate the understanding of the processes involved during wayfinding tasks for the sighted population rather than making an exclusive reference to the significant minority of blind or visually impaired persons living within the community. Passini (1984) analysed the wayfinding abilities of participants when navigating through a number of commercial complexes whereas Butler *et al.*, (1993) used a university building for their experimental setting.

The home or workplace tends to be a familiar environment. The home is an especially intimate and personal space that can be customised to suit the specific needs of the occupants. External environments potentially present a greater risk to the individual's well being as situations can often occur whereby a blind or visually impaired person is alone in an unfamiliar setting. It is often the case that similar elements including level changes, steps, handrails and ironmongery are presented differently in different locations, causing confusion and the increased occurrence of potentially dangerous situations. In a study by Clark-Carter *et al.*, (1986), it was highlighted that:

> "at least 30% of persons with visual impairment or blindness make no independent journeys outside their homes"
>
> (Kitchin & Jacobson, 1997, p. 360)

In another study by Marston and Golledge, (2003) 67% of the visually impaired participants said that they avoided some trips because of travel problems caused by their visual impairments. The participants expressed a desire to take an additional 99% more trips to recreational activities and 79% more trips to entertainment events. In the same study, it was noted that the 70% unemployment rate of blind and visually impaired individuals may be directly attributed to the difficulties of independent travel. The results from this study show a great need for more emphasis to be placed on research involving the problems associated with navigating in an external environment, otherwise the visually impaired population will continue to feel disenfranchised and marginalised within society.

4.3.3. External-Real Environments

There is a clear distinction between conducting an experiment within an artificial, internal setting as opposed to a real, external environment and both strategies require different approaches and present different outcomes. To date, there has been a fairly even mix of studies involving both strategies, with the majority of research dating before the 1990's concentrating on the cognitive processes of blind and visually impaired people within an indoor and predominantly artificial environment. Shearer (1981), Golledge, (1993) and Golledge *et al.*, (1999) have all highlighted the lack of previous research carried out in large-scale urban environments and have stressed the practical importance of such studies. However in more recent years there has been a movement towards observing the navigational abilities of blind and visually impaired individuals within an external real life setting. The following experiments illustrate the variety of work conducted within external settings since the early 1990's.

Rieser *et al.*, (1992) carried out a study using a large number of visually impaired participants from across the South East and Midwest of the United States. All participants were tested on their knowledge of a familiar external environment within their local area and were required to estimate distances and locations within an internal office setting based on the location of landmarks within the external environment. Each test space was unique to the individual and was chosen due to its usage on a daily basis. Ochaíta and Huertas, (1993) carried out a study involving a group of visually impaired teenagers. They were required to travel between a series of landmarks within a public square. After the first guided tour, they were asked to travel independently and thereafter construct a model of the site and estimate distances. The outcome of this study concluded that visually impaired adolescents were able to decode and gain configurational knowledge of an urban setting. A study carried out by Espinosa *et al.*, (1998) involved two main experiments undertaken in complex urban settings, (i) Madrid and (ii) Sheffield, using groups of visually impaired and blind participants. In Madrid the study consisted of a 2.05km route in an unfamiliar area of central Madrid, incorporating eight landmarks. The test conditions in Sheffield were similar to those presented within the Madrid study. Both studies were designed in such a way that they incorporated a large number of environmental cues and decision points therefore representing a real-life scenario. The main objective of both experiments was to decipher the differences between learning a route from direct experience or from studying a tactile map. Jacobson *et al.*, (1998) conducted an experiment in a suburban setting in Belfast, involving fully sighted, visually impaired and totally blind participants.

All groups were initially guided along the route, without any information or advice being given and were then required to complete a further three journeys of the route unaided. By the third journey all groups were able to complete the journey almost without error. A further study was carried out in Santa Barbara (Golledge *et al.*, 2000) and was set in a similar topography and using similar control groups as those used in Belfast. The findings support previous research conducted by Ochaíta and Huertas, (1993), Espinosa *et al.*, (1998) and Jacobson *et al.*, (1998), all supporting the viewpoint that visually impaired people are capable of learning external urban routes successfully. In more recent years, Blades *et al.*, (2002) conducted a study whereby 36 visually impaired participants were required to learn a 483 metre route through the campus of the University of California, Santa Barbara. The experiment was designed in a way that made it possible to evaluate the effectiveness of various route learning techniques. The findings from this research show that visually impaired people are capable of learning a complex route in a fairly short time frame after relatively little experience of the route. Finally, Bradley and Dunlop, (2005) constructed an experiment whereby sighted and visually impaired participants were required to walk to four different landmarks within the city centre of Glasgow. The experimental conditions were designed in such a way that simulated a "*typical contextually rich city-centre environment*" (Bradley & Dunlop, 2005, p. 398).

If the built environment is to become more inclusive and respond more effectively to the needs of the blind and visually impaired population, it is crucial that further research is carried out with the aim of observing the movements of such populations within real life settings. Studies involving participants navigating through a large urban scale environment are more realistic and perhaps more worthwhile than experimental conditions involving simple A-B routes in a laboratory, otherwise designers and architects will not be able to fully understand the current limitations and barriers imposed through their design decisions. Through further research it is hoped that current barriers can be highlighted and brought to the attention of architects and designers, with the aim of creating a more inclusive environment that is accessible to the needs of the visually impaired population. It should be noted however that results obtained from experiments carried out within external environments can be hard to compare as test conditions often vary due to weather conditions, the unpredictable movement of people within space and the potential dangers associated with moving vehicles.

4.4. Subject Groups

In addition to outlining the environmental differences between previous research, it is also important to make reference to the subject groups involved within such studies, as they will inevitably provide researchers with specific knowledge, produce different results and influence the nature of future research as well as the nature of further experiments.

4.4.1. Sighted Subjects

It is important that sufficient knowledge is first gained regarding the strategies adopted by the fully sighted population before it is possible to understand the similarities and potential differences between the spatial understanding and navigational abilities of the blind and visually impaired population. A number of experiments have been conducted using exclusively sighted participants. The nature of these studies was to analyse the wayfinding abilities of the general population with no specific reference to blind or visually impaired individuals.

Such experiments include a study by Passini, (1984) who used 36 fully sighted volunteers to complete a number of wayfinding tasks within a collection of commercial buildings. The participants were required to verbally describe their decision making process during a specified journey. The number of wayfinding decisions was found to be very high with a walk lasting no longer than 20mins involving more than 50 decisions. The findings from this experiment provide researchers with an insight of how the sighted population break down a journey into segments and reveal which features within the environment are used in order to assist in the decision making process, all of which will be of great use for comparison purposes during later research involving the wayfinding decisions of blind and visually impaired people.

Hirtle & Hudson, (1991), completed a study whereby 48 fully sighted students were divided into three groups of 16, forming a map group, slide group and a control group. The experiment had three phases: (i) Spatial-acquisition, (ii) verbal-recall phase and (iii) spatial-testing phase. The aim of the study was to identify the most efficient way of learning a route, with the results indicating a higher success rate among those in the map group. The findings highlight the benefits of receiving information prior to the commencement of a journey.

In an experiment by Butler *et al.*, (1993), 52 fully sighted subjects were asked to find a room in an unfamiliar location using either a “You-are-here” map or by following signage. The aim of the experiment was to determine the advantages or disadvantages of using a “You-are-here map” compared with directional signage, with the results indicating a significant increase in the time taken to complete a journey when using a location map as opposed to signage.

Finally, Kitchin, (1997), performed a study whereby fully sighted participants consisting of 10 males and 10 females were required to produce a sketch map indicating the locations of well-known landmarks within the city of Swansea. The main aim of the research was to analyse and identify the primary contributing strategies used in obtaining configurational knowledge. The results indicated that there are a large number of strategies that people use to construct a visual representation of previously visited landscapes.

Studies involving fully sighted participants have analysed the number of decisions made during a journey, as well as analysing the benefits and/or drawbacks of using a “you are here” map as opposed to signage and the processes involved in order to gain configurational knowledge. The findings from such studies will be of great benefit when comparing the results from experiments involving the cognitive abilities of blind and visually impaired individuals.

4.4.2. Sighted Blindfolded Subjects

There have also been a small number of studies involving sighted blindfolded participants taking part in navigational tasks. In a study by Levine *et al.*, (1982) a number of experiments were conducted using a large sample of sighted blindfolded college students. Tasks included navigating around predetermined routes, marked on the floor in an internal artificial environment as well as retracing routes previously walked using their index finger on a sheet of paper. The aim of the study was to increase the understanding regarding the validity of the cognitive map. Therefore the methodology employed, involved controlling the movement of participants through an artificial environment absent of any barriers or obstacles and environmental cues. In another study by Maeda *et al.*, (2002), sighted participants were asked to wear blindfolds and "*behave as if temporarily blind"* in order to evaluate a Global Positioning based guidance system.

It is questionable as to the effectiveness of conducting an experiment using fully sighted blindfolded participants, as the validity of the results does not accurately represent a real life scenario. When a sighted person is made temporarily blind, their behaviour and actions will be different to those of a blind or visually impaired person who has lived with their disability for most or part of their life and as such may have developed certain coping strategies.

4.4.3. Blind Subjects

All of the following studies were conducted using individuals who were either blind from birth or early in life (congenitally blind) or participants who became blind later in life (adventitiously blind). In addition, a number of studies also contained a sighted control group for comparison purposes.

Byrne and Salter (1983), Rieser *et al.*, (1986) and Hollins & Kelley (1988) all performed experiments involving fully blind and fully sighted sample groups. However, in each case the number of participants involved was limited to small samples ranging from six to eight participants. The study by Passini and Proulx (1988) involved two groups, the first consisting of 15 congenitally blind, all of whom used a white cane throughout all stages of the experiment, with the second group consisting of 15 fully sighted participants. Loomis *et al.* (1993), incorporated three sample groups of 12 people. The participants included congenitally blind, adventitiously blind and fully sighted. Within the blind group the various causes of blindness were noted as: Retrolental Fibroplasia, Glaucoma, Retinoblastoma, Retinal Detachment, Congenital colomboa, Diabetic Retinopathy, Retinitis Pigmentosa and Measles, while some of the participants chose not to disclose the cause of their blindness. The study is unspecific as to whether any of the blind participants had any useful residual vision, however it should be noted that all participants were blindfolded at all times and therefore residual vision (if any) was of no use during this study. In the two experiments carried out by Espinosa *et al.* (1998), the Madrid study contained 30 congenitally blind adults all of whom became blind before the age of 6. It was noted that none of the participants had any useful residual vision that may have been of benefit during the experiment. The Sheffield study contained 6 blind adults and 5 visually impaired adults who had some remaining residual vision although not deemed useful for the purpose of this experiment except for one participant who was able to detect obstacles in the immediate environment.

4.4.4. Visually-Impaired Subjects

The following studies outlined below have been conducted using visually impaired individuals and depending on the particular study, have also included congenitally blind, adventitiously blind and fully sighted participants.

Passini *et al.*, (1990), included five groups of 18 people within their study. The groups were categorised as follows: (i) congenitally totally blind, (ii) adventitiously totally blind, (iii) visually impaired with a visual residue, (iv) sighted blindfolded and (iv) fully sighted. Bigelow (1991) conducted an experiment using 2 blind, 2 visually impaired and 8 sighted individuals. In a study by Rieser *et al.*, (1992), there were four groups including (i) Poor acuity (normal fields), (ii) Small fields (with varying degrees of acuity) and two control groups (iii) a sighted group and (iv) a congenitally totally blind group. The participants in the visually impaired groups were diagnosed at both early and late stages of life. There was a wide range of visual impairments and etiologies (sometimes with multiple causes) including accidental trauma, Paediatric Disease, Retrolental Fibroplasia, Juvenile Diabetes, Cataracts, Macular Degeneration, Detached Retina, Glaucoma, Optic Nerve Atrophy, Albinism and Congenital Toxoplasmosis.

In previous studies only relatively small numbers of participants were involved. However studies conducted by Golledge *et al.* (1999), and Ludt and Goodrich (2002) have involved much larger sample sizes, which allows for greater analysis and comparisons to be established between the differing visual impairments as well as the performance levels between specific sample groups. In the study by Golledge *et al.* (1999), a total of 30 participants took part in each experiment conducted in the city of Belfast and Santa Barbara. Ten of the participants were fully sighted, ten were partially sighted and legally blind and the remaining ten were completely blind. The study by Ludt and Goodrich, (2002) used 65 participants, all of whom were able to demonstrate the ability to use distance vision. The types of visual impairment were recorded as Age Related Maculopathy (42 subjects), Diabetic Retinopathy (9 subjects), Glaucoma (3 subjects), and Other (11 subjects). For the purpose of the research, all subjects were grouped in accordance to their visual field characteristics of peripheral field loss, central field loss or mixed field loss.

A recent study conducted by Bradley and Dunlop, (2005) included 16 participants of which 8 were visually impaired and 8 were fully sighted. The types of visual impairment included advanced Glaucoma, Macular

Degeneration and Blindness (or only some light perception). It was theorised that different visual impairments may give rise to the creation of different cognitive maps which in turn may require different design solutions and environmental cues.

It is evident that the range of subject groups involved in past research has been diverse and varied. It is also clear to observe the transition within the experiments from initially involving and examining the abilities of the fully sighted, blindfolded sighted and totally congenitally and adventitiously blind to the inclusion of individuals with residual vision and a variety of visual impairments. However to date, very few studies have focused on involving subjects with a visual impairment. This was highlighted by Edwards *et al.*, (1998) and again by Ungar (2000):

> "While the literature on the effects of total blindness increases rapidly, there has been little research into the effects of differing degrees and types of visual impairment on spatial cognition."
>
> (Ungar, 2000)

This is crucial, as estimates suggest that only 4% of those registered in the UK as sight impaired or severely sight impaired see nothing at all, while 82% have some useful residual vision (Bright *et al.*, 2004), as described in Section 3.5. In previous years the emphasis has been to investigate the navigational abilities of the totally congenitally and adventitiously blind with the results indicating that this group are able to navigate successfully. However, little knowledge exists regarding the effects that different visual impairments have on a person's ability to navigate through an urban environment successfully:

> "more research is needed to investigate possible differences between visual impairments"
>
> (Bradley & Dunlop, 2005, p. 402)

Another factor to take into account is the number of participants involved in a particular experiment. Kitchin and Jacobson (1997) indicated that the majority of researchers have faced problems in recruiting volunteers to take part in experiments. They highlighted the fact that the majority of experiments involving analyzing the movements of visually impaired people have been carried out with very small sample sizes. This is problematic as a small sample size will make it increasingly difficult for any generalisations and valid conclusions to be made. Therefore future experiments should strive to involve a larger workable sample size including a varied range of visual impairments in order to establish firm conclusions and comparisons between the navigational abilities of the visually impaired population.

In particular, more research is needed to investigate the features within the environment that cause the most difficulties during a navigational task and therefore day-to-day activities. Past research has primarily focused on the presence and strengths of a sighted, blind or visually impaired person's cognitive map with the majority of results concluding that all of the subject groups have the ability to understand and represent space in a mental form and with time, progress from using route knowledge to configurational knowledge with the introduction of shortcuts between various locations along a route. It is also possible that findings from future research may establish a common connection between the difficulties encountered among individuals with varying types and severity of visual impairments. If this is indeed found to be the case then it will be possible to equip architects, designers and urban planners with the relevant knowledge as to the main problematic features within the environment and could potentially lead to a universal design approach whereby 'a one solution fits all' design strategy could be implemented which caters for the needs of the entire visually impaired community.

4.5. Visual Experience & Visual Fields

4.5.1. Visual Experience

The majority of research undertaken to examine the spatio-cognitive abilities of visually impaired people have demonstrated that this population is able to understand spatial concepts. However there has been much debate as to whether the time of onset of blindness affects the wayfinding and navigational abilities of blind and visually impaired people. As a result, a number of theories have emerged resulting from experiments involving congenitally blind, adventitiously blind and sighted participants. The first theory suggests that the adventitiously blind perform significantly better during navigational and wayfinding tasks than those who have been born blind or have lost their sight at an early stage in life. The opposing theory postulates that the age of diagnosis has little or no affect on an individual's spatio-cognitive ability.

Lerner & Busch-Rossnagel (1981) and Dodds & Carter (1983) highlighted the importance that visual experience plays on a person's ability to understand and decode their spatial surroundings. In a study by Rieser *et al.* (1992) it was found that the early congenitally blind group had more difficulties navigating through the environment compared with those who experience sight loss later in life. The early onset field loss group performed worse than the late onset field loss group even though at the time of the experiment, the level of vision between both groups was similar in nature. The study concludes that this can only be explained by a Developmental Phenomenon, resulting in those with late onset vision loss faring better due to their ability to rely on past visual experiences.

> "Rieser, Hill, Taylor, Bradfield and Rosen (1992) noted that people with prior visual experience, particularly of broad-field vision, have advantages in learning environments over those who do not have prior visual experience and that differences in the perception of walking lead to observed differences in sensitivity to spatial structure."
>
> (Ludt & Goodrich, 2002, p. 8)

Passini *et al.*, (1990) however, produced results contradictory to other research. The performance levels of the congenitally blind group indicated that neither vision nor prior experience is necessary in order to use spatio-cognitive skills effectively. It was found that the congenitally blind group outperformed the adventitiously blind suggesting that a lack of visual experience had no influence in this case.

Loomis *et al.*, (1993) aimed to answer the following questions: (i) What are the internal processes necessary for successful nonvisual navigation, and (ii) does past visual experience contribute to nonvisual navigation ability. Their experiment was a reproduction of a previous study by Rieser *et al.* (1986), however the second experiment failed to agree with their findings which showed that the congenitally blind performed significantly worse than the adventitiously blind and sighted group in the pointing after locomotion task. In contrast to the findings by Rieser *et al.* (1986), in some tasks, congenitally blind individuals outperformed blindfolded sighted individuals. One of the reasons that the results differ from similar experiments carried out by other researchers could be attributed to the subjects' characteristics relating to differences in confidence and personality. Loomis *et al.*, (1993) differs from the normal view that prior visual experience is necessary for navigational spatial awareness. In fact they hypothesise that independent travel plays a bigger role and is the main causative factor in spatial ability.

4.5.2. Visual Fields

Previous research has demonstrated that the nature of visual impairment and in particular the type of field loss may have a direct link between the abilities of blind and visually impaired people to complete wayfinding and navigational tasks successfully. The onset and progression of a visual impairment can result in either a loss of central vision with the retention of peripheral vision, the loss of peripheral vision with the retention of central vision or a partial or complete loss of central and peripheral vision (see Section 3.3 for illustrations).

In a study by Marron and Bailey, (1982) it was found that the degree of contrast sensitivity in conjunction with the level of remaining peripheral vision are important factors in the ability to navigate through space. These findings were supported by Rieser *et al.* (1992) who discovered that broad field visual experience assists in accelerating and increasing precision of sensitivity to other multi-modal cues in the environment. Out of the visually impaired groups, the early onset broad field loss group fared significantly worse than the others, including congenitally blind.

> "Persons born with small visual fields might tend, according to this perceptual learning view, to be deficient in their knowledge of spatial structure and similar to congenitally totally blind persons. Low levels of acuity; on the other hand, do provide optic flow fields under high-contrast conditions, and congenital deficits in acuity should not lead to deficits in the development of knowledge of spatial structure.
>
> (Rieser *et al.*, 1992, p. 212)

> "The theory presented here is developmental: It implies that a life history of broad-field vision early in life, not high-resolution vision, facilitates the development of sensitivity to spatial structure of locales explored by walking"
>
> (Rieser *et al.*, 1992, p. 212)

The findings do however suggest that once an individual is familiar with the route, that broad field vision or high resolution or both does not affect their ability to acquire knowledge about the route, although it may speed up the learning process in order to become familiar with the environment. Finally, Ludt and Goodrich, (2002) suggest that there are three variables relating to an individual's visual abilities that will influence their wayfinding abilities. These include contrast sensitivity, extent of visual field and visual acuity.

The importance of such studies should not be underestimated as currently half of all registered blindness in the UK is caused by Age-related Macular Degeneration (AMD) which affects half a million people (Fight for Sight, 2007) and results in the loss of central field acuity with the retention of peripheral vision. Over half of all people in the UK over the age of 65 are visually impaired (Fight for Sight, 2007) and the numbers are set to double over the next 25 years with the impact of an increasingly aging population.

This in turn will result in a visually impaired population that is predominantly made up of adventitiously blind individuals who have had prior visual experience and who have broad field visual capabilities.

Currently there has been limited research regarding the potential differences in the navigational competence between the congenitally and adventitiously blind. Little research has also focused on the possible wayfinding implications relating to the characteristics of a person's visual field. Therefore it is important that further research in this area is undertaken to test the theory by Rieser *et al.* (1992) that those who suffer from blindness later in life are more capable of interpreting spatial arrangements and completing wayfinding and navigational tasks more efficiently than those who suffer from blindness at an early stage in life. Further studies should also aim to prove or disprove the theory that individuals with central vision loss are able to better conceptualise and construct an understanding of their environment than those who have a poor or no visual field but still retain acuity.

4.6. Environmental Cues

The sighted population are able to make use of a variety of near and distant visual cues during a navigational task. The ability of knowing what and where is essential in providing relevant information at an early stage, allowing for the navigational ease through a complex or unfamiliar environment.

> "A blind and vision impaired person must work from memory for they do not have access to the many updating cues, landmarks or signs available to the population at large".
>
> (Golledge, 1993, p. 70)

Individuals with a visual impairment are however are unable to make use of near and distant visual features within the landscape and therefore are forced to adopt different strategies involving the use of auditory, kinaesthetic, olfactory and tactile cues in order to facilitate their movement between locations.

Auditory cues relate to sounds associated with features or locations within the environment, examples of which may include the sound of a fountain or water feature, children playing in a school playground, pigeons in a public square or the noise from moving vehicles. Kinaesthetic cues relate to information retrieved from the movement through an environment. This egocentric cue will alert an individual to the nature of the terrain such as the presence of a change in gradient, a ramp, a flight of stairs or a kerb. Olfactory cues relate to associated smells with regard to features within an environment such as the smell from a bakery, a cosmetic shop or a brewery. Tactile information can be obtained from a change in texture and composition of the ground material, in turn alerting the individual that they are progressing into an area with a change of use. Materials such as grass, concrete, tarmac, cobbled stones, wood chips or decking are just some of the examples of how a change in material can inform an individual to their relative location. This form of sensory information retrieval is perhaps one of the most frequently used cue within the environment for use by the visually impaired population, with a prime example being the implementation of tactile blister paving around the area of a pedestrian crossing. The following studies highlight the differences in information utilised by fully sighted and visually impaired populations when navigating through an internal or external environment.

In the study by Passini and Proulx, (1988) it was found that the sighted and visually impaired subject groups made a total of fifty two decisions while traversing along the route, out of which twenty three were exclusive to the visually impaired group. These decisions centred on three main areas, the first being a change in level, with the main areas of difficulty being the ability to identify the start and end point of stairs as well as locating the position of handrails. The second location where a number of decisions were made exclusively by the visually impaired group was in corridors and open spaces.

The third point at which decisions were recorded was at the location of an architectural feature such as a door handle. It was also highlighted that the door frame of a set of fire doors was a significant decision making point for the visually impaired participants, whereas the sighted group made no decision at this point as they were able to use the end of the corridor as their distant cue and reference point. During the journey, it was evident that the visually impaired group relied on information retrieval in the form of auditory, olfactory and tactile cues. It should be noted that the sighted group did not make use of any of these cues. This illustrates the different approaches used by each group as the visually impaired subjects used different indicators from different sources than those used by the sighted control group. It was also noted that two thirds of the visually impaired group completed the task with errors and hesitations, compared to one third of the sighted control group. Two specific sections within the route were identified as problematic for the visually impaired group. The first was the ability to maintain direction while navigating through the open space of the large hall and the second was the ability to locate a set of stairs.

For the sighted user, landmarks and key circulation routes within a setting help to give an understanding of the characteristics of the space. Passini and Proulx, (1988) argued that visually impaired people rely on the same characteristics, however it is necessary to provide additional sensory information such as the implementation of textures, strong colour contrast and auditory features within design in order to make environments more accessible. Edwards *et al.*, (1998) also supported the view that visually impaired people use different information than those who are fully sighted when wayfinding and believed that this should be taken into account when designing environments.

Espinosa *et al.*, (1998) also found that the participants made use of a variety of cues apart from those relating to vision, in order to orientate themselves and locate significant landmarks along their route. These included auditory, kinaesthetic, olfactory and tactile cues. For example kinaesthetic cues were registered as the presence of a slope, a curve or a set of stairs. Auditory cues were given by traffic changes or by other changes from the environment, such as people, children and pigeons. Tactile cues were noted as the texture of the ground or the presence of a fence, while olfactory cues included the presence of a garden and the associated smells.

Bradley and Dunlop, (2005) conducted a study where participants were required to traverse a route using pre-recorded verbal instructions which were designed to be typical of those either given by a visually impaired or sighted individual. The findings suggest that when the visually impaired group were guided with a description from a visually impaired person they found that they needed less cognitive effort to complete the task, as well as resulting in less deviations from the route and an overall faster journey time. In contrast, when the sighted participants were guided by instructions from a visually impaired person, they required a higher cognitive effort. The results from this study indicate that the visually impaired pedestrians make use of cues different to those of a sighted pedestrian and when each group was made to navigate using the instructions provided by a member of the opposite group, there was found to be a higher demand mentally and temporally, a higher level of frustration and effort, and a lower performance outcome.

The results from previous studies clearly demonstrate the different approaches adopted by the sighted and visually impaired participants throughout the duration of a wayfinding task. However little research has so far been carried out in order to identify which cues will be of most benefit to the visually impaired pedestrian and where such cues should be implemented. Foulke (1982) stated that not enough adequate knowledge has been sourced as to what information should be provided to aid the wayfinding and navigational abilities of the blind and visually impaired population. He also raised concerns as to where such cues should be located within the environment and how such information should be displayed and made available. This issue was further highlighted by Passini and Proulx, (1988) and Golledge (1993) who argued that before any large-scale implementation of environmental supports is undertaken, more detailed research needs to be carried out in order to understand the features which are the most beneficial in assisting the visually impaired pedestrian.

In a recent study by Marston, (2002) five main areas were identified as causing limitations to visually impaired individuals when navigating through the built environment and particularly when the geography is unfamiliar. The first problematic area is often the inability to positively identify a feature within the environment, such as a bus stop or kiosk due to the fact that similar features are often presented differently in different locations. The second area where visually impaired people are at a disadvantage relates to their inability to access distant information from landmarks or associated cues due to the scale at which such features are located. The third area relates to the shortage of guidance cues available within the landscape which assist the navigation process between distant locations. The fourth area is concerned with the inability of visually impaired individuals to orientate themselves within a space, this is particularly prevalent in large open spaces such as a public square. In most cases individuals with a visual impairment have to locate a wall or kerb in order to re-orientate themselves. The final area highlights the difficulty faced when representing a space in a complex map-like form.

The knowledge outlined within this study provides the basis for future research to build upon the five main areas highlighted as being of critical importance with regards to the problems and barriers encountered by visually impaired individuals during navigational and wayfinding tasks. The question of where to locate a specific environmental cue is also an important area for future research. Ludt and Goodrich, (2002) found that individuals with reduced vision often:

> "travelled with a head-down posture, looking just in front of their feet, and used quick, random upward scans or other ineffective scanning patterns."

(Ludt & Goodrich, 2002, p. 12)

This observation may be of interest when considering the implementation of environmental cues within the built environment as it could provide information as to where such cues should be located. Therefore, further studies may benefit from observing the walking activities of the visually impaired pedestrian through a real life urban setting.

4.7. Familiarity

Weisman, (1981) concluded that increased familiarity could reduce preliminary problems during navigation and wayfinding within the built environment. Therefore it was suggested that more emphasis should be placed on providing the user with relevant knowledge prior to interacting with an unfamiliar space. This concept was further reinforced by Golledge (1993) who stated that one of the major barriers faced by the visually impaired population during spatial mobility tasks was the absence and unavailability of information required in order to pre-view and pre-process relevant details prior to a journey. Previous studies by Wycherley & Nicklin, (1970) and Shingledecker, (1983) have also provided strong evidence to show that stress levels among the visually impaired population are greatly reduced when navigating through a familiar environment (Passini & Proulx, 1988).

However it appears that little progress has been made towards the discovery and implementation of environmental stimuli within the landscape as several recent studies have commented on the current lack of environmental cues and features within the built environment. Marston and Golledge, (2003) suggest that the participation in activities and independent travel by visually impaired individuals is still confined to known, familiar routes due to the poor provision of accessible environmental cues.

> "Persons who are legally blind face functional barriers that hinder their full inclusion in activities and opportunities. These barriers include the lack of information and access to environmental cues - factors that are perceived to restrict independent travel. It appears that without additional

> spatially based information on location and orientation, their activities may be confined to local and familiar areas."
>
> (Marston & Golledge, 2003, p. 486)

There is clearly a need for further research to be conducted in order to discover the most relevant circumstances and appropriate locations for cues. There is the potential to create an environment rich in nonvisual egocentric cues that stimulate and inform the olfactory, auditory and kinaesthetic body centred senses. However, care should also be taken as to the reliability of certain environmental cues during such investigations as some auditory and olfactory cues may only be present at certain times of the day and may be influenced by weather conditions, such as a change in the direction of the wind with regards to the source of a smell or sound. Therefore, it seems most appropriate that tactile cues be incorporated into the design of environments after researching the questions of where, what and how.

4.8. Conclusion

The key findings from this review clearly demonstrate the need for further research in order to reclassify visually impaired people from being passive participants to a more active and visible part of society. The evidence from previous research provides a framework for future investigations with the aim of identifying and redesigning the most problematic areas encountered by the visually impaired population within the built environment during day-to-day navigation. This ambition is not an unrealistic proposal, as the significant majority of findings from past research have indicated that those with no vision or a reduced visual field have similar cognitive abilities to those of the fully sighted population. The vast majority of previous studies have favoured the principles of the quantitative difference theory which proposes that individuals with a visual impairment are able to process spatial information in the same way as the fully sighted but are not able to execute their decisions to the same degree due to a lack of past independent travel, heightened stress levels and inaccessibility to information. Findings have also indicated that visually impaired individuals have the ability to organise and represent space in a global map like form under the principles outlined using configurational knowledge but are limited in executing such decisions due to the fear of entering unfamiliar environments.

Further research could result in a built environment that provides the visually impaired population with the freedom and independence to perform shortcuts and not be limited to familiar day-to-day routes as well as enhancing their quality of life due to an increase in independence. It is for this reason that further studies should focus on observing the movements of visually impaired people within non artificial external environments. In particular, the movements within town and city centre environments should be analysed further, as the majority of previous research conducted in external settings have primarily focused on small scale suburban environments which lack many of the barriers and hazards present within a metropolitan area such as street furniture and pedestrian crossings.

The sample groups involved within experiments also needs to be restructured as to date, the majority of research has concentrated on the capabilities of the congenitally blind and adventitiously blind populations. Limited focus has been concentrated on individuals with remaining residual vision, which account for the majority of those registered sight impaired or severely sight impaired. More research needs to be undertaken in order to understand the barriers encountered and problems faced on a daily basis for individuals with different types and degree of visual field loss, as highlighted by Bradley and Dunlop (2005). In doing so, it may be possible to identify similarities across the sample group and re-interpret these into a new set of design guidelines that caters for the needs of the visually impaired population as a whole.

The following chapters will seek to identify which elements within the built environment present the most difficulties to individuals with a visual impairment. This will be achieved by conducting a nationwide questionnaire targeting individuals with different types and degree of visual field loss, to identify whether such barriers are common to all visual impairments. The findings from the questionnaire will be used as a basis for setting parameters for an access audit of Glasgow city centre in order to quantify the number and type of hazards identified as being problematic within the questionnaire. This will be followed by a series of navigational experiments which will record the movements of a number of blind and visually impaired individuals between two predefined locations within a familiar, complex urban environment. The route of each subject will be analysed and compared against a sighted control group in terms of (i) route taken, (ii) time taken, (iii) distance travelled, and (iv) spatial awareness including cognitive mapping abilities.

Chapter 5: The Disabling Nature of the City – A Survey

5.1. Introduction

In order to access facilities goods and services by foot, pedestrians often encounter and make use of pavements, pedestrian precincts, level changes and controlled / uncontrolled crossing points over major and minor vehicular routes. Certain features present within the built environment can prove to be problematic and potentially hazardous to pedestrians of all abilities; however the risk to individuals with a sensory or mobility impairment can potentially be much greater and occur on a more frequent basis (Gallon *et al.*, 1995).

Guidance in place to improve the access requirements for persons with a visual impairment is often specific to the internal aspects of a building and may fail to address the implementation of inclusive design methods within the surrounding areas of a building or the built environment on a wider scale (DPTAC, 2005). As a consequence:

> "accessible buildings are sometimes located in inaccessible places."
> (Scottish Government, 2006, p. 7)

The current lack of guidance and legislation focused on the design of accessible external built environments has significant consequences on the lifestyle choices of the blind and visually impaired population. Estimates suggest that the disabled population have an annual spending power of £80 billion (DPTAC, 2005). DPTAC (2005) also state that 24% of the disabled population have a visual impairment. It is therefore reasonable to conclude that the visually impaired population have an approximate annual spending power of £20 billion. Therefore additional emphasis should be placed on designing more accessible external environments in order to eliminate social exclusion, encourage more independent travel and ultimately generate more sustainable economic growth.

In order to identify the features within the built environment which present the most difficulties to the visually impaired population, it was a necessary and important step to give this population the opportunity to rate those features within the built environment that they find the most problematic and hazardous. For this reason, a survey was implemented on a national scale and completed by a large number of blind and visually impaired individuals. Questions aimed to identify both the physical and psychological barriers to access within UK town and city centres, as well as preferred colour and contrast combinations. Before embarking on the design process of the survey it was important to examine the work undertaken in previous surveys covering issues relating to visual impairment. Therefore a review of previous surveys was undertaken and is detailed in the following section.

5.2. Previous Surveys

There have been a number of surveys undertaken within the UK designed to collate information on the visually impaired population and their views on a broad spectrum of issues relating to everyday living. Previous surveys have focused on; (i) the education of blind and visually impaired children and young adults (e.g. Keil, 2003; MacDonagh, 1995), (ii) the levels of employment among the visually impaired population (e.g. Baker & Simkiss, 2004; Bruce & Baker, 2003) (iii) the financial status of blind and visually impaired adults, (RNIB, 2004) and (iv) the levels of informal social support (e.g. interaction with family and friends) currently experienced by visually impaired individuals (Bruce *et al.*, 2007). In order to promote social inclusion, increasingly surveys have focused on accessibility issues concerning: access to information (e.g. Bruce & Baker, 2001) and access to shops, public services, recreational and leisure facilities (e.g. Crosier, 2009). Another expanding area of interest has been that of transport and mobility (e.g. Bruce *et al.*, 2005; Douglas *et al.*, 2006; Pey *et al.*, 2007). Within this field, studies have been carried out to investigate the level of independent mobility of visually impaired people, their use of navigational aids and the potential benefits of using technological assistance (e.g. Marston & Golledge, 2003).

An important issue arising from such research relates to access to public transport services and terminals which can have a significant influence on the level of independent mobility among the visually impaired population.

Two of the largest and most recent surveys to investigate the everyday living patterns of the blind and visually impaired population within the UK were carried out by Guide dogs for the Blind association, (Pey *et al.*, 2007) and Network 1000, (Douglas *et al.*, 2006) involving 1428 and 1007 blind and visually impaired individuals respectively. Both studies addressed many of the different topics listed above including employment, education, social activities, technology, mobility and service provision. Where relevant, results from both studies are compared with the findings from the survey presented in this chapter.

Perhaps more relevant to the themes explored within this research are the surveys carried out by Project Rainbow (Bright *et al.*, 1999; Bright *et al.*, 1997) and research from the Transport Research Laboratory (Gallon *et al.*, 1995). Project Rainbow investigated the accessibility of internal environments, exploring in particular, preferred colour and contrast combinations, preferred surface finishes, floor patterns and lighting. The work carried out by Bright *et al.* has opened up a new area of research and provided colour and contrast design guidance for use within internal environments in collaboration with ICI paints (ICI Paints, 2000). Their use of Light Reflectance Values in assessing visual contrast has now been incorporated into BS 8300:2009 (BSI, 2009). However Project Rainbow has specifically examined the role of colour contrast in internal settings and there is a distinct shortage of information regarding colour and contrast within the external built environment. Therefore the research presented in this chapter will aim to introduce new knowledge as to the preferred colour and contrast combinations for features commonly located in the external built environment.

The Transport Research Laboratory (TRL) commissioned a telephone survey investigating accidents involving visually impaired pedestrians (Gallon *et al.*, 1995). The objectives of the study were to identify the number of visually impaired individuals involved in accidents; the circumstances surrounding the accident; if any injuries were incurred; how the accidents could be avoided and the number of working days lost as a result of injury. The report focused on accidents involving pavement features, level changes and road crossings with the results indicating a substantial number of incidents involving visually impaired pedestrians injuring themselves when walking on pavements. When questioned, 94% of the 302 visually impaired respondents stated that they had been involved in an accident when walking along pavements (Gallon *et al.*, 1995). 144 reported serious injury accidents; 61% resulted in cuts and bruises, 18% led to ankle and foot injuries, 13% resulted in fractures, 8% resulted in head injuries and 6% suffered from other injuries (Gallon *et al.*, 1995). Participants were unable to quantify the number of non injury and minor injury accidents due to the high frequency of this type of event taking place (Gallon *et al.*, 1995). The results from the study suggest that individuals with a visual impairment experience significantly more accidents and suffer from more severe injuries than the fully sighted population even when navigating within familiar areas (Gallon *et al.*, 1995). It is clear that the current design and layout of the built environment not only disables the visually impaired user but also inflicts injury ranging from mild cuts and bruises to more severe cases resulting in broken limbs and fractures (Gallon *et al.*, 1995). Specific reference should be placed on the features in the built environment which present the greatest risk to the visually impaired pedestrian and the ways in which the dangers associated with such features can be eliminated or significantly reduced. The survey presented in this chapter attempts to identify the features within the built environment, which are most hazardous and problematic to visually impaired pedestrians.

5.3. Survey Objectives

The main emphasis of the survey was to obtain a detailed understanding of the main barriers to access for persons with a visual impairment within the external built environment. The objectives were to:

- Investigate the independent travel behaviour of the blind and visually impaired population.
- Investigate the influence of psychological and physical factors on the travel behaviour of the blind and visually impaired population.
- Identify the main problematic elements within pavement design.
- Identify the most hazardous items of street furniture.
- Investigate the easiest and most difficult colours for the visually impaired population to identify in the built environment.
- Investigate preferred colour contrast combinations for key elements within street design.
- Investigate the influence of environmental factors on travel behaviour.
- Investigate whether common trends exist for all types of vision loss.
- Investigate whether data gathered has a correlation with age of onset of diagnosis.
- Recruit volunteers to take part in a navigational experiment within Glasgow City centre.

5.4. Methodology

5.4.1. Ethical Considerations

Ethical considerations should be taken into account prior to designing a survey and embarking on the recruitment process for participation, particularly in the case of an academic context. The Code of Practice regarding Investigations involving Human Beings produced from the Research and Consultancy Services at the University of Strathclyde requires that any investigation involving the participation of humans is subject to a management risk assessment and ethical scrutiny (University of Strathclyde, 2009). The Code of Practice identifies a set of general ethical principles and legal obligations that affect the conduct of an investigation. In particular reference is made to (i) voluntary participation, (ii) informed consent, (iii) no harm, (iv) confidentiality / anonymity; and (v) privacy.

The data collection methodology in this project was designed to conform to ethical responsibilities towards the survey participants. As a consequence, participation was entirely voluntary and respondents were permitted to cease participation at any time during the survey. Informed consent was a prerequisite for participation in the survey. Participants were provided with an information pack (see Appendix A) explaining the nature, purpose and aims of the survey. Prior to participation, participants were required to read the project disclaimer and either agree or disagree to the terms and conditions. The nature of the survey (web-based and postal) was perceived to be a task with no (or very low) health risk to participants. Confidentiality and anonymity were respected at all times; completed surveys were not traceable back to the sender as participants were not required to provide their name, or contact details (unless they expressed a wish to participate in future experiments). Personal questions relating to age and age of diagnosis of eye condition did not require a definitive number and were categorised into predefined age group categories, therefore further reducing the traceability of a subject. The processing and storing of the research data is in accordance with the Data Protection Act 1998 (Mullock & Leigh-Pollitt, 1999) and the results will only be used in the context of this research project. An individual's right to privacy is slightly more complex to deal with as it cannot be anticipated whether a request to participate will be perceived as an invasion. In an attempt to moderate such effects, all informants were invited rather than pressured into participating in the survey. Furthermore, postal invitations to participate were limited to individuals who had expressed an interest in taking part in research studies (for more information, see section 5.2.6 Recruitment).

5.4.2. Survey Layout

The survey contained a total of seven individual sections: (i) Personal Details, (ii) Visual Impairment, (iii) Travel behaviour, (iv) Psychological & physical barriers, (v) Environmental factors, (vi) Colours & contrasts and (vii) Further study recruitment. An example of the survey can be found in Appendix A.

The personal details section asks participants to give information on their age, gender and occupation. In the visual impairment section participants were asked if they would like to disclose the name of their visual impairment, the type of vision loss their condition involves, if they are colour blind, the age of diagnosis and to indicate the type of mobility aid they use, if any. The travel behaviour section asked participants on average how many times per week they visit their nearest town or city centre (i) independently and (ii) with a sighted companion. They were also asked about the purpose of these visits and if they would like to make more independent visits. In the next section participants were asked to rate psychological and physical factors which prevented them from making independent visits to their nearest town or city centre. Participants were also asked to rate the physical features they found the most hazardous when walking along pavements, in particular in terms of (i) pavement condition and (ii) street furniture. The environmental factors section aimed to investigate the effects of the level of natural light and weather conditions on the travel behaviour of visually impaired pedestrians.

The next section of the survey asked participants to (i) choose the colours they found easiest to identify and (ii) choose the colours they found the most difficult to identify within the built environment. Furthermore participants were asked to suggest colour contrast combinations for three common situations found within the built environment: (i) Stair and Edge Strip, (ii) Pavement and Bollard and (iii) Pavement, Kerb and Road. Finally participants were given the opportunity to participate in a further study to take place at a later date within Glasgow city centre. If the participants expressed a wish to take part in this further study they were asked to provide further details including whether they were familiar with the area, how confident they were travelling in the study area, and provide contact details and information regarding any medical conditions which would affect their ability to participate in the study.

In order to increase the response rate and encourage participation it was decided to minimise the number of questions, in turn reducing the overall time needed to complete the survey. The main body of the survey contained 25 questions, with a further optional 4 questions if the participant wished to take part in a further study. The survey primarily consisted of quantitative questions where all answer categories were provided where possible to reduce the burden to the participant as recommended by Kaczmirek and Wolff (2007). The quantitative questions had a fixed set of responses and were limited to the following four types:

- Ticking Yes or No
- Ticking one or all of the options that apply
- Selecting the category which best applies
- Rating options on a Leichardt scale from 1 – 5.

The number of qualitative questions in the survey was limited to two: the name of the eye condition and the name of the participant's nearest town or city centre. There was also opportunity in the questionnaire for further comments to be made regarding colours in the built environment.

5.4.3. Design of Survey

Before embarking on the design of a survey, the particular requirements of the target audience should be considered. Unlike other user groups, where print format may be commonly used, for the visually impaired population this may present a challenge. A number of alternative methods can complement the traditional print format.

Perhaps the easiest way of obtaining information from visually impaired participants is through face-to-face interviews. For example, Bruce *et al.* (2007) interviewed participants in their own home. This type of interview offers benefits to both the participant and the investigators. For participants, this type of survey avoids the burden associated with filling in a paper based questionnaire, which may be time consuming, laborious and incur eye strain. Furthermore, this format enables the investigators to clarify any uncertainties and to probe further where appropriate. Another form of orally administered questioning which is often used when involving the visually impaired population is telephone surveys (e.g. Bruce *et al.*, 1991; Douglas *et al.*, 2006; Gallon *et al.*, 1995; Pey *et al.*, 2007). Again in this non-visual format, the participants are not required to use any of their residual vision (if present) and all of the information is collated by the operator. Although both of these methods may be the most accessible forms for visually impaired individuals these are not always employed due to limits placed on project budget and resources (travel expenses, telephone costs). Furthermore such methods may be perceived to be intrusive.

In cases where print format is adopted, then careful consideration should be given to page design and layout, in particular to colours, contrast, font type, font size and page orientation. RNIB (2006c) advise that information should be printed on matt or semi-gloss paper of A4 size in portrait format. It is recommended that a sans-serif typeface (e.g. Arial) be used with a minimum of 14-point for clear print and 16-point for large print. The use of underlining and italics should be avoided and text should have a line spacing of 1.5. For example, Bright *et al.* (1999) printed their questionnaire on non-reflective yellow paper, using 14-point Arial in portrait format. Additionally, a Braille version may be made available to participants, although this is not usually adopted on a wide scale, due to the small percentage of blind and visually impaired individuals who are able to read this format which is estimated to be 3% of the blind and visually impaired population (Bruce *et al.*, 1991). Furthermore documents in Braille can be very lengthy and present difficulties to certain users (e.g. those with diabetes) due to the high level of finger sensitivity required.

For this research it was not possible to conduct face-to-face interviews or telephone surveys as the primary mode for the questionnaire dissemination due to time, budget and resource restrictions. The primary mode of the survey was an online version created using Survey Monkey, a survey software package. Provided internet access is available, electronic formats may be more accessible than paper formats due to the assistive technology available to enlarge text (magnifying software) and verbally communicate information (screen readers). The online survey was designed to be compatible with software packages, such as JAWS and ZoomText. ZoomText is a visual screen reader which allows the user to customise the size of text, background colour and text colour. JAWS is a non-visual screen reader commonly used by those with little or no residual vision. Furthermore Survey Monkey allowed the design of the survey to be customized. The survey was initially presented to participants as white text on a black background. However, as a result of user feedback, additional formats were produced including black text on a white background and a downloadable MS Word version, providing alternative options and flexibility to participants. The online questionnaire could be accessed from the project website, www.urbanacuity.co.uk (see Appendix A for details). The survey was available online from 10th March 2008 to 10th March 2009.

Additionally a large print paper format was produced, black text on a white background with Arial font size 18 as recommended by RNIB (2006c). This was primarily for individuals who did not have access to the internet. A small number of telephone surveys were also conducted to accommodate the needs of visually impaired individuals who expressed a wish to participate and preferred not to use paper or electronic methods.

5.4.4. Recruitment

In order for the results to be balanced and representative of the views of the visually impaired population as a whole, it was necessary to source participants from a varied range of ages and from a broad assortment of different types of eye conditions and vision loss. A nationwide recruitment campaign was conducted between the months of March and August 2008. As a means of attracting participation from individuals in younger age groups emails were circulated to all University Disability services in Scotland and to a number in England. This was followed by a regional poster campaign highlighting the research and advertising the project website (see Appendix A). Posters were placed in local institutions including Gartnavel Eye Hospital, Strathclyde Partnership for Transport Travel Card Unit, Glasgow City Council Centre for Sensory Impaired, Visibility (formerly known as Glasgow and West of Scotland society for the blind) and at a number of local University Disability Services, University Libraries and student Unions. An advertisement for volunteers was also placed in the summer edition of the Visibility Newsletter. Information on the research was also advertised in Playback, a nationwide talking newspaper, in the May 2008 edition. In order to target individuals with different types of vision loss a number of national groups and organisations were also contacted including Guide Dogs for the Blind Association, British Retinitis Pigmentosa society, the Macular Disease society and the Nystagmus Network. This stage of the recruitment campaign advertised the project website, where additional information on the research was available and a direct link to the online survey was provided.

The final stage in the recruitment campaign involved gaining access to the RNIB scientific research unit database of blind & partially sighted subjects, which comprises contact details of almost 200 individuals who express the wish to take part in research projects. All of those listed in the database were contacted via their preferred method of communication either by email (36) or by large print postal format (154) which included a stamped addressed envelope to ease return of the questionnaire. The large print postal format also directed people to the project website if this option was preferable.

The recruitment campaign attracted nationwide interest with a total number of 212 completed surveys from across the country. The majority of participants (139) accessed and completed the questionnaire electronically from the project website accounting for 67% of all completed questionnaires. Of the 154 postal questionnaires distributed, 70 were returned accounting for 33% of the overall total of 212 questionnaires. The response rate for the postal survey was 46%. The high response rate may be due to the recruitment source, as all volunteers who were targeted had expressed an interest in participating in research studies. Due to a surge in the responses received online after the postal questionnaires were distributed, it is believed that a number of those individuals who received a postal questionnaire, chose to complete the survey online rather than return the large print version.

In a substantial number of the returned postal questionnaires, the respondents had included additional comments, providing insightful qualitative information which allowed them to expand on a particular theme and to highlight relevant issues specific to their needs. This type of information was particularly important in introducing additional new areas of interest otherwise not discussed within the survey.

5.4.5. Sample Size Calculation

The degree of confidence with regards to the accuracy of the survey sample when compared to the views of the wider population can be established by means of probability theory. It is necessary to decide upon the estimated sampling error that the research is willing to tolerate and the confidence interval for the sample. There are a number of formulae available for estimating sample size (e.g. Yamane, 1967). The formula used here was devised by Cochran (1963) and is a standard method for determining sample size. However, in this study it has been used to determine the confidence interval (sampling error) for the actual survey population:

$$d^2 = \frac{t^2 p(1-p)}{n_0}$$

Where: d is the sampling error (expressed as a decimal), t is the coefficient for the confidence interval (1.96, which is the standard deviation for a confidence interval of 95%), p is the level of variation in the responses (conservative estimate of p =0.5) and n0 is the sample size (212). Cochran (1963) suggests that if the fraction of n0 / N is negligible, then n0 is a satisfactory approximation, where N is the size of the larger population from which the sample is drawn.

Assuming that the visually impaired population of the UK is 2.3 million (Charles, 2006), the sample size of 212 can be representative of the visually impaired population as a whole at a confidence interval of 95% and a sampling error of .07; these settings describe a situation in which the survey results reflect 95% confidence that the measured figures for each questionnaire item in the sample are equivalent to those of the population, plus or minus 7%. Therefore, if 67% of the respondents in this survey give a particular answer, we can be sure that if the question was presented to the entire visually impaired population between 60% and 74% would have selected that answer. This confidence interval and sampling error compares favourably to commercial surveys which usually aim to have a confidence interval of 6%. However it should be noted that the data presented in this chapter is based on actual responses unless otherwise indicated.

5.5. Results

5.5.1. Geographical Response

The geographical distribution of the survey respondents covered all four countries of the UK. The highest percentage of respondents came from Scotland with 30.1%. This was however anticipated as Glasgow and the surrounding area were specifically targeted during the recruitment campaign in order to source participants for a study scheduled to take place in Glasgow city centre at a later stage of the research. The next highest percentages of respondents came from the South East of England (16.4%), South West of England (13.7%) and London (9.8%) which can be attributed to the high general populations found in these areas. Figure 5.1 (a) illustrates the locations of the hometowns of the visually impaired participants and figure 5.1 (b) illustrates the regional breakdown of the 212 survey respondents.

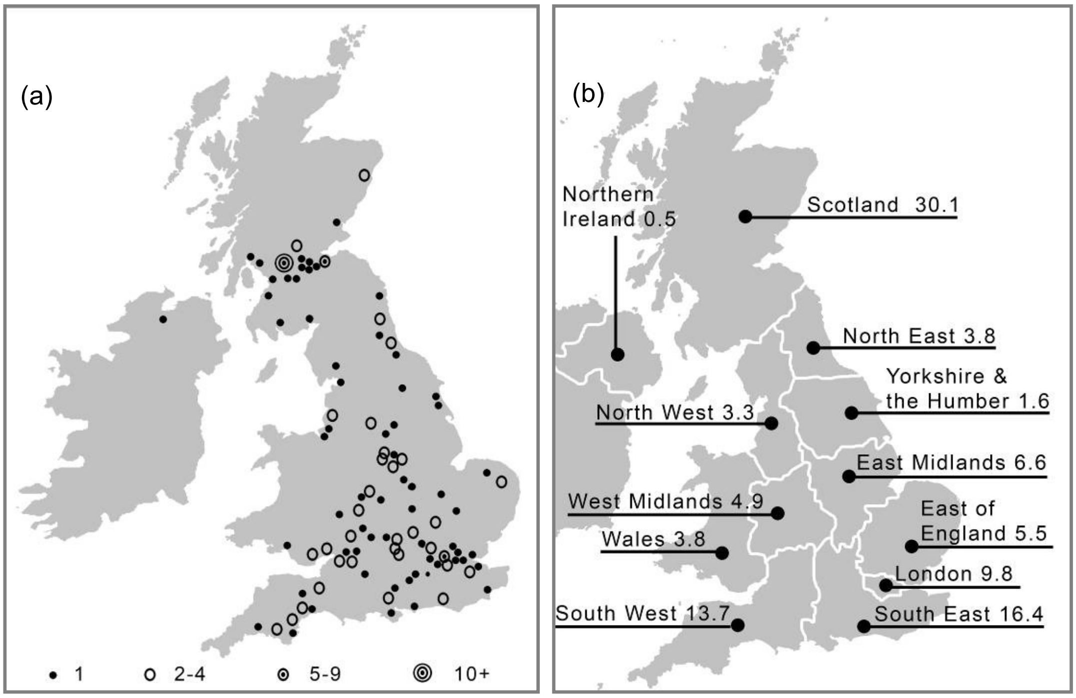


Figure 5.1: (a) Map of the UK illustrating the home towns of the survey participants and (b) regional percentage of survey participants

5.5.2. Demographics

Of the 212 participants questioned, 44% were male and 56% female. The questionnaire was restricted to people over the age of 16 for ethical considerations and also due to perceived differences in the independent travel behaviour of children and young adults. Table 5.1 presents the age distribution of the participants; the age group of 65 years and over had the highest number of respondents (23.6%). This reflects the fact that the majority of the visually impaired population are aged over 65 (Charles, 2006). However, a concerted effort was made to recruit participants from a broad range of ages, so that results were not biased towards the views of the older generation. As people are increasingly likely to suffer from health problems with age (DPTAC, 2005; Tomassini, 2005), it was important to investigate age groups who are less likely to suffer from conditions associated with old age, e.g. mobility issues arising from arthritis, as additional medical conditions other than visual impairment may have an influence on a person's travel behaviour. This attempt to achieve a more balanced population sample is evident in the age distribution of participants presented in Table 5.1, with each age group representing between 10 – 25% of the sample population.

Table 5.1: Age distribution of participants

Age Group	16-24	25-34	35-44	45-54	55-64	65+
(%)	9.9	11.8	17.9	16.5	20.3	23.6

Figure 5.2 presents the occupational status of the respondents; the highest percentage of respondents were retired (36.3%) which reflects the age distribution of the sample population, where 43.9% were over the age of 55. The next highest percentage was the employed category (29.7%) followed by students in higher education (14.6%). It is interesting to note that only 8.0% of respondents were unemployed. In terms of the working age population (16-65) 38.9% were employed. This figure is similar to the Network 1000 study who found that 34% of the working age population in their survey were

employed (Douglas *et al.*, 2006). These figures are significantly higher than figures presented by RNIB (2004) which suggest that 25% of blind and visually impaired people of working age are in paid employment. Perhaps more interesting is the low unemployment rate of participants in this study (8.0% of total sample population). Of the working age population only 10.5% described themselves as being unemployed, this is less than half the value reported by Douglas *et al.*, (2006).

49.1% of the sample population were in employment or actively working either as a student or in the voluntary sector. This data suggests that a large proportion of the visually impaired population may have to negotiate the urban environment on a regular basis in order to access their place of work or education. This further highlights the importance of ensuring that the built environment is designed in a way that enables and facilitates the independent movement of individuals with a visual impairment.

Figure 5.2: Occupation of respondents

5.5.3. Type of Vision Loss

When asked what type of vision loss their eye condition involved, 21% of respondents reported loss of central vision, 20% reported loss of peripheral vision, 37% had mixed vision loss, 15% were blind and 7% chose other (see Figure 5.3). Other refers to conditions which do not involve a loss in the visual field but rather may affect acuity, light sensitivity e.g. Nystagmus photophobia and myopia. Out of the 154 participants who chose to disclose the name of their eye condition, a total of 56 different eye conditions were recorded. The top four most common conditions were Retinitis Pigmentosa (29.2%), Macular Degeneration (13.6%), Glaucoma (11.7%) and Cataract (10.4%). This corresponds with the top four eye conditions prevalent in the UK as cited in Barker *et al.* (1995). No other condition had more than 10% prevalence and 2.6% said that they did not know the name of their eye condition. Participants were asked to state if they were colour blind, 76% said no, 20% said yes and 4% answered not applicable.

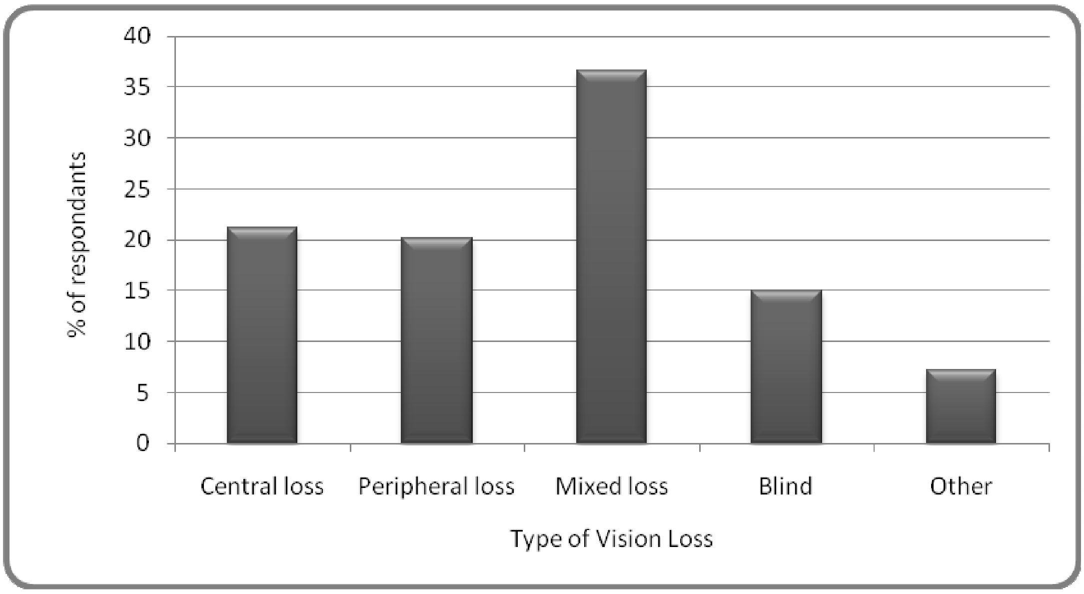


Figure 5.3: Type of visual field loss of respondents

The age at which the participants were diagnosed was an important question to ask as previous studies have shown that the age of diagnosis may be a determining factor on the ease with which a visually impaired individual is able to navigate within the built environment (Dodds & Carter, 1983; Lerner & Busch-Rossnagel, 1981; Passini *et al.*, 1990; Rieser *et al.*, 1992). In particular, it has been noted that people with previous visual experience, particularly with prior broad field vision may have an advantage when learning new environments (Rieser *et al.*, 1992). However, Passini *et al.* (1990) found that the congenitally blind group performed better than both the adventitiously blind and sighted groups in a series of wayfinding tasks (for more information see section 4.5.1). An individual would be considered to be congenitally blind / visually impaired if the onset of their eye condition occurred at birth or before the age of three (Passini *et al.*, 1990). Early blind as used in this study refers to individuals who are congenitally blind or were diagnosed between the ages of 4-12. Adventitiously blind (late blind / visually impaired) refers to individuals who have some visual memory, in this study this is considered from the age of 13 onwards. For this reason, the age of onset for each survey participant will be used as a basis for determining whether a particular trend exists with reference to travel behaviour within the external built environment.

5.5.4. Age of Diagnosis

Table 5.2 presents the distribution of respondents according to the age at which they were diagnosed with their eye condition. 40.3% of participants can be classified as early blind or visually impaired (diagnosed up to the age of 12), of which 33% were diagnosed at birth or before the age of 3 (congenitally blind). The majority of the respondents (59.7%) were diagnosed with their eye condition later in life (from the age of 13 onwards). It is clear that the survey involved participants who were diagnosed with their eye condition at all stages of life, with all age groups of diagnosis representing between 10 - 20%.

Table 5.2: Age of diagnosis of respondents

Age of diagnosis	Birth	0-3	4-12	13-21	22-40	41-59	60+
(%)	16.0	17.0	10.3	9.8	17.5	18.0	11.3

Figure 5.4 categorises the type of vision loss according to the age of diagnosis. Conditions involving central vision loss occur mainly in the later stages of life, particularly over the age of sixty (50.0%). The onset of peripheral vision loss was most prevelent among the adventitiously blind, peaking at 52.6% of all diagnosed cases between 13 – 21, 35.3% between 22 – 40 and 28.6% of diagnosed cases between the ages of 41 – 59. However the percentage of those diagnosed with conditions leading to peripheral vision loss fell substantially to 4.5% for those diagnosed after the age of sixty. The distribution of conditions leading to mixed vision loss were more evenly distributed throughout all stages of life, ranging from a low of 20% for those diagnosed between 4 – 12 to 45% of those born with their visual impairment at birth or between the ages of 0 -3. Conditions leading to blindness typically occured at an early stage in life, with 22.6% occuring at birth, 36.4% occuring between the ages of 0 – 3 and 20% reporting diagnosis between the ages of 4 – 12. Finally, the onset of other conditions not affecting visual field loss were exclusively restricted to birth (22.6%), 0 - 3 (9.1%) and 4 – 12 (20%).

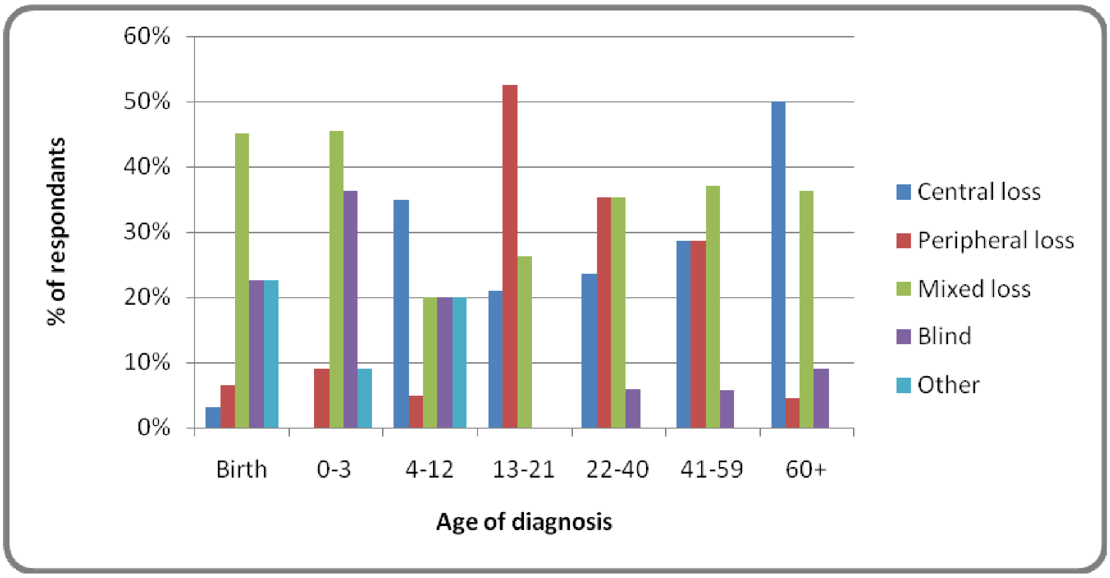


Figure 5.4: Age of diagnosis according to type of visual field loss

5.5.5. Mobility Aids

63.9% of respondents stated that they use a mobility aid, this included the use of a symbol cane (24.7%), long cane (18.6%) and guide dog (11.3%). 9.3% reported using other mobility aids, of which 5.2% involved the use of a sighted companion (Figure 5.5). No one reported using electronic travel aids (ETAs). This concurs with Pey *et al.* (2007) who found that only a small percentage (2%) of those surveyed use ETAs due to the high associated cost and low availability of such equipment. A significant proportion of respondents reported using no mobility aid (36.1%). This was also highlighted by Gallon *et al.* (1995) who found a significant proportion of their survey participants preferred to make use of their residual vision rather than use a mobility aid and be labelled as blind.

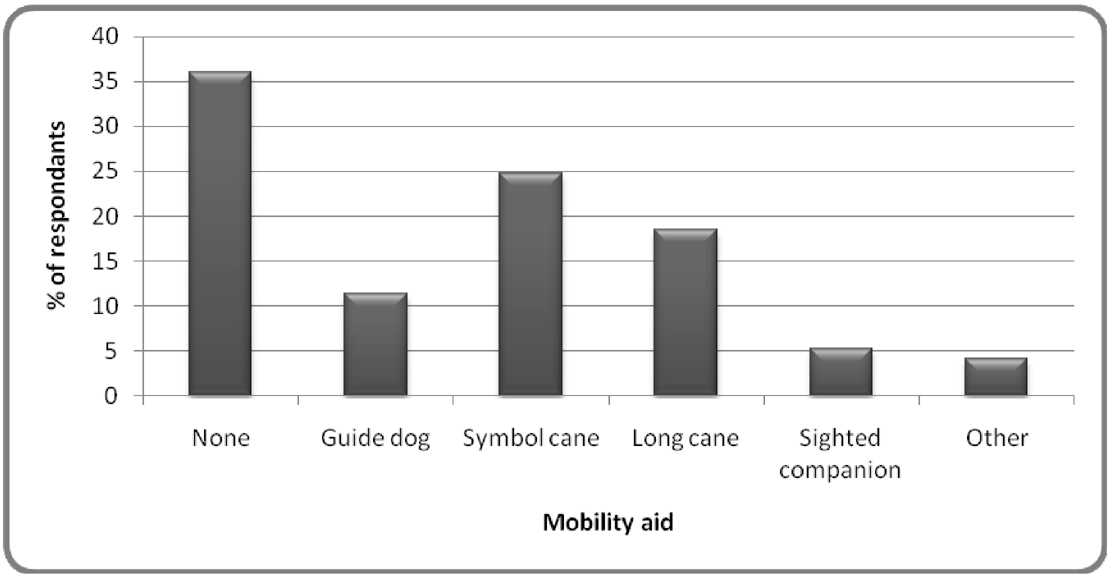


Figure 5.5: Distribution of mobility aids used

Figure 5.6 presents the distribution of mobility aids used according to the type of vision loss. 48.3% of all the blind survey participants reported the use of a long cane, a much higher usage than for any of the other vision loss categories. The blind survey participants also reported the highest usage of guide dogs (24.1%) compared to 10% or below for the other vision loss categories. The highest percentage of users of the symbol cane were those with central vision loss (39%) which contrasts with only 3.4% of the blind participants who reported using a symbol cane. Of those who reported using no mobility aid the highest percentage group was individuals with other types of eye conditions not related to visual field loss (50.0%). This was closely followed by the central vision loss category of which 46.3% reported using no mobility aid and the mixed vision loss category (42.3%). The results indicate that those who are blind (have no remaining useful vision) may have more of a visual presence in the built environment due to their high reliance on mobility aids (93.1% reported the use of a mobility aid). The majority of those who reported using no mobility aid were visually impaired with some useful remaining residual vision.

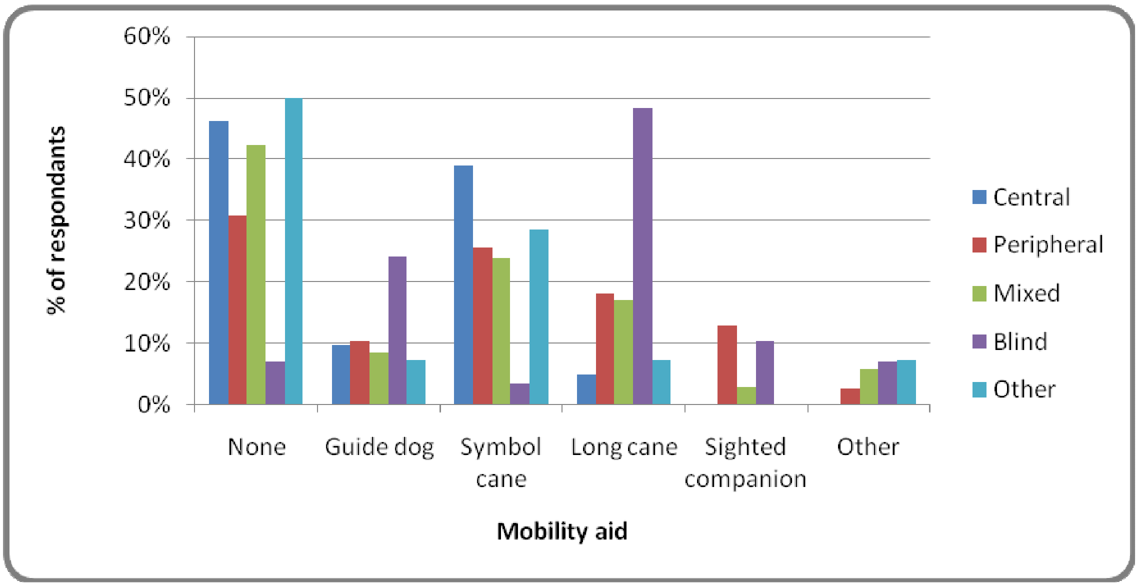


Figure 5.6: Mobility aid used according to type of visual field loss

5.5.6. Independent Journeys

Participants were asked to state the number of visits per week they made to their nearest town or city centre, (i) independently and (ii) with a sighted companion. 29% of respondents stated that they made no independent visits to their nearest town or city centre (see Figure 5.7). This finding closely corresponds with previous surveys undertaken to investigate the independent travel behaviour of blind and visually impaired people, for example Clark-

Carter *et al.*, (1986) found that 30% of participants made no independent visits outside of their home. Furthermore, Pey *et al.* (2007) found 18% of their respondents made no independent visits outside of their home with a further 11% saying that going out by themselves was not important to them, creating a combined total of 29%. In this study 71% of participants stated that they make at least one independent visit per week to their nearest town or city centre, which also closely reflects findings from Pey *et al.*, (2007) who found that 73% of their survey sample made at least one independent journey per week.

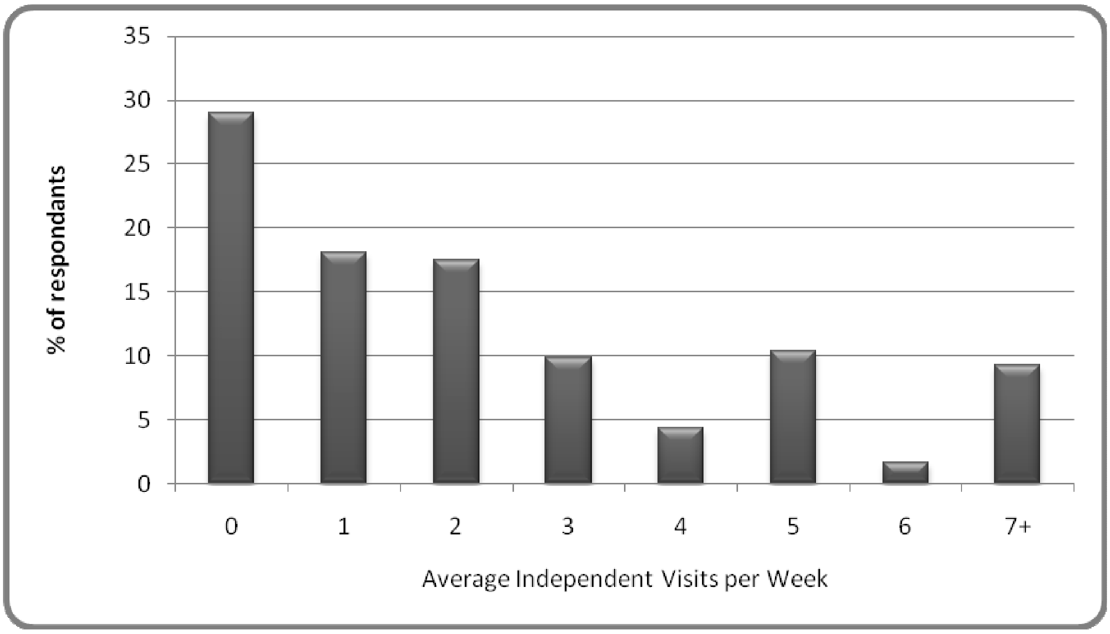


Figure 5.7: Average number of independent visits per week

5.5.6.1. Age Group

In Figure 5.8 it is evident that the 16-24 age group make more independent visits than all other age groups with 100% making more than 1 independent journey per week. The numbers reporting making no independent visits per week is closely correlated with age, increasing from 0% for the age group 16-24 to 44.7% of those aged 65 and over making no independent journeys (Figure 5.8). Furthermore those making seven or more independent journeys per week showed a decreasing trend with age, with 25.0% of the 16-24 age group making this number of independent journeys on a weekly basis compared to 4.3% of those aged 65 years and over (Figure 5.8).

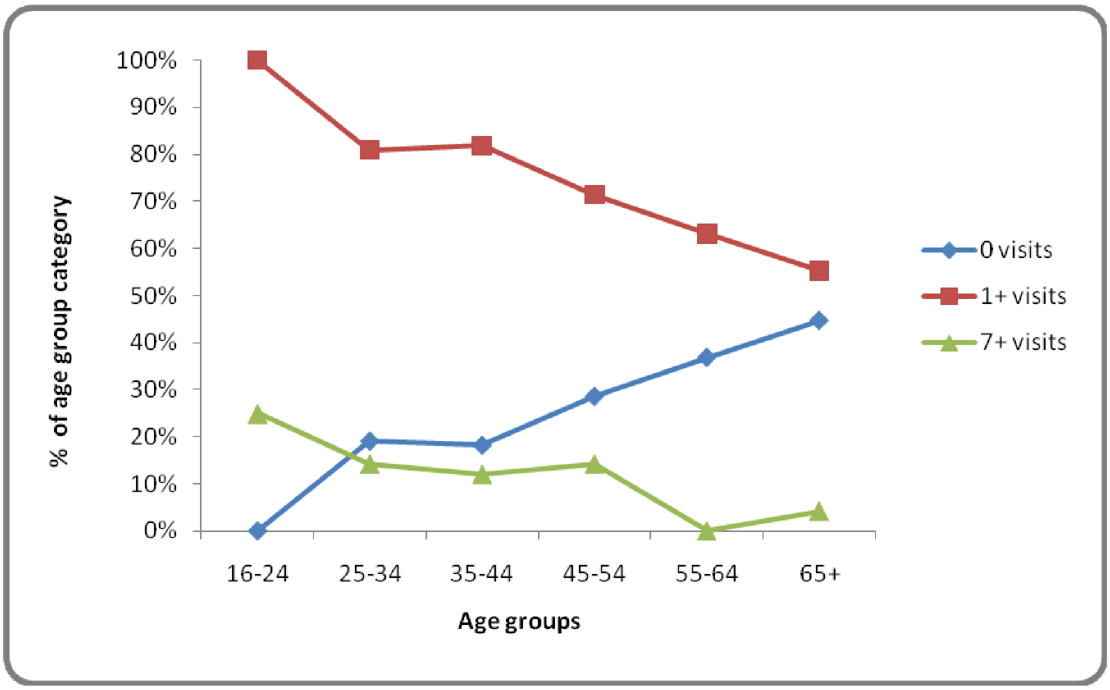


Figure 5.8: Number of independent visits made per week according to age group

5.5.6.2. Gender

Generally it was found that the number of independent visits made was also influenced by gender with men making more independent visits than women. For example, 16.9% of men reported making more than 7 independent journeys on a weekly basis compared with only 3.8% of women.

5.5.6.3. Occupation

There was also found to be a link between occupation and the number of independent visits made. 84.6% of those in employment and 84.0% of those in full time education made at least one or more independent visits per week. This compares to 55.7% of those who are retired and 54.5% of those classified as having another type of occupation (e.g. housewife, or carer).

5.5.6.4. Type of Vision Loss

The number of zero independent visits reported was evenly distributed among the different types of vision loss: 30.0% of those with central vision loss, 34.2% of those with peripheral vision loss, 27.7% of those with mixed vision loss and 34.6% of the blind sample population reported making no independent visits. Interestingly of those with other types of eye conditions not related to visual field loss, only 7.1% reported making no independent visits.

5.5.6.5. Age of Diagnosis

The number of independent visits per week was cross-tabulated with the age of diagnosis in order to identify whether any trends exist between the travel behaviour of the early blind and late blind. It was found that the early blind group (diagnosed before 12 years of age) made more independent journeys than the late blind group, with 85% of the early blind group making at least one independent journey compared to 60% of the late blind group. A higher percentage of the late blind groups made no independent journeys (Figure 5.9). This may indicate that those individuals diagnosed with their eye condition early in life may be more confident making an independent journey than their late blind counterparts. This however may also be due to the fact that they have lived with their eye conditions for longer and have established a set of coping strategies. However it should be noted that the age of diagnosis appeared to have little influence on whether 7 or more independent journeys were made on a weekly basis, which appeared to be more closely related to an individual's current age.

5.5.7. Visits with Sighted Companion

37.7% of all respondents reported making no visits with a sighted companion. 62.3% of all respondents made visits accompanied with a sighted companion at least once a week, which included 34.4% of total respondents who made one visit and 15.3% of total respondents who made two visits with a sighted companion. It was found that the use of a sighted companion was limited to one or two trips a week and the use of a sighted companion to make more than seven visits a week was not reported often (0.5% of total respondents). See Figure 5.10 for more details.

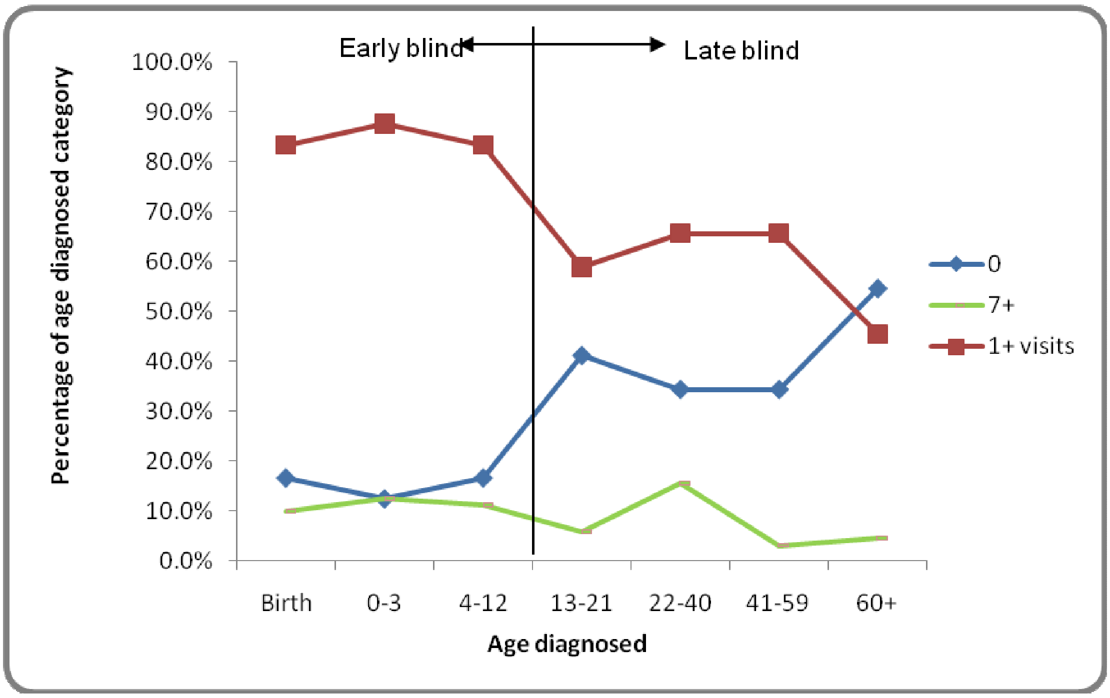


Figure 5.9: Number of independent trips made according to age of diagnosis

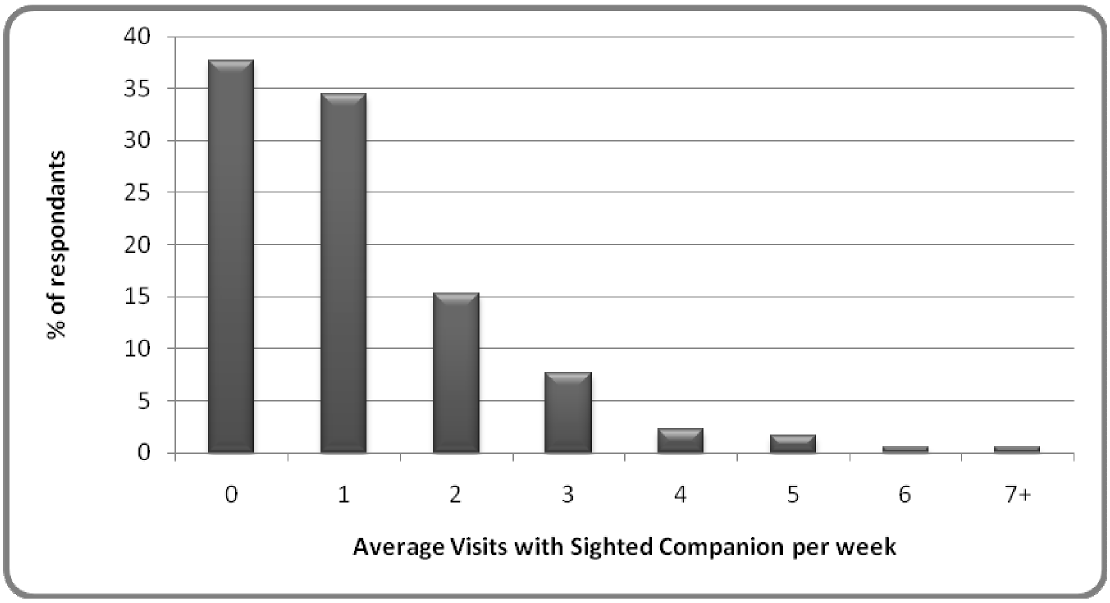


Figure 5.10: Number of visits made with a sighted companion on a weekly basis as a percentage of total respondents.

5.5.7.1. Age Group

I was found that all age groups made visits using a sighted companion, with 55% to 71% of each age group using a sighted companion at least once a week. This did not appear to be heavily influenced by age group. However a general increase in the percentage of each age group making one visit per week with a sighted companion was found (with the exception of the age group 45-54).

5.5.7.2. Type of Vision Loss

There appeared to be no significant influence on the number of visits made with a sighted companion in terms of type of vision loss. 60 - 67.5% of each vision loss category reported using a sighted companion at least once a week. However only 50% of the "other" category (with eye conditions not relating to visual field loss) reported making visits with a sighted companion.

5.5.8. Purpose of Visit

It is important to identify the main reasons for independent travel including the destination points for visually impaired pedestrians. When asked the main reasons for independent travel, the majority of participants (85%) mentioned shopping as a reason for travelling into their nearest town or city centre. This corresponds with the Network 1000 survey which found that 77% of their survey sample left the home to go shopping (Douglas *et al.*, 2006). Other reasons for visiting their nearest town or city centre included going to the bank or post office (52%), meeting family & friends (45%) and entertainment (44%). Fewer people mentioned work (21.6%), sport (12.1%) and education (11.6%) as the purpose of their visits (see Figure 5.11).

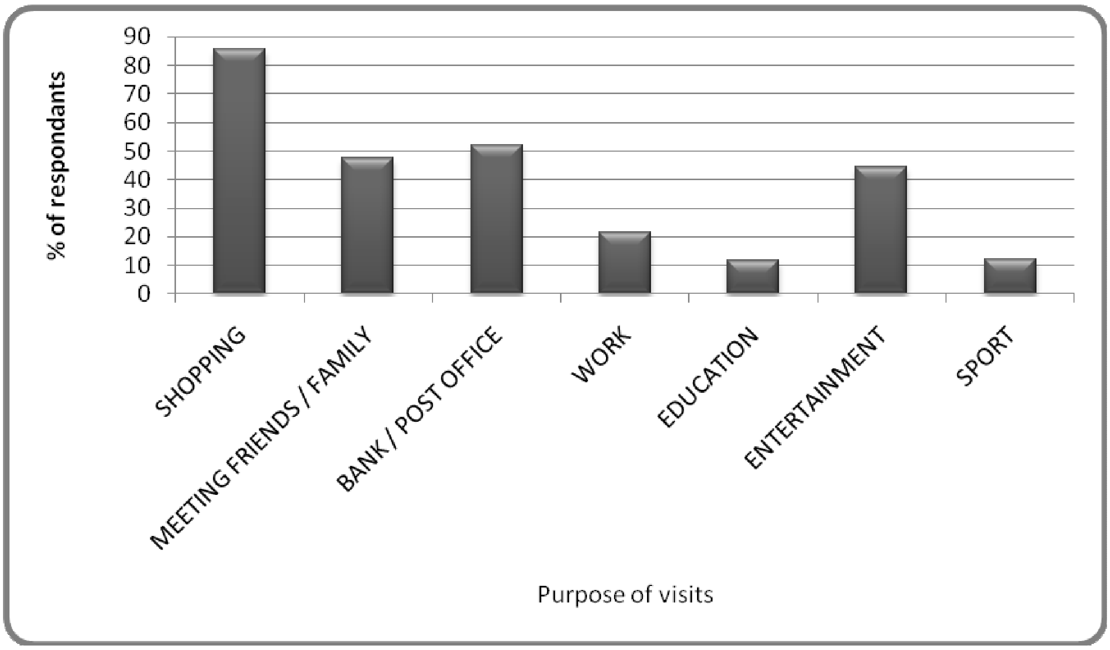


Figure 5.11: Purpose of visiting town or city centre

5.5.9. Desire for more Independent Journeys

When asked if they would like to increase their independent travel behaviour, more than half of the survey sample (51%) expressed a wish to make more independent visits to their nearest town or city centre. This figure is higher than that reported by Douglas *et al.*, (2006) who found that 43% of their sample wished to make more independent visits.

5.5.9.1. Age Group

As Figure 5.12 reports, the age group who expressed the strongest wish to make more independent visits was 25-34 (76.2%) followed by 35-44 (54.4%). The age group with the least desire to make more independent visits was 45-54 (34.5%) followed by 16-24 (37.5%). This is may be due to the fact that those aged between 16-24 consist of independent travellers all of whom made at least one independent trip per week, with 25% making seven or more independent journeys a week (see Figure 5.8). Individuals aged 55 years and over did not express any particular wish to make more or less independent visits.

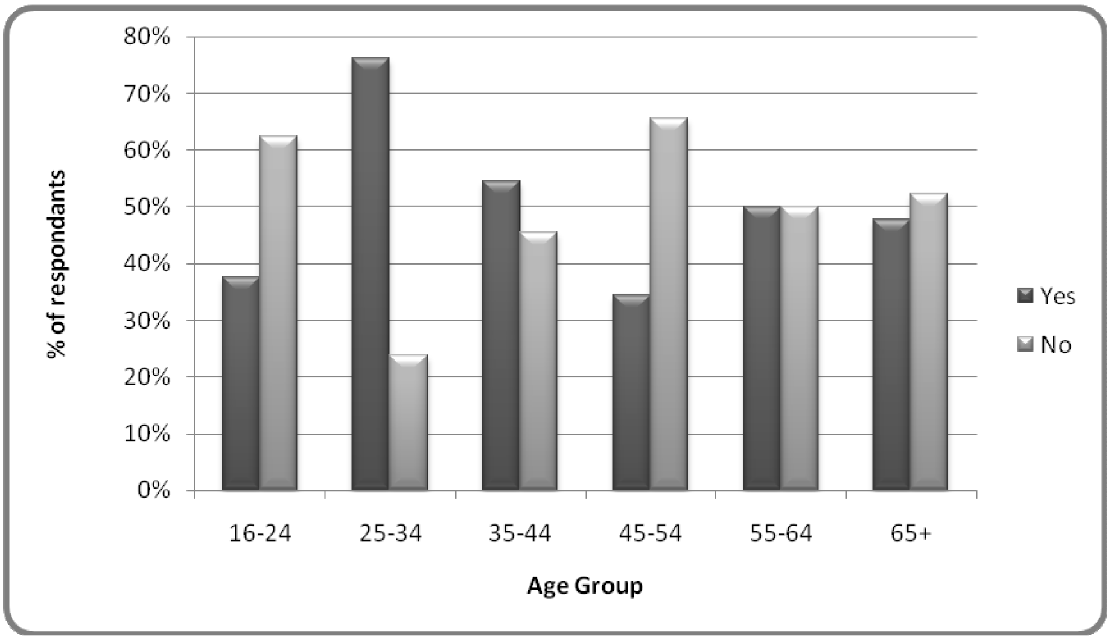


Figure 5.12: Percentage of each age group wising to make more independent visits

5.5.9.2. Gender

It was found that the wish to make more independent visits was influenced by gender, with 59.0% of women wishing to make more independent visits compared to only 37.2% of men. This reflects the fact that the male participants already made more independent visits than their female counterparts (see Section 5.5.6).

5.5.9.3. Occupation

No significant trends were found with regards to a person's occupation and their desire to make more independent visits. Between 44% and 56% of each occupation category expressed the wish to make more independent journeys.

5.5.9.4. Type of Vision Loss

Table 5.3 illustrates the wish to make more independent visits according to each type of vision loss category. The type of vision loss did not appear to have a significant effect on the wish to make more independent journeys. However some differences did exist between the various vision loss categories. The vision loss group which expressed the greatest wish to make more independent journeys were those who were blind (57.7%). Individuals with other eye conditions not affecting visual field loss expressed the least wish to make more independent journeys (35.7%).

Table 5.3: Wish for more independent visits by type of visual field loss

More independent visits	Central loss (%)	Peripheral loss (%)	Mixed loss (%)	Blind (%)	Other (%)	Total (%)
Yes	42.5	50.0	53.8	57.7	35.7	49.7
No	57.5	50.0	46.2	42.3	64.3	50.3

5.5.9.5. Age of Diagnosis

Table 5.4 presents the wish to make more independent visits against the age at which a visual impairment was diagnosed. There was found to be a relationship between the age of diagnosis and the wish to make more independent visits, with those in the late blind category expressing a greater wish than those in the early blind category. Those diagnosed between the ages of 13 and 21 expressed the strongest wish to make more independent visits than those diagnosed at any other stage in life (64.7%), this was followed by those who were diagnosed at birth (56.7%). The percentage of all other age groups of diagnosis who expressed the wish to make more independent visits ranged from 41.9% to 50.0%.

Table 5.4: Wish for more Independent Visits by Age of Diagnosis

	Early blind			Late blind			
Age diagnosis	**Birth**	**0-3**	**4-12**	**13-21**	**22- 40**	**41-59**	**60+**
Yes (%)	56.7	41.9	44.4	**64.7**	46.9	48.5	50.0
Overall Avg. (%)	**47.7**			**52.5**			

5.5.10. Psychological and Physical Barriers to Access

This question was designed to determine whether or not it was physical features or psychological factors which influence the independent travel behaviour of visually impaired people**.** Participants were asked to rate the factors which may prevent them from visiting the city centre alone, scoring each from 1 to 5, with 1 being the most influential and 5 the least influential. A total of ten possible reasons for avoiding independent travel were provided relating to either (i) personal (psychological) factors or (ii) physical factors associated with the built environment. An overall average rating for each factor was calculated and is presented in Table 5.5. Personal factors including the fear of getting lost and lack of knowledge of the area were rated as less important reasons for preventing an independent visit than physical features associated with pavement design such as the positioning of unexpected obstacles, crowded streets, problems walking along pavements and inaccessible pedestrian crossings.

Table 5.5: Physical and psychological barriers to independent travel

Influencing Factors	1 (%)	2 (%)	3 (%)	4 (%)	5 (%)	Average Rating
Unexpected obstacles	**36.0**	24.4	16.5	11.0	12.2	2.39
Crowded streets	**26.7**	20.6	17.0	15.8	20.0	2.82
Problems walking on pavements	20.1	**24.4**	21.3	14.6	19.5	2.89
Inaccessible pedestrian crossings	24.5	11.7	**25.2**	19.6	19.0	2.97
Apprehension of using public transport	24.4	14.6	18.3	14	**28.7**	3.08
Heightened stress levels	14.5	20.0	**24.2**	18.2	23.0	3.15
Fear of personal safety	15.2	11.5	**25.5**	22.4	**25.5**	3.32
Lack of accessible information	17.8	13.5	16.6	12.3	**39.9**	3.43
Lack of knowledge of the area	16.6	14.7	17.2	12.3	**39.3**	3.43
Fear of getting lost	12.1	16.4	17.6	17.0	**37.0**	3.50

5.5.10.1. Age Group

The distribution of response averages according to age group is illustrated in Table 5.6. Participants aged between16 - 24 rated factors as less influential than those from other age groups with an average rating of 3.48. The age group which rated the factors as most influential was 55 – 64 with an average rating of 2.91 (see Table 5.6).

Table 5.6: Average rating according to age group

Age group	16-24	25-34	35-44	45-54	55-64	65+
Average Rating	3.48	3.10	3.05	3.14	2.91	3.11

Table 5.7 presents the factors, which received the lowest average rating (more influential) according to age group, which may influence independent travel. Unexpected obstacles received the lowest average rating for the majority of the age groups, however there were two exceptions. For the 16-24 age group, lack of knowledge of the area received the lowest average rating whereas for the 25 – 34 age group, apprehension of using public transport alone and inaccessible pedestrian crossings received the lowest average ratings.

Table 5.7: Influential factors preventing independent travel according to age group

Age group	Unexpected obstacles	Apprehension of using public transport alone	Inaccessible pedestrian crossing	Lack of knowledge of the area
16-24				✓ (2.93)
25-34		✓ (2.65)	✓ (2.65)	
35-44	✓ (2.48)			
45-54	✓ (2.39)			
55-64	✓ (1.85)			
65+	✓ (2.31)			

5.5.10.2. Gender

Both male and female groups rated unexpected obstacles as the most influential factor for preventing independent travel (Female: 2.31, Male: 2.51). Women rated personal factors and physical features lower than men with an average rating of 2.93 for women compared to 3.33 for men. This could perhaps explain why women make less independent journeys and express a much higher wish to make more independent journeys than their male counterparts (see Section 5.5.6 and 5.5.9).

5.5.10.3. Type of Vision Loss

Table 5.8 illustrates the average ratings given according to each type of vision loss. The overall lowest average rating was obtained for the blind participant group. It should however be noted that the range of ratings given by the different vision loss categories was marginal, between 2.96 for those who are blind and 3.13 for those with peripheral vision loss. This suggests that the type of visual field loss does not have a significant influence on the factors affecting independent travel. The group who were the least influenced by physical and personal factors were those with other conditions not affecting visual field loss with an average rating of 3.80.

Table 5.8: Average rating according to type of vision loss

Type of vision loss	Central loss	Peripheral loss	Mixed loss	Blind	Other
Average Rating	3.07	3.13	2.99	2.96	3.80

Table 5.9 presents the lowest average rating awarded by each vision loss category. In this instance three factors have been awarded the lowest rating. Individuals with central and mixed vision loss were influenced by the presence of unexpected obstacles whereas for those with peripheral vision loss and other conditions, crowded streets would influence their decision to travel independently. The blind participant indicated that their decision to travel independently is strongly influenced by the presence of inaccessible pedestrian crossings, which received a low average rating of 1.77.

Table 5.9: Most influential factors preventing independent visits

Type of vision loss	Unexpected obstacles	Crowded streets	Inaccessible pedestrian crossings
Central loss	✓ (2.70)		
Peripheral loss		✓ (1.94)	
Mixed loss	✓ (2.24)		
Blind			✓ (1.77)
Other		✓ (3.29)	

5.5.10.4. Age of Diagnosis

It was found that the early blind participants (diagnosed from birth – 12 years of age) had a higher overall average rating of the features listed in Table 5.5, than those diagnosed with their eye condition from age 13 onwards (see Table 5.10). This indicates that the early blind group view these factors as being less influential than the late blind group, suggesting that those who were diagnosed with their eye condition at an early stage in life are more confident independent travellers then those who were diagnosed at a later stage in life.

Table 5.10: Average rating according to age of diagnosis

	Early blind			Late blind			
Age diagnosis	**Birth**	**0-3**	**4-12**	**13-21**	**22- 40**	**41-59**	**60+**
Avg. Rating	3.04	3.37	3.63	2.85	2.99	2.73	3.17
Overall Avg. Rating	**3.35**			**2.93**			

Table 5.11 details the most influential factors which prevent independent travel according to the age of diagnosis. The majority of the sample population selected unexpected obstacles as having the most influence on preventing independent travel, regardless of age of diagnosis. The two exceptions were those who were diagnosed between 4 – 12 and those diagnosed after the age of 60, where apprehension of using public transport alone and problems walking along pavements were given the lowest average ratings respectively. For those diagnosed after the age of 60, the low rating given to problems walking along pavements may be due to other conditions affecting mobility related to age.

Table 5.11: Most influential factors preventing independent travel according to age of diagnosis

Age of diagnosis	Unexpected obstacles	Problems walking along pavements	Apprehension of using public transport alone
Birth	✓ (2.24)		
0-3	✓ (2.57)		
4-12			✓ (3.22)
13-21	✓ (2.38)		
22-40	✓ (2.20)		
41-59	✓ (1.57)		
60+		✓ (2.71)	

5.5.10.5. Mobility Aid

Finally, the type of mobility aid used by each survey participant was investigated in order to find out whether those who use a mobility aid are less influenced by psychological and physical factors when deciding to make an independent journey than those who travel without a mobility aid. Lower average ratings were found for individuals who use a mobility aid, indicating that they are more influenced by physical and psychological factors as opposed to those who travel without an aid (see Table 5.12). In particular those who are accompanied by a sighted companion had an average rating significantly lower than the other mobility aid categories. This may be due to a lower confidence level with respect to travel behaviour in individuals who rely on sighted assistance. All categories rated unexpected obstacles as the most influential factor, with those using a sighted companion rating unexpected obstacles the lowest with an average rating of 1.29.

Table 5.12: Average rating according to mobility aid

Mobility Aid	None	Guide dog	Symbol cane	Long cane	Sighted companion	Other
Avg. Rating	3.31	3.14	2.99	3.01	2.24	3.22

5.5.10.6. Summary

This question has clearly demonstrated that it is not factors relating to a person's visual impairment that are preventing them from making independent journeys to their nearest town or city centre but rather it is the physical factors relating to the design of pavements and the built environment on a wider scale. The presence of unexpected obstacles on pavements received the lowest overall average rating and was the lowest within many of the categories together with problems walking along pavements, crowded streets and inaccessible pedestrian crossings. The final outcome is the relationship of the rating behaviour between the early and late blind. There was a clear separation between the way in which those who were diagnosed with their condition from birth to twelve rated factors in comparison to individuals who were diagnosed from the age of thirteen onwards. The higher rating among the early blind may suggest that this population are more confident travellers resulting from the increased time that they have lived with their condition, providing time and opportunity to develop, test and fine tune a set of coping strategies.

5.5.11. Pavement Features

Participants were asked to rate the features they find problematic, when walking along pavements, with 1 being the most problematic and 5 the least problematic. Table 5.13 presents the average ratings for problematic pavement features. Uneven paving and street furniture obtained the lowest average ratings at 2.02 and 2.04 respectively, indicating that these features are the most problematic for the visually impaired pedestrian when walking along pavements. This was closely followed by unexpected level changes which had an average rating of 2.13. The factors with the highest average ratings were lack of tactile paving, misuse of tactile paving and lack of dropped kerbs, indicating that the absence or misuse of assistive features do not present significant problems to visually impaired pedestrians. This result is important because it indicates that the implementation of assistive features alone will not eradicate the problematic nature of pavements. More basic measures to improve issues such as uneven paving, presence and location of street furniture and unexpected level changes need to be addressed to reduce the problematic nature of pavements.

5.5.11.1. Age Group

The distribution of response averages according to age group is illustrated in Table 5.14. Once again, participants aged 16 – 24 provided higher ratings than any other group, suggesting that the pavement features are not as problematic to them as they are to older age groups. Those aged 55 and over had the lowest average ratings for pavement features indicating that they find these features more problematic than other age groups.

Table 5.13: Problematic pavement feature

Pavement features	1 (%)	2 (%)	3 (%)	4 (%)	5 (%)	Average Rating
Uneven paving	**47.6**	26.5	9.0	10.2	6.6	2.02
Street Furniture	**50.0**	22.0	11.0	8.5	8.5	2.04
Unexpected level changes	**43.0**	26.1	13.3	9.7	7.9	2.13
Varying kerb heights	**27.5**	23.8	18.8	18.1	11.9	2.63
Narrow pavements	**25.5**	24.8	24.2	11.5	13.9	2.64
Type of street lighting	**29.3**	14.6	17.1	9.8	**29.3**	2.95
Type of paving	18.2	**23.0**	20.0	17.6	21.2	3.01
Lack of dropped kerbs	17.5	15.0	22.5	14.4	**30.6**	3.26
Misuse of tactile paving	16.8	14.9	17.4	14.9	**36.0**	3.39
Lack of tactile paving	14.3	14.9	19.3	18.6	**32.9**	3.41

Table 5.14: Average rating according to age group

Age group	16-24	25-34	35-44	45-54	55-64	65+
Average Rating	3.23	3.08	2.73	2.93	2.49	2.54

The pavement features with the lowest average ratings according to the age group of participants are presented in Table 5.15. There does not appear to be a relationship between age and problematic features associated with pavement design. Uneven paving received the lowest rating from both the youngest and oldest age groups (16 – 24, 35 – 44 and 65 +). Street furniture received the lowest ratings from three age groups, (25 – 34, 45 – 54 and 55 –

64) while unexpected level changes was also rated as most problematic for those aged between 16 and 24.

Table 5.15: Most problematic pavement features

Age group	Uneven paving	Street furniture	Unexpected level changes
16-24	✓ (2.73)		✓ (2.73)
25-34		✓ (2.40)	
35-44	✓ (1.97)		
45-54		✓ (1.87)	
55-64		✓ (1.47)	
65+	✓ (1.65)		

5.5.11.2. Type of Vision Loss

Table 5.16 presents the average overall rating awarded for problematic pavement features according to type of vision loss. Individuals with eye conditions involving peripheral and mixed vision loss had the lowest average rating (2.57) suggesting that these groups experienced more problems with pavement features than the other vision loss categories. The group with the highest average rating for pavement features were those with other conditions not involving visual field loss, with an average rating of 3.15, indicating that these features do not present significant problems to them.

Table 5.16: Average rating according to type of vision loss

Type of vision loss	Central loss	Peripheral loss	Mixed loss	Blind	Other
Avg. Rating	2.84	2.57	2.57	3.07	3.15

The most problematic pavement features according to type of vision loss are illustrated in Table 5.17. Uneven paving received the lowest rating among those with central and peripheral vision loss. For individuals with mixed vision loss and other conditions not related to visual field loss, the presence of unexpected level changes received the lowest rating, whereas blind individuals indicate that they experience the most problems with street furniture (see Table 5.17)

Table 5.17: Most problematic features according to type of vision loss

Type of vision loss	Uneven paving	Street furniture	Unexpected level changes
Central loss	✓ (2.03)		
Peripheral loss	✓ (1.50)		
Mixed loss			✓ (1.91)
Blind		✓ (2.05)	
Other			✓ (2.57)

5.5.11.3. Age of Diagnosis

Pavement features received a higher average rating from the early blind group than from the late blind group (Table 5.18), indicating that individuals who were diagnosed with their visual impairment at birth or before the age of twelve (early blind) find pavement features to be less problematic than those who were diagnosed from age thirteen onwards (late blind). This provides further evidence to support the theory that individuals who were diagnosed with their visual impairment at an early stage in life have developed an established set of coping strategies (see Table 5.18).

Table 5.18: Average rating according to age of diagnosis

	Early blind			Late blind			
Age diagnosis	**Birth**	**0-3**	**4-12**	**13-21**	**22- 40**	**41-59**	**60+**
Average Rating	2.92	3.03	3.17	2.82	2.57	2.23	2.66
Overall Average Rating	**3.04**			**2.57**			

Table 5.19 details the most problematic pavement features according to the age of diagnosis. There did not appear to be a relationship between the age of diagnosis and the reporting of problematic pavement features. Five out of the seven age of diagnosis categories rated uneven paving as the most problematic pavement feature, ranging from diagnosis at birth to 60 years and over. Those diagnosed with their visual impairment after the age of 60 also rated street furniture with the same rating as uneven paving. The two remaining categories (0-3 and 22-40) rated street furniture as the most problematic pavement feature.

Table 5.19: Most problematic pavement features according to age of diagnosis

Age of diagnosis	Uneven paving	Street furniture
Birth	✓ (2.07)	
0-3		✓ (2.30)
4-12	✓ (2.53)	
13-21	✓ (1.92)	
22-40		✓ (1.53)
41-59	✓ (1.34)	
60+	✓ (1.94)	✓ (1.94)

5.5.11.4. Mobility Aid

Individuals who use a mobility aid rated pavement features as more problematic than those who travel without an aid, ranging from 2.24 (sighted companion) to 2.92 (no mobility aid), see Table 5.20. The low average rating for the group which use sighted assistance, may be due to the fact that this group may already be less confident independent travellers, hence their reliance and preference for sighted help.

Table 5.20: Average rating according to mobility aid

Mobility Aid	None	Guide dog	Symbol cane	Long cane	Sighted companion	Other
Average Rating	2.92	2.83	2.46	2.90	2.24	2.53

Table 5.21 illustrates the pavement features which were awarded the lowest rating according to the type of mobility aid (if any) used. The majority of those who use a mobility aid rated uneven paving as the most problematic feature; interestingly this was also rated as the most problematic among those who travel without any mobility aid. Individuals who use a long cane or other forms of mobility aid rated street furniture as the most problematic feature. Finally unexpected level changes also received the lowest rating among individuals who use a sighted companion.

Table 5.21: Average rating according to mobility aid

Mobility aid	Uneven paving	Street furniture	Unexpected level changes
None	✓ (2.18)		
Guide dog	✓ (1.89)		
Symbol cane	✓ (1.74)		
Long cane		✓ (1.73)	
Sighted companion	✓ (1.29)		✓ (1.29)
Other		✓ (1.17)	

5.5.11.5. Summary

In summary, the results from this question strongly indicate that the lack of or misuse of assistive features does not create the problematic nature of pavements, but rather it is due to more basic elements such as uneven paving, location and presence of street furniture and unexpected level changes. These results illustrate that the additional implementation of tactile paving and dropped kerbs alone will not eradicate the problems experienced by visually impaired people when walking along pavements.

Once again it was noted that the age of diagnosis influences the way in which visually impaired people perceive problems in the built environment. In particular, results of the early blind group suggest that they find features associated with pavement design less problematic than the late blind group. This distinction may be a result of the development and experience in using coping strategies to navigate independently within the built environment.

5.5.12. Hazardous Items of Street Furniture

Participants were asked to rate each item of street furniture in terms of how hazardous they find them when walking along pavements, scoring each from 1 to 5, with 1 being the most hazardous and 5 the least hazardous. Table 5.22 presents in order from lowest to highest, the average ratings awarded for each type of street furniture. The item of street furniture which received the lowest average rating were bollards (2.28), followed by litter bins, outside dining areas and signage, indicating that visually impaired pedestrians find these items of street furniture to be hazardous. The three items which received the highest average ratings were telephone boxes, trees and railings. The high average rating (3.93) obtained for telephone boxes may be explained due to its increasingly rare presence on our pavements.

Table 5.22: Hazardous nature of street furniture

Items of street furniture	1	2	3	4	5	Average Rating
Bollards	**40.2**	20.1	22.0	6.7	11.0	2.28
Bins	26.1	**27.3**	23.6	11.5	11.5	2.55
Outside dining areas	**27.7**	19.9	24.7	12.0	15.7	2.68
Signage	**28.0**	17.7	27.4	11.0	15.9	2.69
Lampposts	18.9	22.0	**33.5**	12.8	12.8	2.79
Seating	15.9	**25.6**	22.0	18.9	17.7	2.97
Bus stops	11.0	16.5	**27.4**	20.7	24.4	3.31
Railings	9.1	15.2	**32.3**	20.1	23.2	3.33
Trees	13.9	17.0	20.0	20.6	**28.5**	3.33
Telephone boxes	2.4	9.8	23.8	20.7	**43.3**	3.93

5.5.12.1. Age Group

The distribution of response averages according to age group is presented in Table 5.23. It is evident that the younger age groups, (16-24, 25-34) find street furniture less hazardous than the older age groups. However over the age of 35 there did not appear to be a significant relationship between age group and the hazardous nature of items of street furniture. The item of street furniture which received the lowest rating (i.e. most hazardous) according to each age group is presented in Table 5.24. All age group categories rated bollards the most hazardous item of street furniture with the exception of the 60+ age group who rated litter bins the most hazardous, followed closely by bollards.

Table 5.23: Average rating of hazardous items of street furniture according to age group

Age group	16-24	25-34	35-44	45-54	55-64	65+
Average Rating	3.64	3.12	2.90	2.95	2.82	2.90

Table 5.24: Most hazardous items of street furniture according to age group

Age group	Bollards	Bins
16-24	✓ (3.20)	
25-34	✓ (2.35)	
35-44	✓ (2.19)	
45-54	✓ (2.13)	
55-64	✓ (2.03)	
65+		✓ (2.14)

5.5.12.2. Type of Vision Loss

Table 5.25 illustrates the average rating given to items of street furniture according to the type of vision loss. Individuals with eye conditions involving peripheral vision loss experienced the most problems with street furniture when walking along pavements, with an overall rating of 2.75. This was followed by individuals with mixed vision loss (2.84), blind (2.93) and central vision loss (3.17). As expected those with other conditions not involving visual field loss experienced the least problems with street furniture with an average rating of 3.81.

Table 5.25: Average rating according to type of vision loss

Type of vision loss	Central loss	Peripheral loss	Mixed loss	Blind	Other
Average Rating	3.17	2.75	2.84	2.93	3.81

The most problematic types of street furniture according to type of vision loss are illustrated in Table 5.26. The majority of vision loss categories rated bollards as the most problematic feature they encounter when walking along pavements. The one exception came from the blind group who awarded outside dining the lowest rating (see Table 5.26).

Table 5.26: Hazardous items of street furniture according to type of vision loss

Type of vision loss	Bollards	Outside dining
Central loss	✓ (2.68)	
Peripheral loss	✓ (1.91)	
Mixed loss	✓ (2.08)	
Blind		✓ (2.41)
Other	✓ (2.86)	

5.5.12.3. Age Diagnosed

The early blind group once again experienced fewer problems than the late blind group. For individuals who were diagnosed from birth up until the age of twelve, street furniture obtained an overall average rating of 3.21 compared with an average rating of 2.89 for the late blind group (see Table 5.27).

Table 5.27: Average rating according to age of diagnosis

	Early blind			Late blind			
Age diagnosis	Birth	0-3	4-12	13-21	22- 40	41-59	60+
Average Rating	3.15	3.09	3.39	3.12	2.64	2.65	3.14
Overall Average Rating	3.21			2.89			

Table 5.28 details the most problematic items of street furniture according to age of diagnosis. For the early blind groups, bollards received the lowest average rating. The late blind group however differed slightly, with those diagnosed between 13 – 21 experiencing the greatest problems with outside dining while the 60 + group experienced problems with litter bins and signage.

Table 5.28: Average rating according to age of diagnosis

Age of diagnosis	Bollards	Bins	Outside dining	Signage
Birth	✓ (2.14)			
0-3	✓ (2.44)			
4-12	✓ (2.72)			
13-21			✓ (2.31)	
22-40	✓ (1.83)			
41-59	✓ (1.79)			
60+		✓ (2.58)		✓ (2.58)

5.5.12.4. Mobility Aid

Individuals who use a mobility aid rated items of street furniture as more problematic than those who travel without an aid (see Table 5.29). In particular, the lowest overall average rating was obtained for the group who use a long cane (2.75).

Table 5.29: Average rating of hazardous features according to mobility aid

Mobility Aid	None	Guide dog	Symbol cane	Long cane	Sighted companion	Other
Average Rating	3.21	2.90	2.88	2.75	2.90	2.99

Table 5.30 illustrates the items of street furniture which received the lowest average rating according to the type of mobility aid (if any) used. Bollards had the lowest average rating for those who used no mobility aid, a symbol cane, long cane and those who used other forms of mobility aid. Guide dog owners found outside dining areas to be the most hazardous type of street furniture. Those who make use of a sighted companion rated litter bins as the most hazardous item of street furniture (see Table 5.30).

Table 5.30: Most hazardous features according to mobility aid

Mobility aid	Bollards	Litter Bins	Outside dining	Signage
None	✓ (2.48)			
Guide dog			✓ (2.21)	
Symbol cane	✓ (2.17)			
Long cane	✓ (1.93)			
Sighted companion		✓ (2.00)		
Other	✓ (1.83)			✓ (1.83)

5.5.12.5. Colour Blind

The hazard rating of street furniture according to individuals who are affected by colour blindness was also investigated to determine if this had an influence on the hazardous nature of the items. An average rating of 2.93 was obtained for the colour blind group compared with 3.01 for the non-colour blind group, indicating that colour blindness does not have a significant influence on the hazardousness of items of street furniture. Bollards were rated as the most hazardous item of street furniture for both the colour blind and non-colour blind groups.

5.5.12.6. Summary

This investigation into the hazardous nature of items of street furniture has identified that bollards are the most hazardous type of street furniture. It was also noted that individuals affected by peripheral vision loss find street furniture to be more hazardous than other vision loss categories, suggesting that peripheral vision is important for detecting obstacles in the built environment. Again the early blind group perceived street furniture on average to be less hazardous than the late blind group.

5.5.13. Colour

Participants were asked to rate the colours they find the easiest to detect within the built environment. Figure 5.13 presents the percentage of the population sample which selected each colour as being easily identifiable. Participants were able to select as many colours as were applicable. 45% of all participants selected yellow as being easy to identify, followed by red (42.5%) and orange (38.8%). The colours selected by the least number of participants as being easy to identify were silver (8.8%), followed by green (15.6%) and blue (22.5%). These results clearly indicate a preference for bright, vibrant and warm colours.

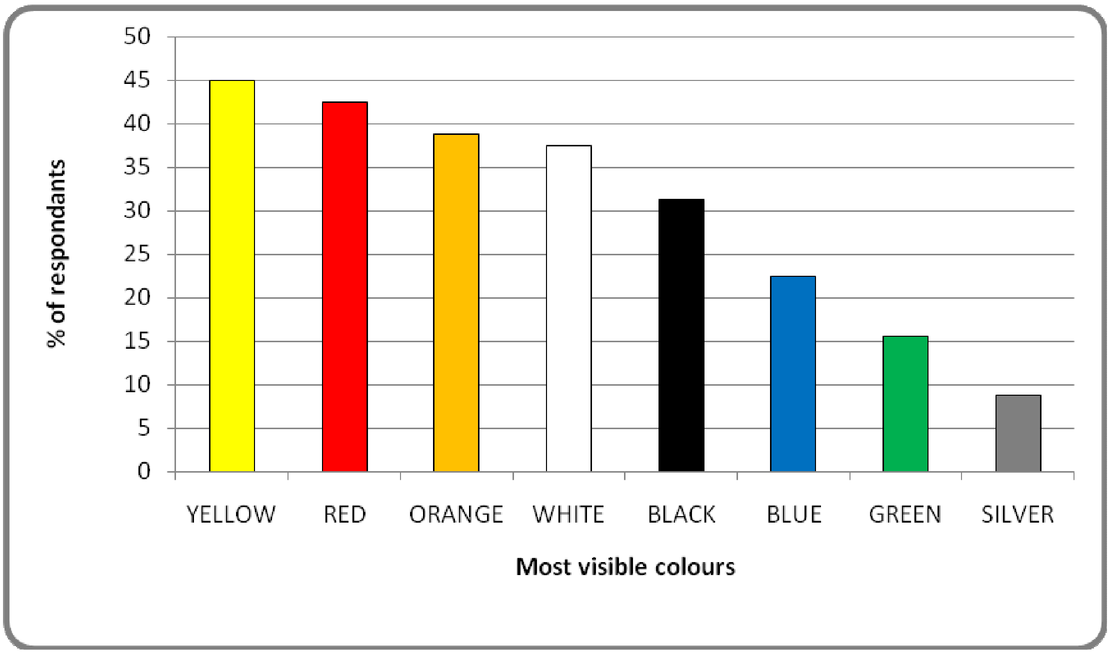


Figure 5.13: Easiest colours to identify within the built environment

5.5.13.1. Type of Vision Loss

Figure 5.14 illustrates the colour spectrums according to type of vision loss ranging from the easiest to the most difficult to identify. General trends show that for all types of vision loss warm, bright and vibrant colours such as yellow, red and orange are preferable to blue, green and silver. Interestingly, the three colours selected as the least visible were the same within each vision loss category. In particular silver was selected as the least easy colour to identify for all types of vision loss including individuals with other conditions not affecting visual field loss, followed by green and then blue.

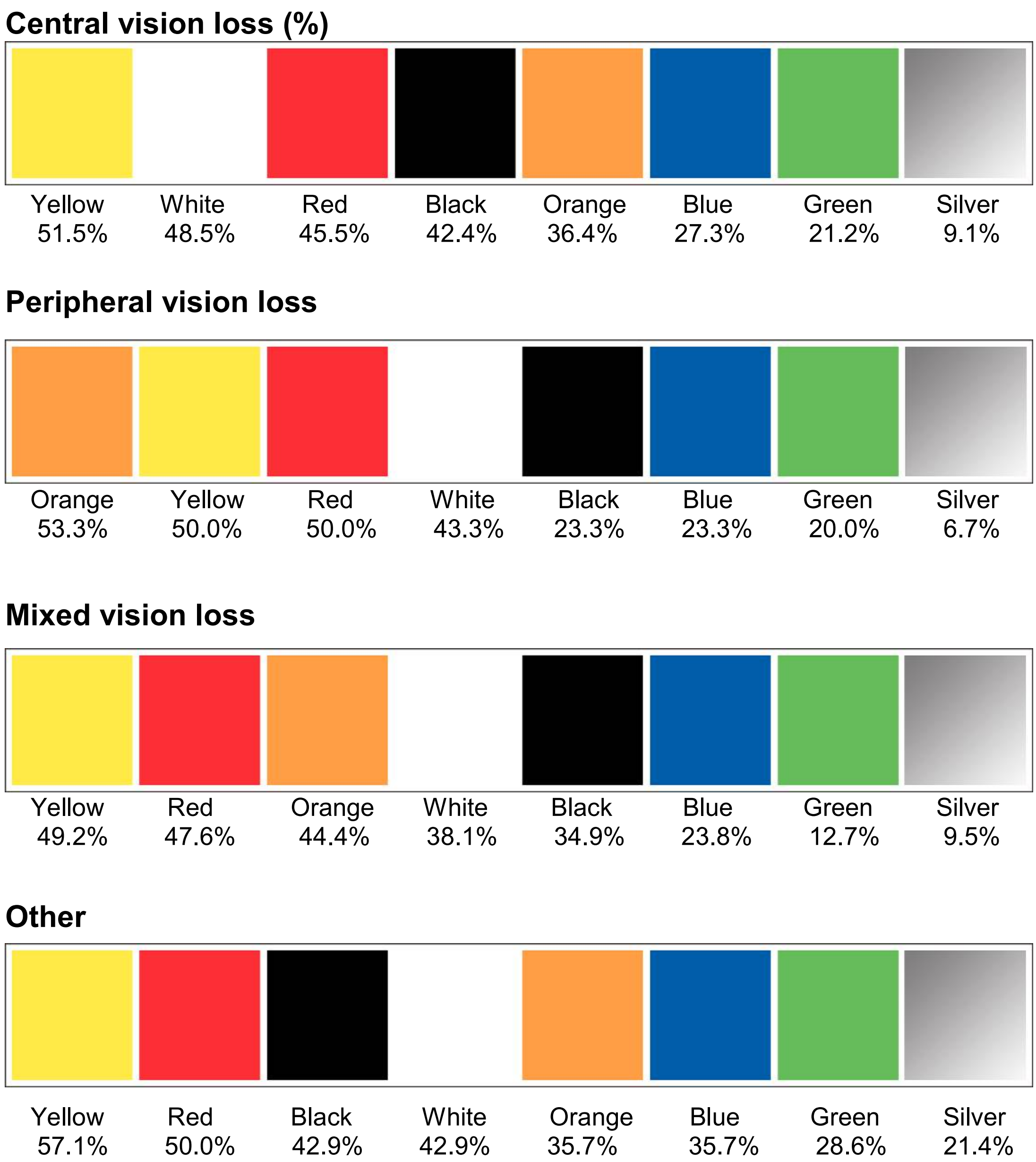


Figure 5.14: Colour spectrums according to type of vision loss

5.5.14. Colour Contrast Combinations

To further investigate the use of colours within the built environment participants were asked a series of questions relating to colour contrast combinations, with specific reference to three common scenarios found within the built environment. This is of particular importance as the visibility of an object depends not only on its surface colour but on adjacent colours and the resulting colour contrast. If used appropriately colour combinations can significantly increase the visibility and improve the detection of objects and elements, thereby reducing the hazardous nature of the built environment.

5.5.14.1. Stair & Edge Strip

In the first scenario participants were asked the two colours they felt best contrasted each other in the scenario of a stair and edge strip. Highly contrasting edge strips (nosings) can be particularly beneficial for visually impaired people in the detection of the edge of steps when negotiating level changes. Each participant was required to select their preferred colour for the stair and their preferred colour for the edge strip. Figure 5.15 illustrates the most popular colour choices for (a) stair and (b) edge strip. There is a clear preference for black stair (49%) and yellow edge strip (40%).

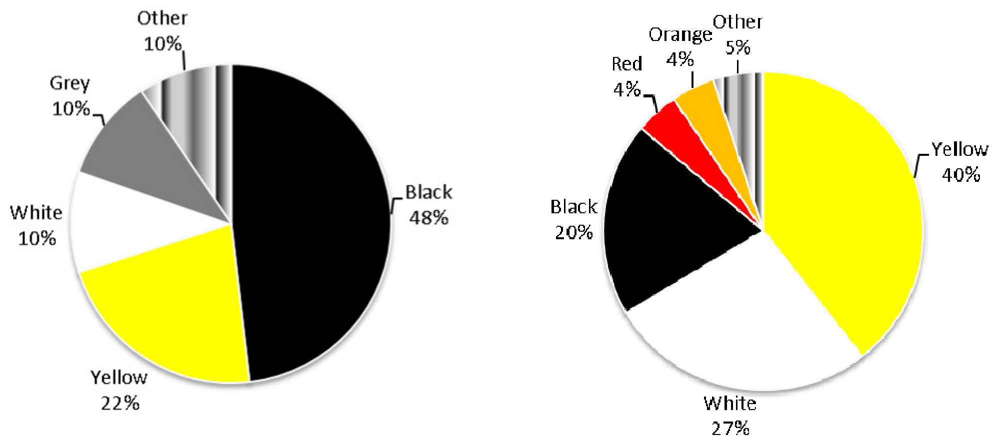


Figure 5.15: Preferred colour choices for (a) stair and (b) edge strip

Figure 5.16 illustrates the preferred stair colour shown along the x axis, in conjunction with its relevant edge strip preference indicated by the key. 24.8% of all respondents selected a black stair with a yellow edge strip as their preferred colour combination for this scenario. This was followed by a black stair with a white edge strip which was selected by 20.4% of respondents. The choice of a yellow stair with a black edge strip was selected by 10.4% of respondents. All of which provide highly contrasting combinations.

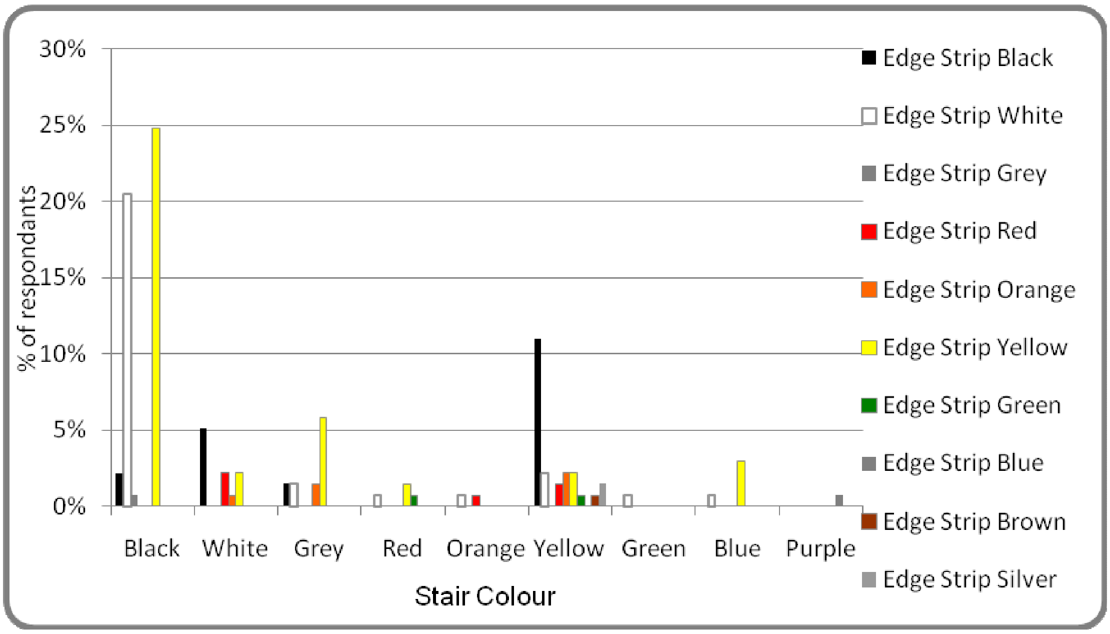


Figure 5.16: Preferred colour combinations for stair and edge strip scenario

Table 5.31 illustrates the top five colour combination ratings for stair and edge strip selected by each vision loss group. Two combinations were favoured by all four groups. Individuals with central vision loss (24.5%) and mixed vision loss (31%) preferred a black stair with yellow edge strip whereas individuals with peripheral vision loss (27.6%) and other conditions not affecting visual field loss (23.1%) preferred a black stair with white edge strip. Lower percentages were awarded to the following three combinations It is interesting to note that no one from the peripheral vision loss group selected a white stair with black edge strip, which perhaps indicates that this is not a preferable colour contrast combination when trying to accommodate the needs of all visually impaired users.

Table 5.31: Stair-edge strip combinations according to vision loss category

Colour Combination	Central loss	Peripheral loss	Mixed loss	Other
Black stair – Yellow edge strip	**34.5**	13.8	**31.0**	15.4
Black stair – white edge strip	10.3	**27.6**	24.1	**23.1**
Yellow stair- black edge strip	13.8	13.8	10.3	7.7
White stair – black edge strip	10.3	0.0	3.4	7.7
Grey stair – yellow edge strip	10.3	13.8	1.7	0.0

5.5.14.2. Pavement & Bollard

In the second scenario participants were asked the two colours which they felt best contrast each other in the scenario of a pavement and bollard. Each participant was required to select their preferred colour for the pavement and their preferred colour for the bollard. Figure 5.17 illustrates the most popular colour choices for (a) pavement and (b) bollard. There is a clear preference for either a grey or black pavement with both receiving 34%. The top three preferred colour choices for bollards, all receiving over 20% were yellow (28%), white (23%) and black (21%). Figure 5.18 illustrates the preferred pavement colour shown along the x axis, in conjunction with the preferred bollard colour which is indicated by colour coded key. 26% of all respondents selected a black pavement with either a yellow or white bollard as their preferred colour combination for this scenario. This was followed by a grey pavement with a yellow bollard which was selected by 7.6% of respondents. The following five combinations all received the same rating of 5.3%: a grey pavement with either white, black, red or orange bollard; or a yellow pavement with black bollard. All other combinations were lower than 4%.

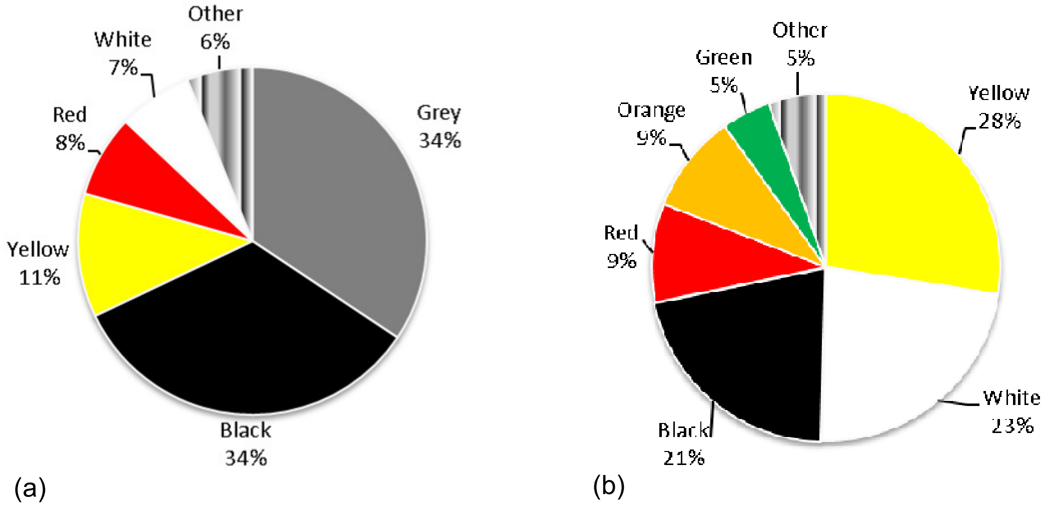


Figure 5.17: Preferred colour choice for (a) pavement and (b) bollard

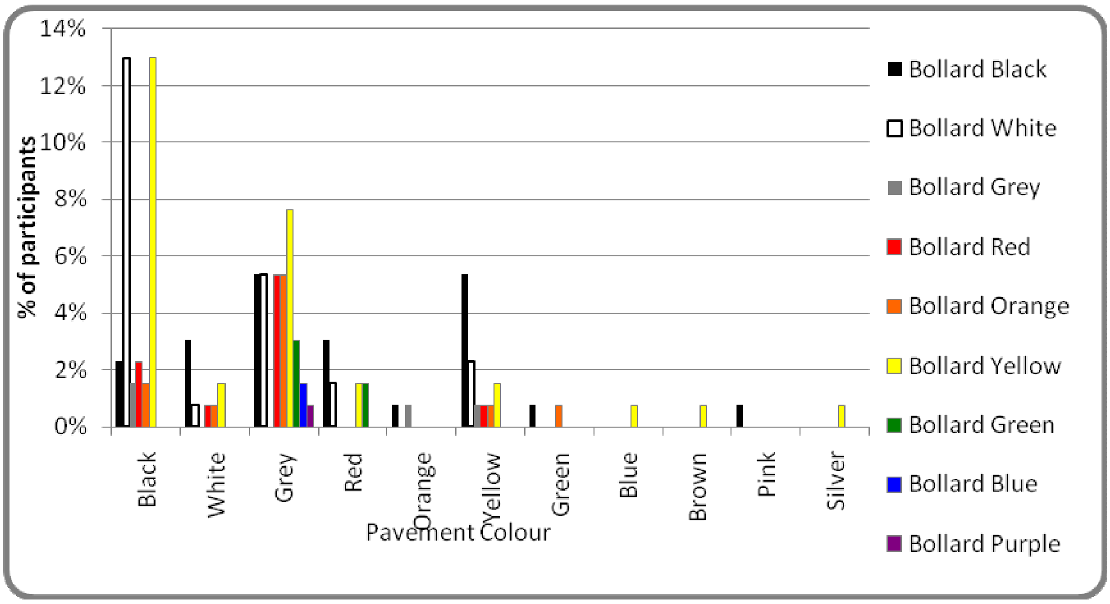


Figure 5.18: Preferred colour combinations for pavement and bollard scenario

Table 5.32 details the top three colour combinations for pavement and bollard as selected by each vision loss group. As was the case with stair and edge strip, two combinations were favoured by all four groups. Individuals with central vision loss (14.8%) and mixed vision loss (31%) preferred a black pavement with yellow bollard whereas individuals with peripheral vision loss (27.6%) and other conditions not affecting visual field loss (23.1%) preferred a black pavement with white bollard. It is interesting to note that the colour combinations selected by each vision loss group concur with those selected in the scenario of stair and edge strip.

Table 5.32: Pavement and bollard colour combinations according to type of vision loss

Colour Combination	Central loss	Peripheral loss	Mixed loss	Other
Black pavement – Yellow bollard	**14.8**	13.8	**31.0**	15.4
Black pavement – White bollard	11.1	**27.6**	24.1	**23.1**
Grey pavement – yellow bollard	7.4	13.8	1.7	0.0

5.5.14.3. Pavement, Kerb & Road

In the third scenario participants were asked the three colours which they feel best contrast each other in the scenario of pavement, kerb and road. Figure 5.19 illustrates the most popular colour choices for (a) pavement, (b) kerb and (c) road. The preferred colour choice for pavement was grey with an overall percentage of 40% followed by black (28%). In terms of the kerb, yellow and white were selected as the most popular colour choices with 38% and 33% respectively, to contrast with a black road which received a majority rating of 59%. This shows that there is a clear preference for the kerb to contrast with the pavement and the road, in order to indicate the edge of the pavement, the location of the level change and the presence of moving vehicles beyond this point.

Table 5.33 illustrates the top three colour contrast preferences for pavement, kerb and road. In all three circumstances black was the preferred option for the road. The most popular colour combination was a grey pavement with a yellow kerb, followed by a grey pavement with a white kerb, and a black pavement with a white kerb.

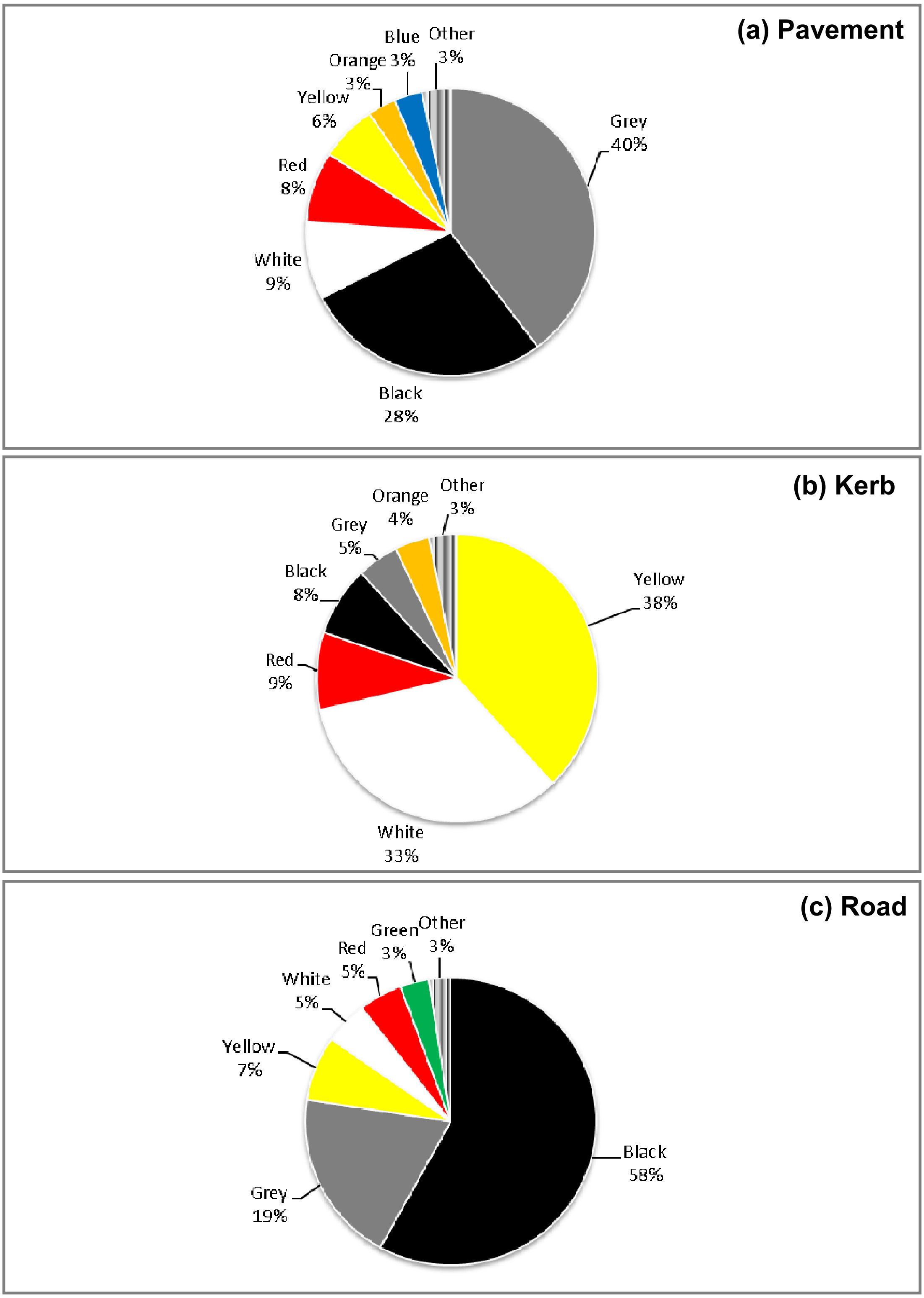


Figure 5.19: Preferred colour choice for (a) Pavement, (b) Kerb and (c) Road, as a percentage of total respondents

Table 5.34 illustrates colour combinations selected for pavement, kerb and road according to type of vision loss group. All vision loss groups selected grey as their preferred pavement colour with the addition of black for those with other conditions not affecting visual field loss. The preferred kerb colour was selected as white for those with central vision loss and other conditions and yellow for those with peripheral vision loss and mixed vision loss. Black was selected by all groups as the preferable road colour.

Table 5.33: Top 3 colour combinations for pavement, kerb and road colour

Pavement	Kerb	Road	% of total respondents
Grey	Yellow	Black	11.1
Grey	White	Black	9.5
Black	White	Black	7.1

Table 5.34: Top colour combinations selected according to type of vision loss

Type of Vision Loss	Pavement	Kerb	Road	% of vision loss group
Central	Grey	White	Black	12.0
Peripheral	Grey	Yellow	Black	17.2
Mixed	Grey	Yellow	Black	11.8
Other	Black / Grey	White	Black	15.4

5.5.15. Daylight and Weather

When participants were asked if the nature of their eye condition meant that they find it more difficult to travel at certain times of the day due to levels of natural light 74.6% of respondents said yes. The majority (76.2%) stated that night time was the most difficult period of the day to travel, followed by dusk (56.3%), evening (40.5%), dawn (19.8%), afternoon (16.7%) and morning (14.3%) (see Figure 5.20). It is important to note that only 1.6% of respondents stated that they have no preference over time of day at which to travel due to levels of natural light. This indicates that for the vast majority, the time of day has an influence on their travel behaviour. In particular, as the day progresses and levels of natural light decrease, visually impaired people find it more difficult to travel.

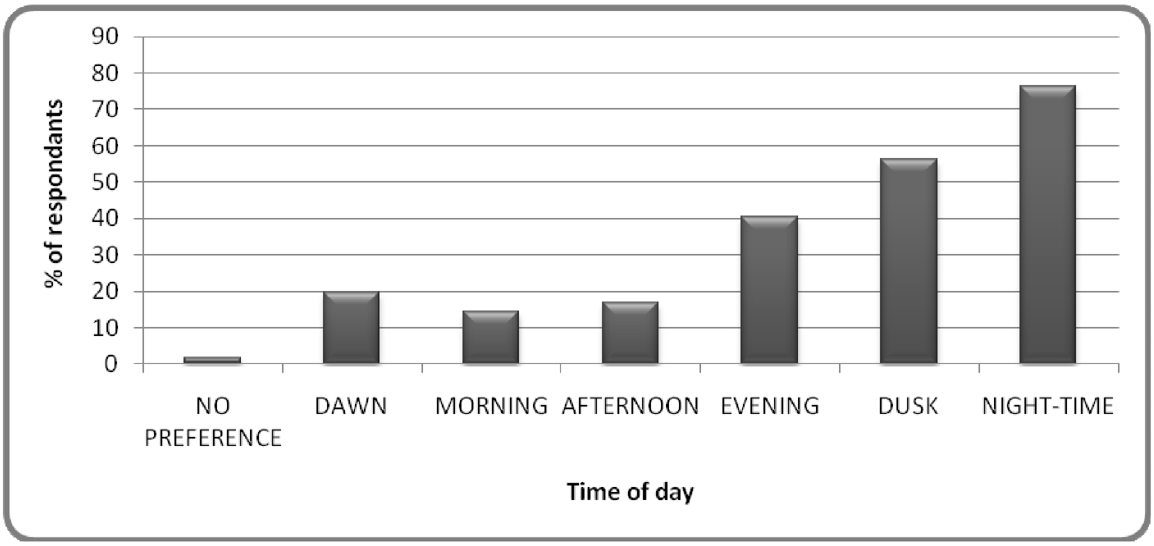


Figure 5.20: Time of day at which it is most difficult to travel due to levels of natural light

5.5.15.1. Type of Vision Loss

With respect to the type of vision loss, it was found that the majority of individuals in the blind group were not affected by levels of natural light (95.5%), this is in strong contrast to the peripheral vision loss group and mixed vision loss groups of which 96.9% and 90.9% reported being affected by levels of natural light, respectively. A high proportion of the central vision loss group also reported being affected by levels of natural light (74.3%). Table 5.35 presents the percentage of each vision loss group who are affected by levels of natural light.

Table 5.35: Percentage of each vision loss category affected by levels of natural light

Type of Vision Loss	Yes (%)	No (%)
Central	74.3	25.7
Peripheral	96.9	3.1
Mixed	90.9	9.1
Blind	4.5	95.5
Other	57.1	42.9

Night time was selected as the most difficult time of day to travel by all types of vision loss categories. 83.9% of those with peripheral vision loss reported night-time as being one of the most difficult times of day to travel. Similarly 81.7% of those with mixed vision loss found travelling at night time difficult, followed by central vision loss (61.5%) and other (50.0%). The high percentage reported by the peripheral vision loss group may be explained by the nature of their vision loss which often results in tunnel vision, a small area of useful vision surrounded by darkness, which without sufficient lighting levels renders the individual night blind.

5.5.15.2. Weather Conditions

When participants were asked if the nature of their eye condition meant that they find it more difficult to travel under certain weather conditions 71% of respondents said yes. 66.4% of all respondents reported that it was difficult to travel under bright and wet weather conditions due to glare and the resulting appearance of the ground material. This was closely followed by bright and dry conditions (55.7%) and snow (52.5%) (Figure 5.21).

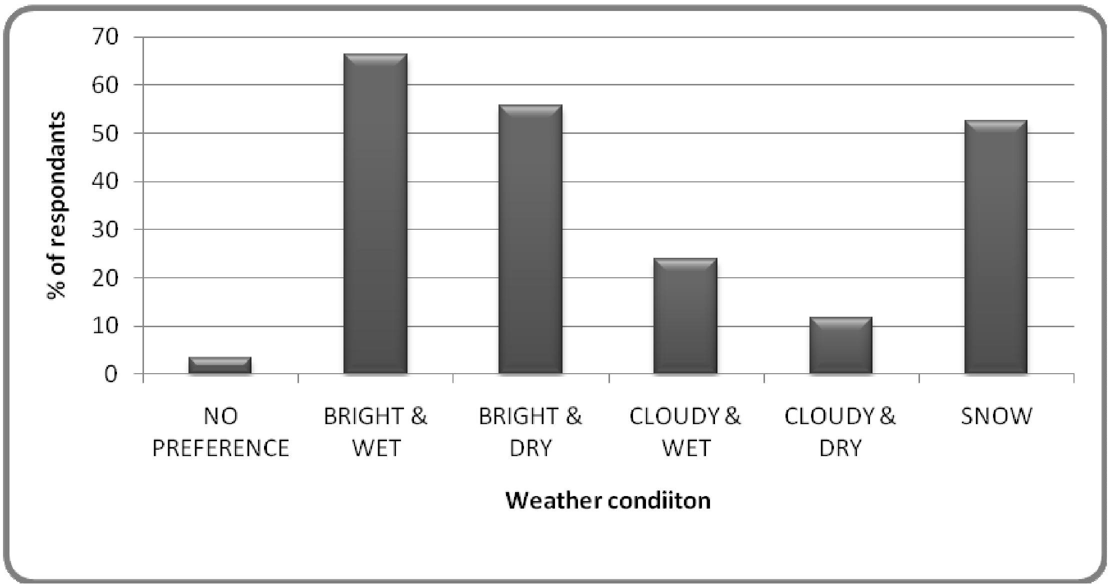


Figure 5.21: Weather condition under which it is difficult to travel

5.5.15.3. Type of Vision Loss

Individuals who have visual field loss but still have some useful remaining vision experience the greatest problems with weather conditions due to the effects these factors may have on the appearance of the ground for example: glare, reflections and shadows (see Table 5.36). As perhaps expected individuals with other types of visual impairment not related to visual field loss reported fewer problems resulting from weather conditions (50.0%) and only 36.4% of those who are blind reported difficulty travelling due to weather conditions.

Individuals who are affected by central, peripheral or mixed vision loss experience the greatest problems under bright and wet weather conditions, due to the effect that these conditions can have on the appearance of the ground, introducing glare, reflections and shadows on the ground surface.

Table 5.36: Percentage of each vision loss group who experience problems when travelling under certain weather conditions

Type of Vision Loss	Yes (%)	No (%)
Central	77.1	22.9
Peripheral	78.1	21.9
Mixed	80.3	19.7
Blind	36.4	63.6
Other	50.0	50.0

Table 5.37: Most problematic weather conditions according to type of vision loss

Weather Condition	Central (%)	Peripheral (%)	Mixed (%)	Blind (%)	Other (%)
Bright and wet	✓ (66.7)	✓ (70.8)	✓ (77.4)		
Bright and dry	✓ (66.7)				✓ (85.7)
Snow				✓ (50.0)	

5.6. Conclusion

The principle aim of the survey was to determine the main problems which visually impaired pedestrians encounter when navigating within the built environment. As such, a questionnaire was conducted on a national scale involving 212 participants of varying age, types of vision loss and age of diagnosis. The main topics of investigation were related to: (i) independent travel behaviour, (ii) the wish for more independent travel, (iii) psychological and physical barriers preventing independent travel, (iv) problematic pavement features, (v) hazardous items of street furniture, (vi) colour and contrast combinations and (vii) daylight and weather conditions.

A key finding of the survey revealed that almost one third of all respondents made no independent journeys to their nearest town or city centre. Over 60% of the respondents were accompanied with a sighted companion on visits; however this was limited to 1 or 2 visits per week, with a very small percentage being accompanied on a more frequent basis. There was found to be a high demand to make more independent journeys, with over half of all respondents expressing the desire to increase their independent travel behaviour. These findings clearly indicate that there are factors preventing visually impaired people from making independent journeys within or to their nearest town or city centre. Furthermore a large percentage of respondents cited shopping as the main reason for travelling to their nearest town or city centre, which emphasises the need to make services accessible within urban environments.

An investigation into the factors responsible for preventing independent travel demonstrates that visually impaired people are less disabled by personal factors such as fear, stress and level of confidence and are more disabled by the design and physical influence of features within the built environment. The survey results also highlight that physical elements are more of a deterrent to independent travel than a lack of spatial understanding of the area.

With regards to physical pavement features it may perhaps be perceived that the lack or misuse of features implemented to assist navigation within the built environment, such as tactile paving and dropped kerbs would cause the most problems for visually impaired pedestrians. However, on the contrary more fundamental aspects such as uneven paving, location and presence of street furniture and unexpected level changes were highlighted to be the most problematic by visually impaired pedestrians. The rating of uneven paving as the most problematic pavement feature highlights the importance of conducting regular maintenance within the urban landscape. The hazardous nature of items of street furniture was also investigated. Bollards received the lowest overall average rating, followed by litter bins, outside dining areas and signage, including road signs and A-boards.

With respect to colour and contrast combinations within the built environment, the survey responses show a general trend favouring the visibility of warm, bright, vibrant colours and also establish silver as the most difficult colour to identify. The three least visible colours (silver, green and blue) were identical for each visual field loss category. This result is significant as it could provide guidance on colour choices that can improve the visibility of features within the built environment for all types of visual field loss. There was general agreement among all vision loss categories as to the most suitable colour contrast combinations for use in the three scenarios of: (i) stair and edge strip, (ii) pavement and bollard and (iii) pavement, kerb and road. The four main colours to be used were black or grey in combination with yellow or white in any of these scenarios.

It was found that lighting levels also have an influence on the time of day at which it is preferable to travel. Night time was established as the most difficult period of the day to travel. This finding may be due to a number of factors including a fear of personal safety and inadequate night time lighting conditions, for which further investigation is necessary. The type of weather condition under which participants found it most difficult to travel due to glare and the resulting appearance of the ground and objects was during bright and wet conditions. This suggests that further investigation is also required in order to better understand the way in which materials react under natural and artificial lighting during both wet and dry conditions.

It was evident in the analysis of the survey results that age was an important influence on the responses of participants. In particular, the 16-24 age group made more independent journeys than any other group and also expressed the least wish to make more independent trips. Throughout the survey, the younger age groups rated factors and features as less influential, problematic and hazardous then the older age groups. This indicates the confident nature of the younger traveller compared to their older counterpart. Furthermore it may suggest that other factors affect the navigational behaviour of the older age groups e.g. health related conditions other than vision loss.

Many similarities were found in the responses given by the different visual field loss groups throughout the survey. In particular the type of vision loss did not have a significant influence on the number of independent journeys made or whether individuals travelled with the assistance of a sighted companion. In terms of the wish to make more independent trips, notably the blind group expressed a greater desire, although among the other vision loss categories there was little difference in demand. The type of visual field loss also does not have a significant influence on the psychological and physical factors affecting independent travel. However with respect to physical pavement features and items of street furniture, the peripheral and mixed vision loss categories rated features and items more problematic and hazardous than the other visual field loss groups. All of the groups except for the blind category rated bollards as the most hazardous item of street furniture. Interestingly individuals with other conditions not affecting visual field loss tend to perceive their environment to be less disabling than those affected by visual field loss and blindness. Perhaps most remarkable is the similarity between the vision loss categories for the least visible colours, where silver, green and blue were selected in that order as the least visible colours for each category. These findings suggest that a common design solution accommodating the needs of all types of vision loss is possible particularly with respect to colours used in the built environment.

There were clear distinctions in the survey responses between individuals diagnosed before the age of 12 (early blind) and individuals diagnosed from the age of 13 onwards (late blind). In particular, it was evident that the early blind made on average more independent visits than the late blind group. The independent nature of the early blind group was further highlighted by the noticeable difference in demand for more independent travel, with the later blind group expressing a greater wish to make more independent trips. Through all stages of the questionnaire it was found that individuals in the early blind category rated factors and features as less influential, problematic and hazardous than those in the late blind group. This leads to the conclusion that this population are more confident independent travellers, which may result from having more experience living in a world with low vision and from the development of coping strategies in order to navigate more efficiently within the built environment.

Finally, there was found to be a link between the responses of individuals who use a mobility aid and those who do not. In particular, those who use a mobility aid rated factors and features as more influential, problematic and hazardous than individuals who travel without the use of an aid. This could perhaps be explained by a higher degree of vision loss in individuals who prefer to travel with a mobility aid. Alternatively it may be due to the aid alerting them to the many obstacles while navigating in the built environment.

These results are of significant importance as they indicate that the use of a mobility aid alone does not eliminate the hazardous nature of the built environment as it is perceived by the visually impaired pedestrian.

The final outcome of the survey was the recruitment of fifteen blind and visually impaired individuals to take part in a walking task, within Glasgow city centre. In order to assess the current state of accessibility and barriers present within Glasgow, a sample access audit was conducted of a typical area of the city prior to commencing the navigational experiments, details of which are presented in Chapter 6.

Chapter 6: The Disabling Nature of the City – An Access Audit

6.1. Introduction

The access audit forms stage two of the research and extends on the many themes explored within the survey presented in Chapter 5. After gaining an understanding of the design features which pose a hazard to visually impaired pedestrians, the next stage of the research involves quantifying the number and type of such hazards present within a typical built environment, in order to assess the overall accessibility and further highlight the disabling nature of everyday spaces for persons with a visual impairment. Throughout all stages of the access audit reference has been made, where applicable to Scottish Building Regulations (Section 2.4.2), British Standards, BS: 8300 (Section 2.4.3), Inclusive Mobility (Section 2.4.4) and Guidance for the use of tactile paving (Section 2.4.5).

The process of categorisation and assessment of typical hazardous features within the built environment was informed by both personal experience and the canvassed views of other visually impaired users. Information extrapolated from the survey in Chapter 5 was supplemented through the formation of a focus group consisting of visually impaired users of the city with varying types and degree of vision loss. This allowed users to expand on and provide additional information regarding problematic features identified within the survey. The areas of investigation are categorised into three main sections, focusing on (i) pavement condition, (ii) street furniture and (iii) pedestrian crossings. The methods used in order to record specific features are detailed throughout this chapter, with enabling and disabling features illustrated through the use of photography or annotated diagrams.

The findings from the access audit will assist in the creation of a strategy for a hazard rating system, by which each street is assigned a percentage rating, indicating overall accessibility for the visually impaired pedestrian (see Chapter 8 for full details). Prior to detailing the access audit, it is first important to investigate the current policy and design guidelines in place to assist designers when planning streets and urban spaces within town and city centres, as this may provide an insight into the reasons behind why our public spaces are perceived by the visually impaired population to be so hazardous.

6.2. Urban Management

The responsibility for the overall management of pavements, streets and roads is dependent on a number of factors including the location of the road and the type of road. In the UK, roads are assigned one of two categories; trunk roads and non trunk roads. A trunk road is a nationally important route that predominantly takes the form of a dual carriageway or motorway; they are managed and maintained by the national highways authority of each devolved government within the UK. All other non trunk roads including local, urban and residential roads are maintained by city or county / regional councils within each local authority area.

Guidance documents in place to assist local authorities in the design and management of streets, pavements and roads have for many years predominantly focused their attention on the motorist with little reference to the needs of non road users. This is clearly evident in governmental documents such as ‘Design Bulletin 32’ (Noble *et al.*, 1992) providing design guidance for residential roads and the ‘Design Manual for Roads and Bridges’ (Highways Agency, 1994) providing design guidance for strategic trunk roads. This has resulted in a hierarchical system whereby the vehicle has been allowed to dominate the street to the disadvantage of other users (CABE *et al.*, 2002). This situation not only leads to considerable confusion with regards to the rights of pedestrians and cyclists but also creates an environment whereby other users of the street, particularly the disabled, feel vulnerable on a daily basis (CABE *et al.*, 2002). In order to readdress this situation, it has been suggested that the Highway Code should be rewritten to place greater emphasis on the multiple functions of streets leading to an environment that benefits all users and not just motorists (CABE *et al.*, 2002).

It was not until the late 1990s that the first noticeable emphasis was placed on equalling the balance between motorists and pedestrians, therefore taking into account the needs of other street users. This change came in the form of guidance documents such as 'Places, Streets and Movements' (DETR & Baxter, 1998), 'Paving the way' (CABE *et al.*, 2002) and 'Inclusive Mobility' (Dept. for Transport, 2005a). In 2007 a new guidance document for England and Wales was introduced entitled 'Manual for streets' (Dept. for Transport, 2007). This document supersedes 'Design bulletin 32' (Noble *et al.*, 1992) and companion document 'Places, Streets and Movement' (DETR & Baxter, 1998). The document focuses on the design of 'lightly trafficked' residential streets and places a strong emphasis on prioritising the needs of pedestrians and cyclists to ensure that all user groups are considered at an early stage of the design process. A similar guidance document to be entitled 'Designing Streets,' is currently being prepared by the Scottish Government and is due for publication in 2010. It should however be noted that to date only limited guidelines exist for the design of urban local roads; with the result being that inappropriate published trunk road standards are often implemented by local authorities when designing inner urban streets within town and city centres (CABE *et al.*, 2002). Furthermore, the lack of guidance available to local authorities when designing urban streets may result in a confusing distribution of responsibilities either between different local authorities or among different departments within the same authority. This often corresponds to a non coherent design and management strategy when maintaining streets, pavements and roads, ultimately placing the pedestrian at a disadvantage (CABE *et al.*, 2002).

Another aspect to consider is the role in which utility companies have in shaping the layout and appearance of streets (CABE *et al.*, 2002). Since the deregulation of the telecommunications industry in 1987, there have been a growing number of competing companies using space above and below public roads and pavements to locate pipelines and telecommunication systems. This not only places extreme demands on many urban streets, but also results in an environment inherent with features located above the ground to connect with underground services (such as service boxes). Furthermore, the appearance of the ground can change considerably after an installation of services has been undertaken. It is often the case that once the installation of equipment has taken place; the original paving is not reinstated, resulting in a streetscape with a patchwork appearance and missing paving. By conducting an access audit of a complex city centre environment it will be possible to highlight the main areas of concern with regards to the design and management of local urban streets.

6.3. Access Audits

An access audit is essentially an assessment of the accessibility of an environment (Grant *et al.*, 2005). The assessment generally investigates the usability of a space in order to determine its suitability for accommodating the needs of as many user groups as possible. The increase in access audits over recent years has primarily been as a consequence of the introduction of the Disability Discrimination Act 1995 (DDA, 1995). The code of practice for Part 3 of the act outlines the benefits of conducting an access audit in order to identify the presence of potential barriers to access and subsequently undertake suitable adjustments in order to eliminate as far as is reasonably possible, disabling features within the built environment. As mentioned in Chapter 2, the DDA does not provide specific design criteria or dimensional guidance with regards to physical features and it is therefore the responsibility of the service provider to implement reasonable adjustments on a case by case basis where areas of concern are highlighted.

An access audit generally consists of four main tasks: (i) Briefing/data gathering, (ii) Site survey, (iii) Consultation and (iv) Preparation of a written report (Grant *et al.*, 2005). It is important to note that an access audit only records the accessibility of an environment at a particular moment in time and can quickly become outdated, especially in external environments, as a result of maintenance, alteration and modernisation works taking place. The definition of an access audit given by the Centre for Accessible Environments describes the process as a means of:

> "examining the accessibility of services and facilities, identifying where physical barriers may compromise access to services by assessing the feature against predetermined criteria and measuring the 'usability' of facilities within a building and the services being delivered in it"
>
> (Grant *et al.*, 2005, p. 2)

It is important to note that this definition makes exclusive reference to the usability of facilities within a building and fails to mention the accessibility of external environments. There is also a lack of realisation and acknowledgment with regards to the role that streets, footpaths and pedestrian precincts play within a person's daily life. It is argued in this thesis that a street should be recognised as a facility, which people use in order to navigate within a town or city, allowing pedestrians to access goods, facilities and services and as such should also be covered under Part 3 of the DDA (1995). Often guidance concentrates on access into and out of buildings rather than access between buildings in a more general sense, such as Building Regulations (SBSA, 2009) and British Standards (BSI, 2009). This could be the case due to the complex nature of managing communal public spaces, as outlined in section 6.2. The Access Audit Handbook does however provide some limited guidance for carrying out an access audit in an external environment, with specific reference and checklists focusing on the areas of street furniture, ramps, steps, handrails, and routes into and out of buildings (Grant *et al.*, 2005). This guidance, as well as information from the survey and feedback from the focus group, was used as a basis for developing the methodology and criteria for the access audit.

6.4. Study Area

It was important to select a study area which is inhabited and used by a large number of disabled individuals and more specifically for this research, visually impaired individuals. Glasgow, the largest city in Scotland, with a population of 584,240 (GRO, 2003), has the largest number of disabled residents of any town or city in Scotland. It is estimated that over 26% of Glasgow residents have a disability or long term limiting illness (ScotPHO, 2010).

Glasgow also has the largest visually impaired population of any local authority in Scotland with a total of 6,362, of which 2,374 are registered as sight impaired and 3,988 registered as severely sight impaired (ONS, 2009). This figure suggests that 10.9 out of every 1,000 residents of Glasgow are visually impaired (ONS, 2009). However as registration is a voluntary process, it is believed that only between one quarter and one third of the visually impaired population are actually registered (Bruce *et al.*, 1991). If it is assumed that only one third of Glasgow residents are registered, there may be as many as 19,086 visually impaired residents of the city which equates to a substantially increased value of 33 residents per every 1,000 living with a visual impairment in Glasgow.

Glasgow attracts over three million tourists every year (Glasgow City Council, 2008) and is the second largest retail city in the UK outside of London West End (Javelin Group, 2009, p. 8). The city is served by numerous transportation hubs, linking Glasgow on both a national and international scale. On a local level, the city is equipped with an extensive suburban rail network linking Glasgow to the surrounding eleven local authorities with a fast and frequent commuter service.

The regional transportation network is utilised by a large number of people from surrounding local authorities in order to travel into the city centre for business, work, education, leisure and entertainment. If population statistics from the eleven surrounding authorities are included, the number of visually impaired people who may make use of the facilities and services within Glasgow on a frequent basis is 18,548, as is detailed in Table 6.1 (National Statistics, 2009).

Again assuming that only one third of visually impaired people are registered, there may actually be as many as 75 000 visually impaired individuals potentially making use of the facilities within Glasgow.

Table 6.1: Total registered and estimated total visually impaired population in local authorities surrounding Glasgow city covered by SPT train network (National Statistics, 2009)

Local Authority	VI Pop	Local Authority	VI Pop
Glasgow City Council	6,362	Argyle and Bute	927
North Lanarkshire	2,836	East Ayrshire	698
South Lanarkshire	2,233	East Renfrewshire	631
North Ayrshire	1,205	West Dumbartonshire	569
Renfrewshire	1,106	Inverclyde	539
South Ayrshire	981	East Dumbartonshire	461
Total Registered	**18 548**		
Estimated Total	**75 000**		

Having selected Glasgow as the city in which the study would take place, it was necessary to identify a specific area which contains a large variety of land use types, a broad range of amenities, facilities and services and a varied selection of pedestrian and vehicular routes. Taking all these factors into account it was decided that the Merchant City quarter and the adjacent city centre of Glasgow would fulfil all of these requirements. The selected area is bound by Cathedral Street to the north, High Street to the east, Argyle street to the south and Buchanan Street to the west (see Figure 6.1 and 6.2). The area is located within the grid pattern of the city and includes several major transportation hubs, a University campus, two public squares, pedestrian shopping streets, shared space zones and numerous intersections with busy roads. The city centre and Merchant City are currently undergoing a process of modern aesthetic alterations. This work includes the replacement of older paving and kerb edges, the installation of new street furniture, including bollards, bins, bike racks, seating and new lighting, and the installation of accessible pedestrian crossings. By selecting a complex urban environment as the location for the access audit it is possible to assess all of the features highlighted in the survey as well as introducing new elements associated with a typical city centre environment, such as public squares, pedestrian precincts and shared space zones.

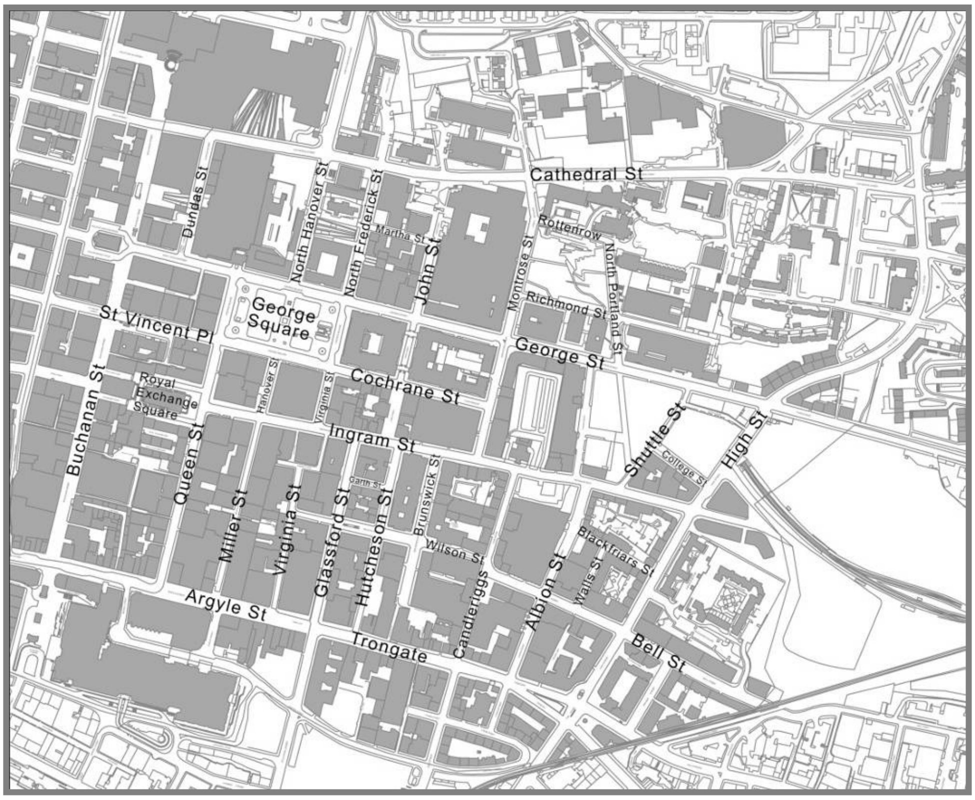


Figure 6.1: Study Area with street names

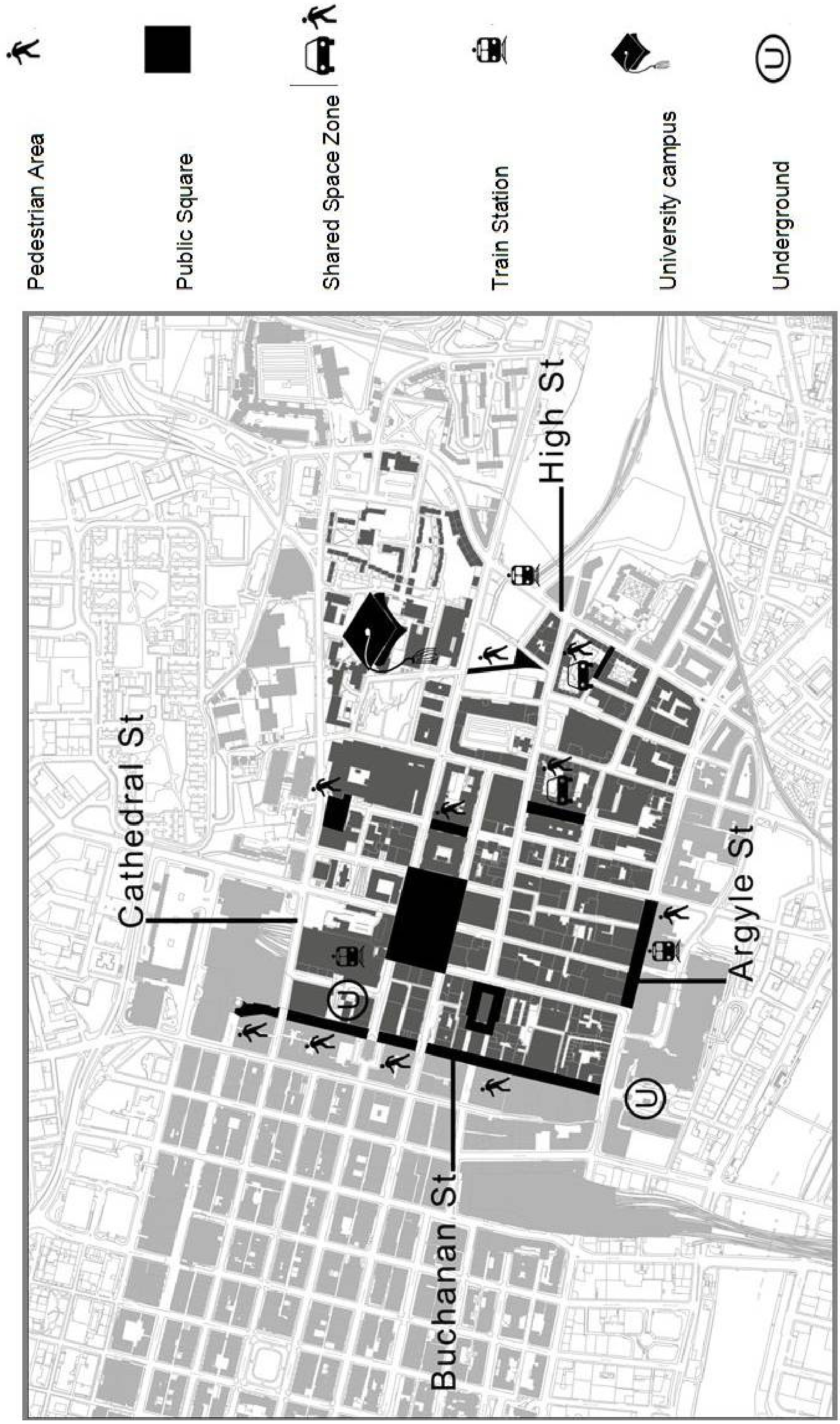


Figure 6.2: Annotated diagram of study area

6.5. Methodology

The access audit was conducted over a six month period between October 2007 and March 2008. The audit was later updated in May 2009 in order to take into account the dynamic nature of the external built environment. During this process a reassessment of the provision of controlled pedestrian crossing points was conducted in order to include the upgrading of controlled crossing points within the boundary of the city centre. The access audit consisted of a data gathering exercise which was carried out by assessing individual streets within the study area. A total number of 35 streets and 2 squares were included within the access audit. Items to be audited were selected through the results from the survey as well as continued informal dialogue with visually impaired users of the city affected by varying types and degree of vision loss. The user-orientated approach provided additional comments and feedback on the hazardous nature of identified items in order to establish key areas of concern. The area of investigation focused on three principle design features relating to (i) pavement characteristics, such as paving type, overall condition, kerb height and pavement width, (ii) the design, visibility and zoning of street furniture and (iii) accessibility and location of pedestrian crossings. These features were observed and documented on site using a blank A3 sized map of each individual street and later transferred to an electronic spreadsheet for preservation and processing. An example of an annotated street map is provided in Figure 6.3, furthermore a full set of data sheets and annotated street maps can be sourced in Appendix B. Additional equipment used in order to gather data included a digital camera, site maps, a tape measure and a digital tape recorder.

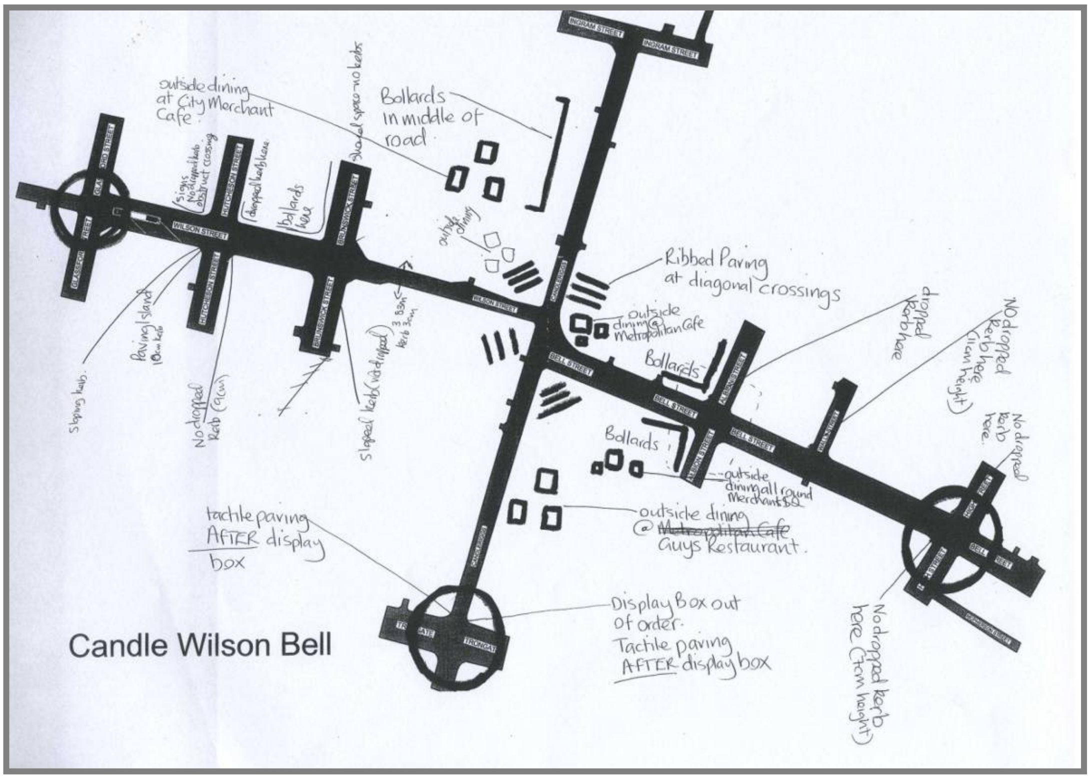


Figure 6.3: Annotated street map illustrating enabling and disabling features on Candleriggs, Wilson St and Bell St

6.6. Results and Interpretation

6.6.1. Pavement Characteristics

Pavements provide the primary means of access for pedestrians between buildings and locations within a town or city. The design, layout and general condition of a pavement can have a significant impact on the movement patterns and the ease with which a visually impaired pedestrian is able to access goods, facilities and services. A pavement which has not been designed with the needs of the visually impaired pedestrian in mind can limit movement, evoke a sense of fear and stress and ultimately cause accidents and injuries. For this reason it was necessary to investigate and document the enabling and disabling features inherent within the design of pavements located throughout the study area. This included the analysis of (i) the general condition of the pavement, (ii) the type of paving used, (iii) pavement width, (iv) kerb heights and (v) level changes. Each of these design features is described here in more detail with comparison made where applicable to compliance with mandatory Building Regulations (SBSA, 2009) and design guidelines (BSI 2009; Dept. for Transport, 2005a). The inclusion of diagrams and images are presented here to further assist in illustrating the features responsible for creating an environment that is either disabling or enabling to the visually impaired user.

6.6.2. General Pavement Condition

This category provides information with regards to the overall treatment of the pavement, with particular attention to the condition of the pavement surface material. Depending on the type of paving surface in use, it is possible for the material to become displaced, uneven or damaged as a result of maintenance work, installations from utility companies, underlying tree roots, subsidence or high volumes of pedestrian and vehicular traffic. An event of this nature may be problematic to pedestrians of all abilities, potentially creating a trip hazard and loss of balance. The impact on visually impaired pedestrians however may be significantly greater due to the inability of this population to foresee the presence of uneven or broken paving. If a visually impaired individual is using a mobility aid such as a long cane then there is also the possibility for this to become trapped in between cracks in the pavement. The results from the survey indicate that uneven paving is perceived as the most problematic pavement feature among individuals with a visual impairment, receiving an average rating score of 2.02 (highly problematic).

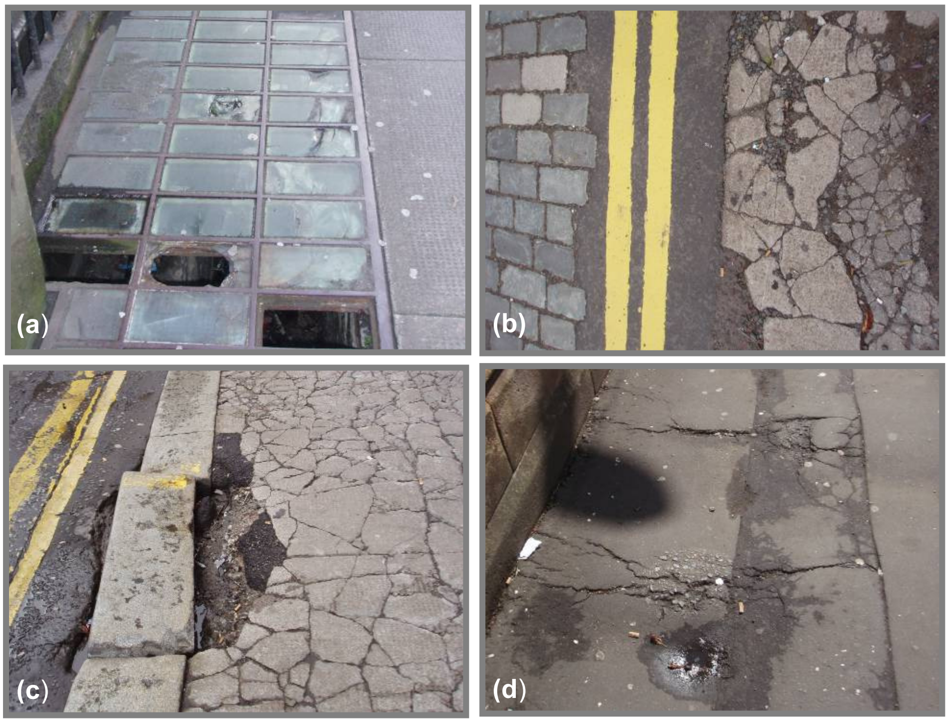


Figure 6.4: Poor pavement condition (a) S. Fredrick St, (b) Albion St, (c) Wilson St, (d) High St

Figure 6.4 illustrates four examples of badly maintained paving which were identified during the access audit. All four examples can be problematic and dangerous to visually impaired pedestrians. Figure 6.4(a) illustrates an incidence whereby a number of glass bricks have become broken and removed from the building line of the pavement. This design feature was initially intended to allow natural daylight down into lower basement levels of a building, however the glass bricks in their current state can present a serious hazard for the visually impaired pedestrian as it may be possible for a shoe (for example ladies footwear) or mobility aids such as a long cane or walking stick to become trapped or fall through the open hole. Figures 6.4(b) and (c) provide examples of incidents where concrete paving has cracked and broken at the kerb edge of the pavement. Incidents of this nature can often be sporadic and as such can be a danger to the visually impaired pedestrian, especially in circumstances where no mobility aid is in use to provide prior warning of the changing nature of the pavement surface.

Finally, Figure 6.4(d) illustrates the way in which a tarmac paving surface can alter over time. In this example, a strip starting from the centre of the pavement extending to the building edge has cracked and is suffering from subsidence, this results in a series of peaks and troughs creating sudden and unexpected changes in the level of the pavement. This unforeseen event may catch a visually impaired pedestrian by surprise and cause a loss of balance.

The appearance and general condition of the pavement can also alter significantly as a result from the intervention of utility companies and the presence of construction works. The frequency of this type of physical feature was recorded extensively throughout the study area with only a limited number of streets being exempt from any modifications to the surface material. Figure 6.5 presents three examples of cases where the pavement surface has been affected in this way. Figure 6.5(a) illustrates a typical example of how a pavement surface can alter in appearance after a utility company has excavated the original paving in order to install services and Figure 6.5(b) provides an example of a situation where new paving meets old at the edge of a construction site. In both examples, the variation in colour, material and texture of the ground surface can be extremely confusing to a visually impaired pedestrian. This type of change in material may be perceived as a deep hole in the ground or a change in the surface level or function of the paving and may be responsible for influencing the walking speed and choice of path taken along the pavement. Figure 6.5(c) illustrates an example where the pavement has been excavated in order to maintain or upgrade utility services located underground. In this circumstance the original area has not been recovered in a similar material but has instead been covered by two metal sheets that are not positioned at the same level as the original paving, creating an unexpected level change and potential trip hazard. The material is also not in a contrasting colour to the existing paving and would not be easily distinguishable to pedestrians affected by a visual impairment.

Figure 6.5: Poor pavement reinstatement (a) Garth St, (b) Shuttle St, (c) Cathedral St

6.6.3. Type of Paving

The type of paving surface present within the study area was documented and recorded using a digital camera and spreadsheet. The findings demonstrate a varied selection of materials including concrete, tarmac, bitumen, sandstone, granite, Caithness stone, cobbles, brick and gravel, many of which differed in colour, texture, size and layout. It was also noted that the type of paving in use on any one particular street may not necessarily always be formed from the same material. Areas of regeneration intertwine with older less developed sections of the city to create an unusual blend of materials and palettes. This was evident at several locations within the study area and is further highlighted in Figure 6.6 which illustrates the varying paving types present at specific locations within the predefined boundary of the study area.

The type of paving material present within the built environment can vary considerably in terms of size, shape, texture, colour, pattern and reflectance and can therefore significantly affect the ease with which a person with a visual impairment is able to walk along a pavement. The type of paving received an average rating score of 3.01 within the survey, indicating that this feature may cause potential problems to visually impaired pedestrians. A surface material consisting of many different parts such as cobbles may be dangerous and create a trip hazard especially if the surface is uneven. (BSI, 2009, p. 18; Dept. for Transport, 2005a, p. 16; SBSA, 2009, p. 13). This type of paving can also reduce the effectiveness of a long cane as it may become caught in the gaps between the cobbles (Dept. for Transport, 2005a, p. 16). A patterned surface or a pavement with several different paving types may create a disorientating and confusing environment for a visually impaired pedestrian, leading to a difficulty in distinguishing objects on the footpath or even creating the illusion of an object or change in level. Bright *et al.* (1999) found strong evidence to suggest that plain uniform non-patterned floor designs are preferable and beneficial for individuals with a visual impairment as opposed to busy non-uniform patterns which in many cases can have a detrimental effect to an individual's navigational behaviour and therefore should be avoided. In the case of Bright *et al.* (1999), the research focused on internal floor patterns, however the same logic can be applied to paving design in external environments with the additional problem of daylight and weather, and the potential effects this may have on the appearance of the ground surface.

Figure 6.6: Types of paving present in Study Area

Figure 6.7 provides three examples of the way in which the appearance of the paving can alter in response to (a) dry, (b) wet and (c) sunny conditions. All three examples explore the changing appearance of Caithness stone as this paving type is currently being introduced on a large scale as part of the regeneration plan for the city centre. Figure 6.7(a) and (b) provide a comparison of Caithness stone when dry and wet. Under dry and cloudy conditions, the paving has a plain matt appearance, free from glare, reflection and shadows, however when wet, the material transforms into a glossy surface which produces a large amount of glare and reflection caused from other pedestrians, street furniture and surrounding buildings. The colours from individual stone pieces become more vivid and appear as if varnished. Investigations carried out by Bright *et al.* (1999) also concluded that the floor surface finish is an important factor in determining the ease with which a visually impaired person is able to navigate. They found that matt finishes are much preferable to reflective and shiny surfaces. They further highlight the problematic nature of glare and reflection and suggest that this may introduce misleading information whereby the reflection of surrounding objects may be perceived as physical obstructions on the ground, causing confusion and apprehension. This is further reinforced in Inclusive Mobility which states that pavement surfaces should not be made of reflective material (Dept. for Transport, 2005a, p. 16).

Under sunny conditions the appearance of paving can alter significantly as a result of shadows cast from surrounding objects. The position of the shadow is determined by the direction of the sunlight and therefore changes in appearance and location in accordance to the time of day. Figure 6.7(c) demonstrates the effect that a shadow cast from a tree can have on the appearance of the surrounding pavement surface. Shadows of this nature are seldom static and on a windy day the shadow can move erratically causing continuous movement on the ground surface. Bright *et al.* (1997) highlight that shadows across floors and stairs can be “*extremely disconcerting and in many cases very dangerous*” for persons with a visual impairment (Bright *et al.*, 1997, p. 3). This is further emphasised in Inclusive Mobility:

> Reflection, glare, shadows and large variations in lighting levels generate visual confusion and, in some cases, discomfort.
>
> (Dept. for Transport, 2005a, p. 65)

Therefore it is essential that careful consideration is given when selecting the type of paving and determining the position of street furniture and trees within pavements and pedestrian areas. Forward planning, careful selection of materials and sensible zoning can significantly reduce or even eliminate unnecessary glare and shadows, both of which are detrimental to the visually impaired pedestrian.

Figure 6.7: Pavement appearance under different weather conditions (a) Argyle St – dry, (b) Argyle St – wet and (c) Buchanan St – sunshine & shadow

6.6.4. Pavement Widths

The width of each pavement within the study area was measured using a digital measuring tape at five locations along each pavement in order to calculate an overall average for the entire street. As with paving type, the width of a pavement can vary significantly throughout a small area, either along the same street or between neighbouring streets; this can influence the ease with which a visually impaired person is able to navigate safely and independently. An average unobstructed pavement width of 4.31 metres was recorded in the study area, ranging from a minimum unobstructed pavement width of 1.57 metres recorded on Martha Street to a maximum unobstructed pavement width of 21.17 metres recorded on Buchanan Street (see Figure 6.1 for street locations). The full list of minimum and maximum street widths recorded within the study area is presented below in Figure 6.8. Individual measurements taken for each street can be viewed in more detail in Appendix B.

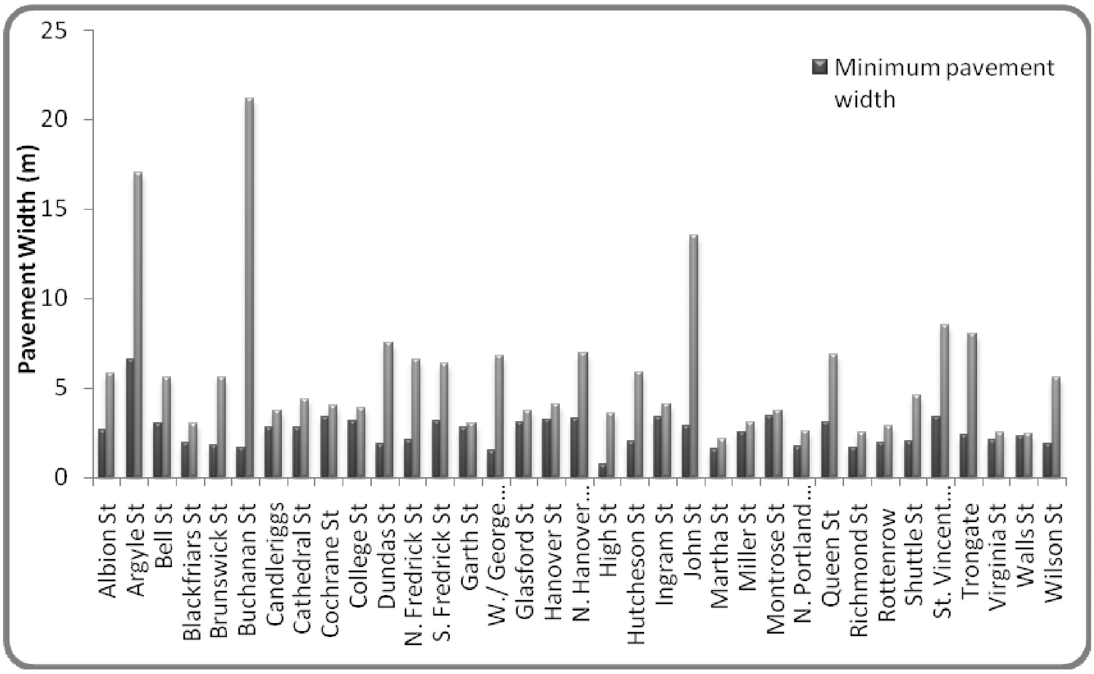


Figure 6.8: minimum and maximum pavement widths in study area

There are no mandatory regulations for the width of a pavement, however guidance offered in British Standard BS 8300 (BSI, 2009, p. 17) and Inclusive Mobility (Dept. for Transport, 2005a, p. 11) recommends a preferred pavement width of 2m, however variable widths are suggested for different circumstances. In particular it is advised that a width of 1.1m will allow a blind long cane or guide dog user adequate room to navigate and 1.2m for a visually impaired person who is accompanied by a sighted guide (Dept. for Transport, 2005a, p. 5). However it should be noted that these measurements only refer to one-way pedestrian traffic and therefore should be regarded as half the adequate width to allow two-way pedestrian traffic.

Figure 6.9 illustrates three examples of varying pavement widths at two principle streets within the city centre. The first two examples originate from Buchanan Street, one of Glasgow's principle pedestrian shopping streets, and illustrate the dramatic way in which the width of a pavement can reduce in size at specific points along a street, from 21.17 metres (Figure 6.9a) to 1.68 metres (Figure 6.9b). A very wide pavement or pedestrian street can often create a disorientating environment for a visually impaired pedestrian, especially if they have a reduced visual field and are unable to use peripheral cues such as the wall of a building, contrasting kerb edge or parked vehicle to orientate and assist in the navigation process. Similarly, a very narrow pavement can cause difficulties to visually impaired pedestrians (BSI, 2009, p. 16). Such an environment can evoke stress and anxiety due to pedestrian congestion and close proximity to the kerb edge and moving vehicles. A high frequency of pedestrian traffic and presence of street furniture may also lead to the narrowing of a pavement at specific sections, resulting in increased anxiety and stress levels as well as the more frequent occurrence of accidents and injuries through collisions with street furniture hidden by other pedestrians.

Figure 6.9: Variation in pavement width within Study Area (a) Buchanan St – wide section, (b) Buchanan St – narrow section and (c) Montrose St

Figure 6.9(c) provides an example of a good pavement width, allowing pedestrians from both directions to pass by with ample space. The pavement has no street furniture or other obstacles which may otherwise impede movement or result in a narrowing of the pavement. Furthermore the contrasting kerb edge and building line are at a suitable distance apart to act as peripheral cues and assist in the navigational process.

Pavements can also reduce in width as a result from inappropriate positioning of street furniture. In circumstances where the occasional narrowing of the pavement is necessary due to the presence of an obstacle Inclusive Mobility recommends an absolute minimum width of 1 metre stretching for a maximum distance of 6 metres (Dept. for Transport, 2005a, p. 11), where as British Standards recommend a minimum clear width of 1.2

metres stretching for maximum distance of 2 metres (BSI, 2009, p. 16). However within the study area, pavements were found to be less than the recommended values at several locations due to the presence of street furniture. Figures 6.10 (a) and (b) illustrate the narrowing effect that (a) a bus shelter and (b) an advertisement sign can have on the width of a pavement. In the case of Figure (a) the presence of a bus stop narrows the pavement to 0.73 metres. This is substantially less than the recommended values outlined in Inclusive Mobility which suggest a minimum of 3 metres clear pavement width at bus stops (Dept. for Transport, 2005a, p. 11). Furthermore this measurement falls below the absolute minimum widths of 1 metre and 1.2 metres as recommended by Inclusive Mobility and British Standards respectively.

Figure 6.10: Reduction in pavement width due to (a) Bus shelter on High St and (b) Sign on High St

It is important to reinforce that the presence of unexpected obstacles, crowded streets and narrow pavements were all rated as highly influential factors for preventing independent travel among the visually impaired survey participants.

6.6.5. Kerb Height

The presence of varying kerb heights received an average rating score of 2.36 from the visually impaired survey participants, making it the fourth most problematic feature associated with pavement design. A pavement with varying kerb heights can be a hazardous and confusing environment for the visually impaired pedestrian, due to a lack of uncertainty over the vertical distance between the footpath and road along the length of the pavement at any two given points. The extent to which this hampers a person's movement may also depend on the use of a mobility aid such as a long cane, which will generally indicate significant differences between kerb heights along a route. The access audit identified and highlighted the changing kerb heights across the city and indicated the presence or lack of dropped kerbs at designated pedestrian crossing points. Measurements of kerb heights were recorded using a digital tape measure at five locations along each pavement in order to gain an overall kerb height average for each street within the study area.

The average kerb height within the study area was calculated as 8.6cm, ranging from 0cm on shared space zones such as Blackfriars Street and Brunswick Street, where no kerb is present, to a maximum kerb height of 33cm found on Garth Street. The minimum and maximum kerb heights for each street within the study area are presented in Figure 6.11. A full account of individual kerb height measurements on a street by street basis is available in Appendix B. All streets present in the study area with the exception of the two shared space zones were found to have variable kerb heights. The degree of variation was dependant on each specific street however a general trend was found to exist between the kerb heights of new and old streets, with older streets generally featuring more extreme variations in kerb height compared to newly paved regenerated streets.

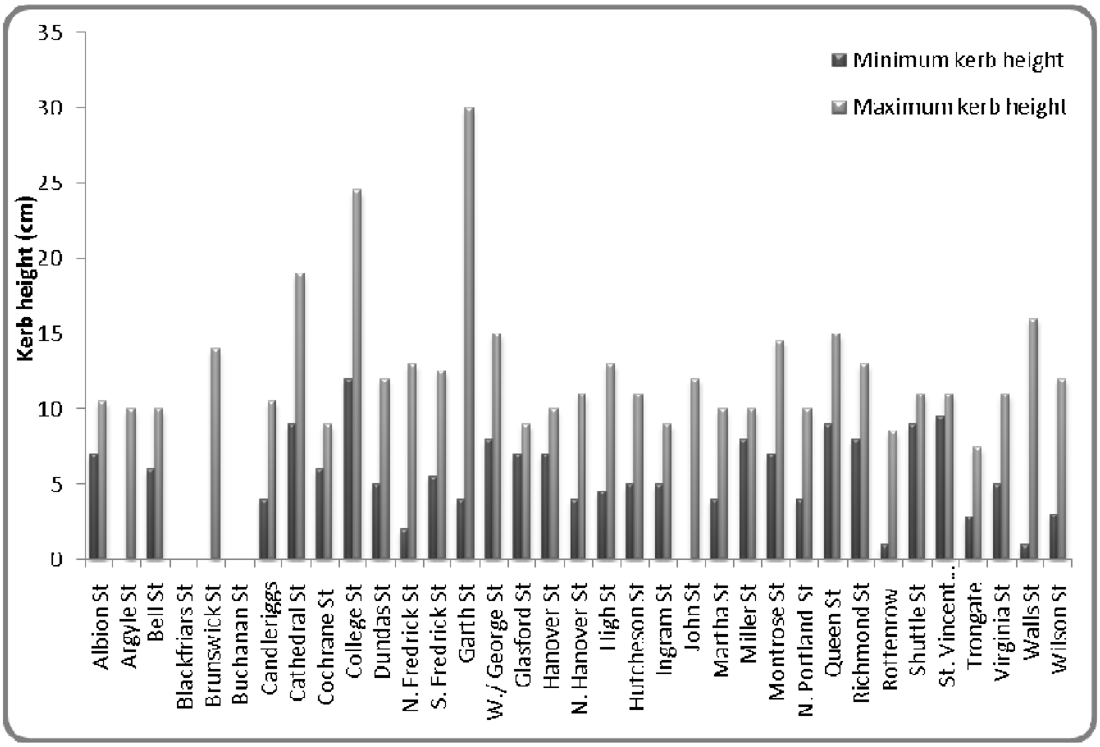


Figure 6.11: minimum and maximum kerb heights in study area

The largest variation in kerb heights was recorded on Garth Street, a 55 metre length street connecting Hutcheson Street on the east to Glassford Street on the west (see Figure 6.1 for street location within study area). The street has not yet been included in the city centre modernisation programme and as such the general condition is poor. Figure 6.12 presents a range of kerb height measurements in centimetres at five specific locations along the street. A high kerb height of 33cm was recorded on the northern pavement with a low kerb height of 4cm on the southern pavement, equating to difference of 29cm.

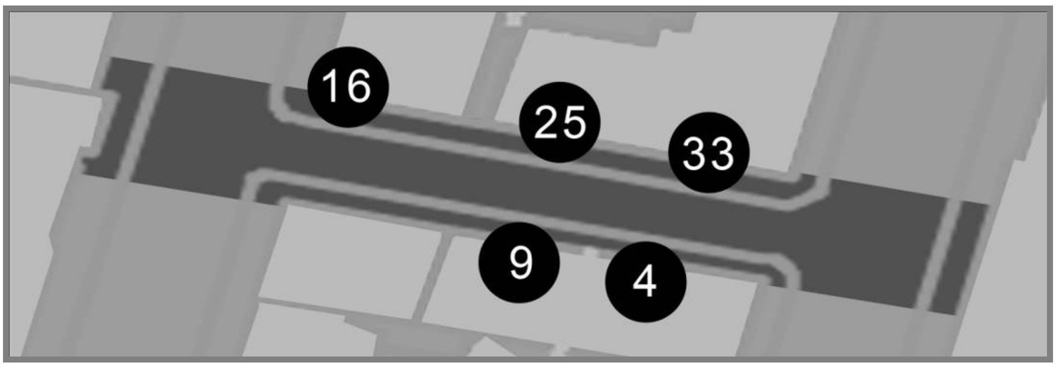


Figure 6.12: Variation of kerb height in cm at five locations on Garth St

Figure 6.13(a) illustrates a particularly hazardous kerb design, referred to here as a double kerb. This feature is problematic and dangerous for visually impaired pedestrians due to its rare occurrence within the study area. In particular this type of stone and kerb edge material is used differently throughout the rest of the city centre. As a consequence a visually impaired pedestrian may not expect to encounter a double level change at the edge of the pavement in a streetscape dominated by single kerb edges. In this example the double kerb stems from a single kerb at either end of the street, therefore pedestrians may be unaware that they are on a pavement with a double level change, until they step off the edge. Figure 6.13(b) presents the kerb as viewed from the pavement. In this example the poor contrast does little to indicate the presence of a double level change. Figure 6.13(c) presents the kerb as viewed from the road; from this position the double kerb is more visible due to the presence of shadows.

Figure 6.13: Double kerb along Albion St (a) Double kerb, (b) kerb as viewed from road and (c) kerb as viewed from pavement

6.6.6. Level Changes

The term level change as used in this thesis, refers either to a break in the pavement to facilitate vehicular access to and from a building or a flight of steps located on a pavement. A change in level of this nature can be particularly hazardous to individuals with a visual impairment, especially if it is unexpected and unmarked:

> A sudden and unguarded change of level on an access route can present a hazard to a person with a visual impairment.
>
> (SBSA, 2009, p. 35)

The presence of unexpected level changes received an average rating score of 2.13 from the survey participants, placing it as the third most problematic pavement feature for individuals with a visual impairment. A digital measuring tape was used to record the dimensions of any level change present on the pavement; this included the number of steps, height of risers and depth of treads. In addition it was also documented if there were any enabling features built into the design such as tactile warning paving, contrasting stair edge strips and handrails, details of which are described below.

Figure 6.14 compares two examples of the treatment of vehicular access entrances within the study area. In Figure 6.14(a) the vehicular access intersects with the pavement, creating two level changes. This type of feature may be unforeseen by visually impaired pedestrians who do not use a mobility aid, and could present a serious trip hazard (BSI 2009, p. 26) leading to disorientation or a loss of balance. Figure 6.14(b) presents an example of the way in which vehicular access entrances are treated on streets where the pavement has been upgraded. In accordance with advisory guidelines (Dept. for Transport, 2002, p. 33) the access route has been raised to meet the height of the pavement therefore eliminating two unnecessary level changes for pedestrians, benefitting not only those with a visual impairment, but also individuals with mobility impairments and parents with young children in pushchairs. The change in material and colour alerts the pedestrian to the fact that there is a change in use of the pavement at that particular location. Furthermore the contrasting light stone, as used for kerb edges throughout the upgraded streets of the city, indicates to the pedestrian that there may be vehicles crossing at this point.

Figure 6.14: Treatment of level changes at vehicular access entrances (a) North Fredrick St, (b) Ingram St

The following images provide examples of level changes at prime locations within the city centre. Figure 6.15(a) presents a flight of ramped steps at Queen St Station as viewed from below. From this angle it may be possible to detect the presence of steps due to the occurrence of shadows. However, when viewed from above (Figure 6.15b) it may not be evident to a visually impaired pedestrian that there is a flight of steps in the direction of travel, as the material of the steps is the same as the surrounding pavement. This may result in a scenario whereby the steps are interpreted as a continuous ramp, creating a dangerous situation and potentially causing accidents for visually impaired pedestrians.

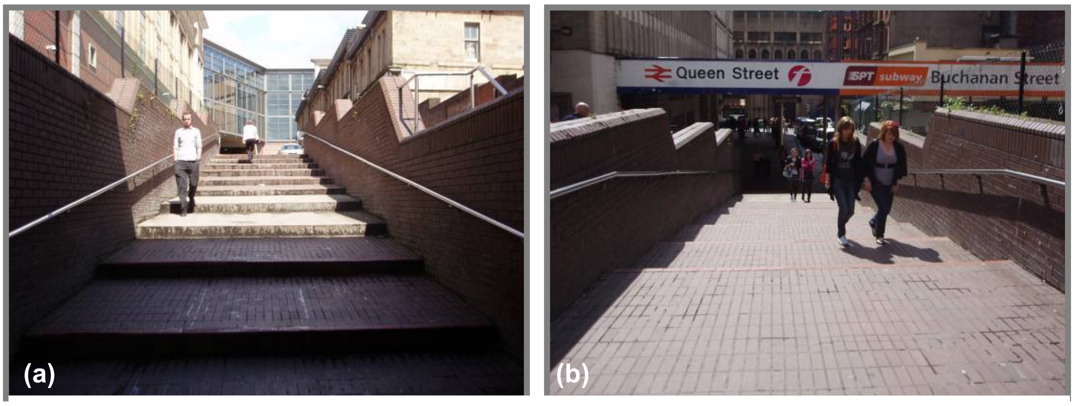


Figure 6.15: Steps at Queen St Station (a) viewed from below & (b) viewed from below

Figure 6.16 presents two examples of tapered steps found within the study area. Tapered steps are generally found where there is a gradient in the pavement resulting in the steps appearing to rise out of the pavement. Tapered steps can be particularly misleading for visually impaired pedestrians as they may be unaware that they have walked up onto a different level or onto a flight of steps. Both examples presented in Figure 6.16 are located on a busy pedestrian street. High levels of pedestrian congestion in this area can obscure a pedestrian's view of the pavement including ground features. Furthermore the poor contrast in the materials used for the pavement and the steps do little to indicate the presence of these level changes.

Figure 6.16: Tapered steps on Buchanan St

As illustrated, level changes in the form of ramped steps and tapered steps combined with poor contrast and a lack of visibility contribute to the creation of a disabling environment. However it is possible to enable the pedestrian by incorporating a few simple additional design features into external steps. Mandatory standards are provided in the Scottish Building Regulations detailing the provision of assistive features to reduce the risk levels associated with negotiating level changes for visually impaired pedestrians (SBSA, 2007, pp. 29-34). More detailed information is also available in British Standards BS 8300 (BSI, 2009, pp. 25-30), Inclusive Mobility (Dept. For Transport, 2005, pp. 21, 22, 40 - 45) and Guidance on the use of tactile paving surfaces (Dept. For Transport, 2002, pp. 42-45).

6.6.6.1. Corduroy Tactile Paving

Corduroy tactile paving should be used at the top and bottom of a flight of steps to warn visually impaired pedestrians that they are approaching a level change and to proceed with caution (Dept. For Transport, 2002, p. 42). This form of tactile paving consists of rounded bars, 6mm (± 0.5mm) high, 20mm wide and spaced, centre to centre at 50mm (Dept. For Transport, 2002, p. 42). The surface should be laid so that the bars run transversely across the direction of pedestrian travel (Dept. For Transport, 2002, p. 44) and extend across the full width of the steps plus an additional 400mm either side at the top and bottom (Dept. For Transport, 2002, p. 45). The paving should be laid 400mm away from the nosing of the bottom and top step (Dept. for Transport, 2002, p44), and extend for a distance of 800mm in cases where the level change is in the direct line of travel and 400mm in circumstances where a conscious change of direction is required (Dept. for Transport, 2002, p. 45). The surface should contrast with the surrounding area but should not be red (Dept. for Transport, 2002, p. 42) as this colour is reserved for use at controlled pedestrian crossings (see Section 6.8.1).

6.6.6.2. Handrails

The Scottish Building Regulations state that a handrail must be provided for every level change over 600mm (SBSA, 2009, p. 33). It is recommended that handrails are provided at either side of the steps in order to take account of personal preferences and requirements (SBSA, 2009, p. 33). Handrails should extend horizontally for a distance of at least 300mm at the top and bottom of each flight (SBSA, 2009, p. 33). The recommended height dimensions vary from between 840mm and 1000mm in the Scottish Building Regulations (SBSA, 2009, p. 34), to between 900mm and 1000mm in Inclusive Mobility (Dept. for Transport, 2005a, p. 44) and Building Standards (BSI, 2009, p. 28). Handrails should be of a profile and design that is comfortable to use and visually contrasting with the surroundings (SBSA, 2009, p. 34).

6.6.6.3. Stair Nosings

It is essential to incorporate high contrasting stair nosings along the full width of each step to assist with the detection of the beginning and end of each individual level change (SBSA, 2009, p. 29). The Scottish Building Regulations fail to provide any dimensional criteria for the design of stair nosings. Guidance documents offer recommendations of 55mm deep on both tread and riser (Dept. for Transport, 2005a, p. 41) and 50mm to 65mm wide on the tread and 30mm to 55mm on the riser (BSI, 2009, p. 26).

Figure 6.17 provides an example of a flight of steps located within the study area which has a number of enabling features designed to increase their visibility therefore alerting the visually impaired pedestrian to the presence of a level change. Contrasting corduroy tactile warning paving has been installed at the top of the steps in order to advise a visually impaired pedestrian that they are approaching a change in level. A continuous handrail has been fitted to both sides of the flight of steps, which reflects the change in level: it begins level at the top and angles downwards at the first step, with a gradient corresponding to that of the steps. Furthermore high contrasting stair nosings (white) have been applied to each tread (black) as a means of defining the edge of the step, and informing the pedestrian of each individual level change. Figure 6.17(b) illustrates the steps as viewed from above and highlights the effectiveness of high contrasting stair nosings if compared to Figure 6.15(b). Although a good example, these steps could further be improved by levelling off the handrail at the bottom of the steps and by also providing tactile corduroy paving at the bottom of the flight, both of which would signify the completion of the steps. All of these features assist in making level changes more visible to the visually impaired pedestrian, thus making them safer and easier to use.

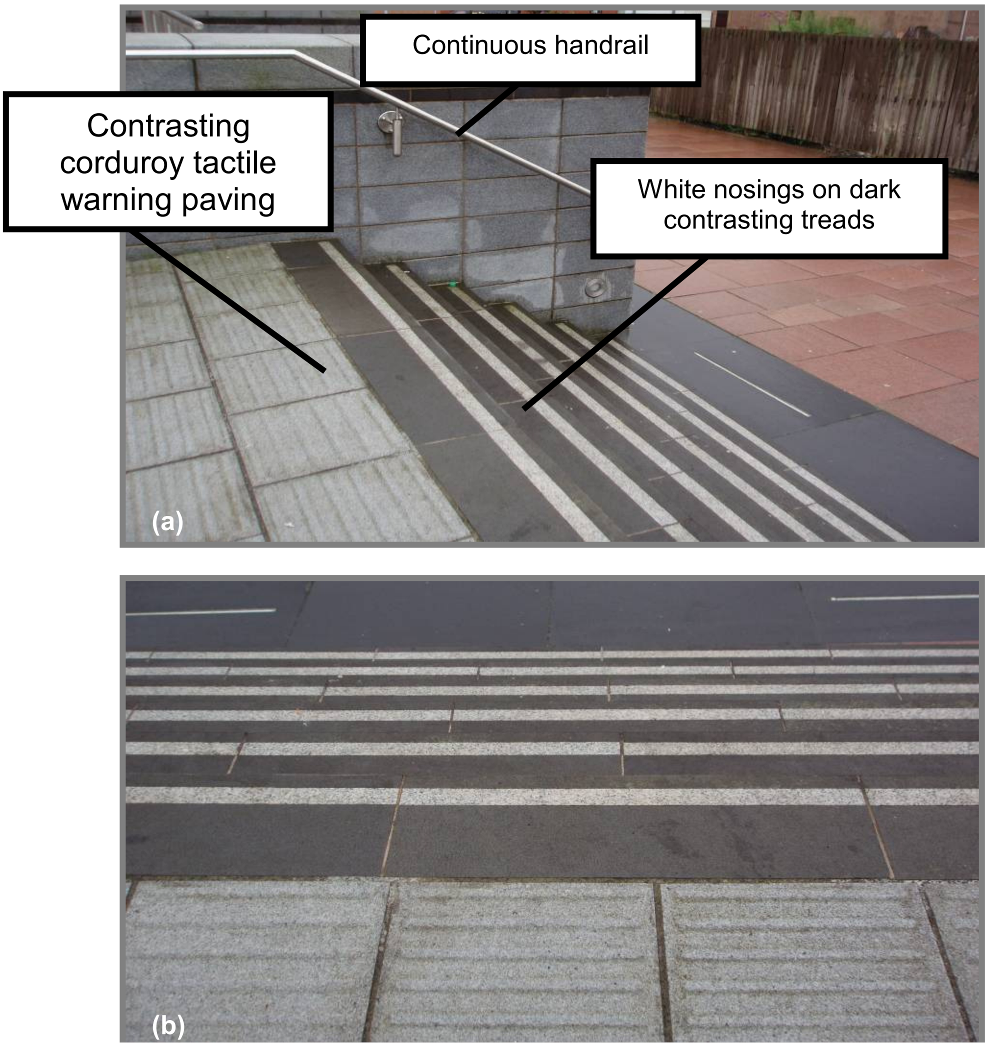


Figure 6.17: Flight of steps equipped with assistive cues (a) side on view (b) looking from above.

6.7. Street Furniture

The term street furniture refers to a collection of objects and items of equipment which are installed on pavements in order to provide a specific function or service. Items may include: bollards, bins, bicycle racks, outside dining furniture, service boxes, traffic barriers, seating, phone boxes, street lighting, traffic signage and bus shelters. The placement of street furniture on pavements can introduce problematic situations for pedestrians. According to the Building for All guidelines:

> Furniture in the external environment [...][are] often placed independently over time and without co-ordination. In urban environments the complexity of the layering of these elements can result in an assault course for most people, particularly for people with visual impairments and those using a wheelchair or pushing a buggy.
>
> (Gilbert & National Disability Authority, 2002, p. 16)

The positioning and zoning of street furniture can be problematic to the visually impaired pedestrian, especially in cases where a mobility aid is not in use to detect the location of unexpected obstacles. Items placed on the street can be particularly hazardous if they are of a poor colour contrast with the surrounding environment. There should be an explicit understanding of the practical role of street furniture and their implications when designing streets. As the NCBI *Guidelines for Accessibility of the Built Environment* forcefully state:

> Street furniture should not blend into the background. Safety of citizens must take priority over fashion trends among architects. Strong yellow and black stripes on poles are both cheerful and highly visible. Art work on hoardings and phone booths can also be visually appealing for all citizens, as well as enabling people with low vision to find and/or avoid bumping into them.
>
> (NCBI, 2005)

Over recent years, the study area has seen a substantial increase in the quantity and variety of street furniture as a direct result from the ongoing city centre public realm works. The introduction of new colours, materials and designs has resulted in a streetscape radically different to that of older, less developed areas of the city. Results from the survey presented in Chapter 5 indicated that the presence of street furniture is perceived to be one of the most problematic features associated with pavement design. Perhaps one of the main reasons why street furniture is perceived to be so hazardous could be due to the choice of colour and material used. The predominant choice of colour and material for street furniture within the study area is silver / stainless steel. Interestingly this colour choice was regarded as the least visible to detect within the built environment among all of the visual field loss groups participating in the survey. This finding supports guidance from Inclusive Mobility which discourages the use of grey as it can often blend into the general background colour, making the object very difficult to detect (Dept. for Transport, 2005a, p. 14). The most prevalent items of street furniture within the study area are listed below in accordance to the average rating scores they received from the survey presented in Chapter 5. Comparisons are provided between old and new styles, highlighting the way in which choice of colour, zoning and general design can contribute to the disabling nature of the built environment.

The Scottish Building Regulations do not currently provide mandatory regulations for the design of street furniture. Limited specifications are however provided in guidance documents such as British Standards BS 8300 (BSI, 2009) and Inclusive Mobility (Dept. for Transport, 2005a). It is recommended that items of street furniture should be positioned out with the boundary of an access route to leave a minimum unobstructed width of 2 metres (BSI, 2009, p. 20; Dept. for Transport, 2005, p. 14). Items should be zoned in a consistent and logical manner so as not to create a hazard for visually impaired pedestrians (Dept. for Transport, 2005a, p. 11). Street furniture should contrast visually in terms of the overall design and with respect to the surrounding environment. In particular, lamp posts and free standing poles and columns should have a contrasting band 150mm in depth positioned at a height of between 1400mm and 1600mm above ground level.

Bollards should incorporate a 150mm contrasting band at the top of each post (BSI, 2009, p. 20; Dept. for Transport, 2005, p. 14). Where relevant, recommended best practice solutions will be outlined and compared against the design of items of street furniture currently present within the area bound by the access audit.

6.7.1. Bollards

The most hazardous item of street furniture according to the views of the visually impaired survey participants was the bollard. A bollard is a small vertical post which is primarily used to control and limit the movement of road vehicles. A total number of 22 out of 37 streets and squares were found to have bollards present, making the bollard one of the most frequently used items of street furniture within the study area. The most common locations were found to be (i) at the beginning and end of pedestrian precincts to prevent the entry of vehicles, (ii) along the kerb edge of pavements to prevent vehicles from parking on the pavement, (iii) at the entrance to important buildings to prevent a vehicle or terrorist attack (iv) as decorative features incorporated into the design of pedestrian areas and (v) as markers in shared space zones intended to separate pedestrians from moving vehicles.

Bollards can often cause problems for visually impaired pedestrians due to their high frequency, poor colour contrast and irregular zoning on the footpath. The design can vary considerably in terms of shape, height, colour and material, in turn influencing the ease with which a visually impaired pedestrian is able to identify and locate their presence on the footpath. The city centre modernisation programme has led to the placement of additional bollards on streets otherwise absent from their presence as well as the replacement of older style bollards with modern alternatives.

Figure 6.18 provides an example of both the old style and new style bollards. Over recent years the black bollards have been removed and replaced by a new silver stainless steel variety resulting in the black bollard only being present at four locations within the study area. Although the old and new style bollards do not incorporate a contrasting strip within the design, the black bollards are more visible against the surrounding background due to their size, shape and colour. The new style bollards are much smaller in size and diameter making them harder to distinguish. Furthermore their height and diameter measuring 890mm and 50mm respectively do not conform to the minimum best practice guidelines of 1000mm height (Dept. for Transport, 2005a, p. 14) and 250mm diameter (NCBI, 2005). They also have a very poor colour contrast with the surrounding background and produce a lot of glare especially under sunny conditions.

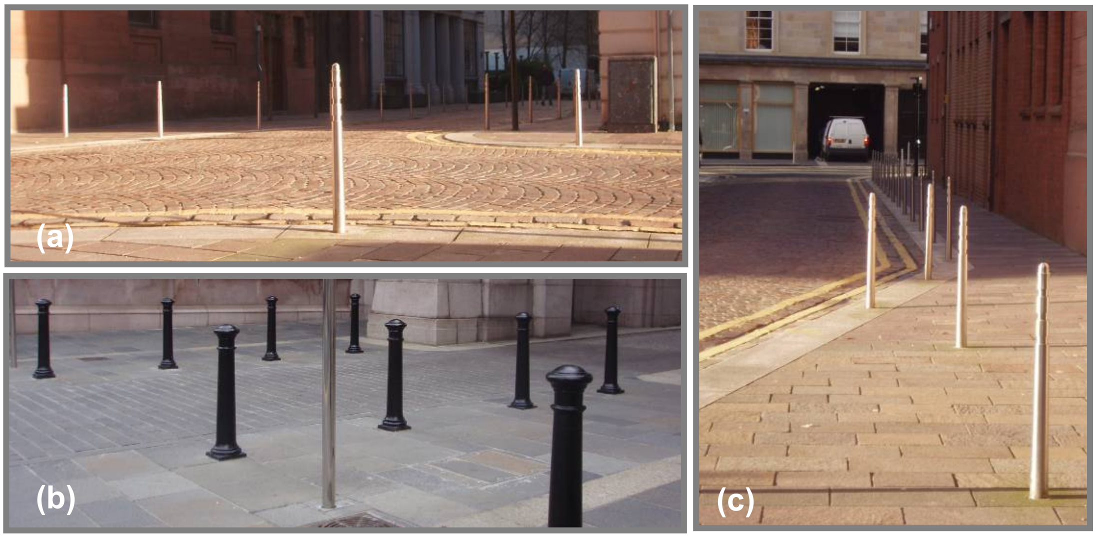


Figure 6.18: Different types of bollards (a) stainless steel bollards on Blackfriars St, (b) black bollards on John St and (c) irregular positioning of bollards.

Figure 6.18(c) illustrates the way in which bollards have been used to define the boundary between the pavement and road in a shared space zone. In this example the bollards have not been placed in a consistent manner. They first follow the curvature of the road and then change direction moving into the centre of the pavement. In this case the irregular zoning and intrusion into the access route / footpath creates a significant collision hazard for the visually impaired pedestrian and ignores all guidance contained within British Standards BS 8300 (BSI, 2009, p. 20) and Inclusive Mobility (Dept. for

Transport, 2005a, pp. 11, 14). It is important to note that situations of irregular zoning were identified on a frequent basis throughout the study area.

6.7.2. Decorative Items

The presence of decorative items of street furniture on pavements and pedestrian precincts can be hazardous to visually impaired pedestrians especially if the items have a poor colour contrast with the surrounding background and paving material. Figure 6.19 illustrates two examples of decorative cubes both of which are situated on busy pedestrian streets. The colour contrast is very poor in Figure 6.19(a) as the white cube has a very similar colour to that of the surrounding paving. This can be particularly problematic to individuals who are colour blind as the colour of the cube and paving may appear to be the same or very similar when viewed in greyscale, effectively rendering the cube as invisible in the eyes of a visually impaired pedestrian. The black cubes provide a good colour contrast with the surrounding paving; however they are smaller in size and may present more of a trip hazard to pedestrians of all abilities, particularly when the pavement is busy and they are obscured by other pedestrians. In both cases the design of the cubes fail to comply with the recommended dimensions contained within best practice guidance documents. It is advised that freestanding objects should be of minimum height 1000mm and should be constructed with rounded edges (Dept. for Transport, 2005a, p. 14).

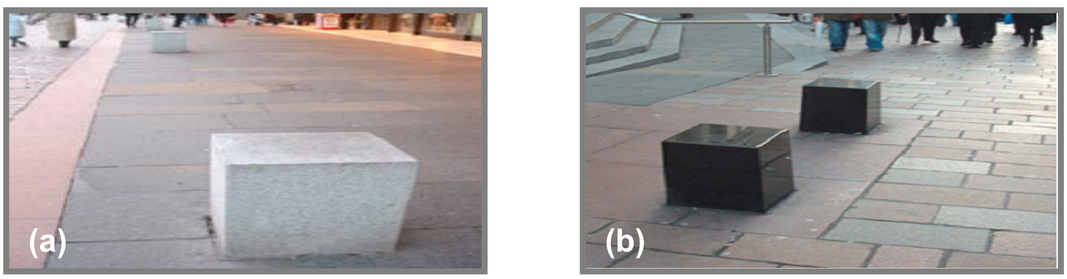


Figure 6.19 : Different types of decorative cubes (a) white stone on Argyle St and (b) black polished stone cubes on John St

6.7.3. Litter Bins

Litter bins were identified by the survey participants as the second most hazardous item of street furniture present within the built environment. As with bollards and decorative cubes, the same logic is also applicable to the many litter bins located in the study area. Figure 6.20 illustrates an example of where old meets new. The older style black litter bins provide a much greater colour contrast than the newer stainless steel bins. The gold banding at the top of the black litter bin also assists a visually impaired pedestrian as to the location of the gap in which items of litter are to be placed. There was found to be a high frequency of irregular zoning of litter bins within the study area. In certain locations the bins were placed in the centre of the pavement, while on other streets they were zoned towards the kerb edge or opposite at the building line of the pavement. This leads to a high level of uncertainty with regards to the location of a litter bin as well as to the areas of the pavement which are free from obstacles.

Figure 6.20: Different types of bins located along Buchanan St

6.7.4. Outside Dining

The third most hazardous item of street furniture as rated by the visually impaired survey participants was outside dining. A total of 14 out of 37 streets and squares within the study area were found to have outside dining areas present on the pavement. The extent to which this can affect the movement of a visually impaired pedestrian can depend on a number of factors. One of the main problems associated with outside dining areas is that unlike other forms of street furniture, they are not static. The presence of tables and chairs on the pavement can reflect the operational hours of a cafe or restaurant and can also be seasonal. Items may be placed on the footpath when the weather conditions are favourable and removed during adverse conditions. Furthermore, the location of the furniture may be moved and repositioned by customers and staff. This can result in a very confusing and potentially dangerous situation for a visually impaired pedestrian as there is always an uncertainty with regards to the potential presence and zoning of such items. It may often be the case that outside dining is absent from a pavement in the morning but present in the afternoon, leading to difficulties navigating even in familiar environments.

The choice of colour and material of outside dining areas can further contribute to the disabling nature of the built environment. The majority of the tables and chairs within the study area were found to be silver / stainless steel, which can be very difficult to detect for the visually impaired pedestrian. The presence of a protective barrier can increase the visibility of an outside dining area and help to contain tables and chairs within a specified boundary; however this practice was not found to be universal. Figure 6.21 illustrates a particularly hazardous example of an outside dining area, where the poorly contrasting low visibility tables and chairs have been placed on the pavement without the provision of a protective barrier. Finally it is also necessary to consider the effect that outside dining may have on the pedestrian flow of a pavement. The presence of tables and chairs can significantly reduce the available walking area leading to pedestrian congestion and an uncomfortable walking environment where people are forced to the kerb edge or even onto the road in an attempt to navigate around the obstacle.

Figure 6.21: Outside dining area on George St

6.7.5. Signage

The presence of signage received a very similar rating to that of outside dining making it the fourth most hazardous item of street furniture according to the visually impaired survey participants. Within the study area there was found to be a high frequency and irregular zoning of directional signage on the pavement for the benefit of road users. In the majority of cases the signage was poorly positioned leading to a reduction in the unobstructed pavement width, resulting in the disruption of pedestrian traffic flow. Figure 6.22 provides three examples of incidents where road signs may be hazardous to visually impaired pedestrians. The first example (Figure 6.22 a) highlights a situation whereby a large directional sign with two poles has been placed in the centre of the footpath, effectively splitting the footpath into three sections along a stretch of pavement which was already reduced in width due to the presence of an outside dining area. Figure 6.22(b) provides an example of a poorly placed road sign which has been located in the centre of an L-shaped tactile paving surface at a controlled pedestrian crossing. This situation can be extremely hazardous as the pole has been placed in the direct line of pedestrian traffic at a location which is supposed to be free from obstacles and obstructions.

Figure 6.22: Road signs: Double post road sign (a) on Trongate, (b) No entry sign located within tactile paving on Fredrick St and (c) Diversion road sign on George St

The presence of temporary road signs (Figure 6.22c) can also be particularly hazardous to visually impaired pedestrians as this type of sign is not a permanent feature on the street and may not be identified in time to prevent a collision. Furthermore this type of sign is also subject to movement from the weather and other pedestrians. If the sign has fallen over and is level with the pavement it may form a trip hazard. It was also noted that a large number of signage poles remained on the pavement long after their signage has been removed. This unnecessary feature only adds to the number of obstacles and collision hazards currently present within the built environment and should therefore be removed as a matter of urgency (Dept. for Transport, 2007, p. 21).

6.7.6. Street Lighting

Street lighting was rated as the fifth most hazardous item of street furniture among the survey participants. Figure 6.23 provides two examples of the zoning of street lighting within the study area. In the first example (Figure 6.23a) the street lights have been placed in the centre of the pavement. As street lights are commonly placed either at the kerb edge or building line of the pavement (see Figure 6.23b), the presence of this feature could lead to an unexpected collision between the visually impaired pedestrian especially in cases where a mobility aid is not in use to detect its presence. The choice of colour and finish of the lighting pole provides a very poor colour contrast with the surrounding background and on a grey cloudy day the silver of the pole merges in with the grey of the sky. It is important to note that contrasting bands were not present on any of the street lighting columns within the study area as recommended in British Standards BS 8300 (BSI, 2009, p. 20) and Inclusive Mobility (Dept. for Transport, 2005a, p. 16).

Figure 6.23: (a) Inappropriately zoned lamppost located on centre of pavement on Ingram St and (b) Consistently well zoned lighted columns on Shuttle St

6.7.7. Seating

The design and zoning of seating was ranked as the sixth most hazardous item of street furniture among the visually impaired survey participants. The provision of seating is a necessary feature within the built environment as it provides a resting point for individuals who require a break in their journey for reasons relating to a disability or health condition. It is recommended that seating should be provided at intervals of 150 metres for visually impaired pedestrians and wheelchair users and every 50 metres for individuals with a mobility impairment who use a walking stick (Dept. for Transport, 2005a, p. 10). Figure 6.24 provides a comparison between new and old style seating present within the study area. The new stainless steel seating (as illustrated in Figure 6.24a) has a slender and minimal design formed from many different parts. This type of seating may not be easily visible to individuals with a visual impairment due to the colour and material used. It may also not be detectable to individuals who use a mobility aid such as users of a long cane, as the stick may pass underneath the seat and not alert the pedestrian to its presence, in turn not allowing sufficient time to negotiate the obstacle. The older style black bench however is more visible to the visually impaired pedestrian as there is a stronger contrast between the bench and surrounding paving. The nature of the design should also alert mobility aid users to its presence due to the solid design of the base, (see Figure 6.24b).

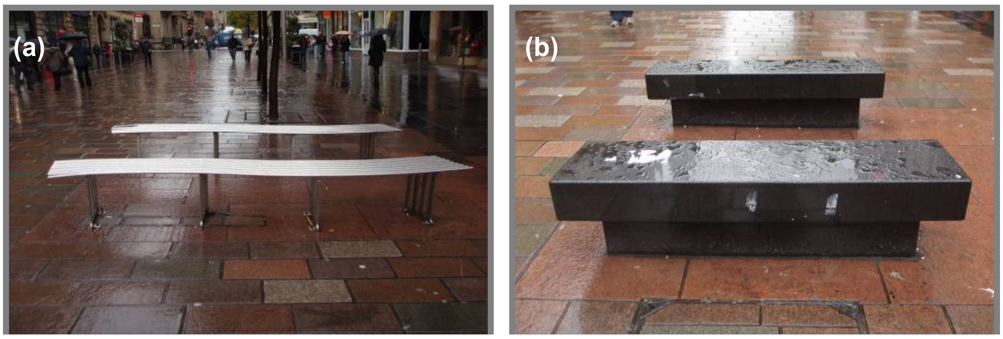


Figure.6.24: Different types of benches (a) stainless steel benches located on Buchanan St and (b) black granite benches located on Buchanan St

6.7.8. Zoning of Street Furniture

It is very important to position items of street furniture in a logical place that does not cause an obstruction and affect the flow of pedestrian traffic. The following items of street furniture have all been placed in positions which can be hazardous to not only visually impaired pedestrians but all users of the public realm. Figure 6.25 illustrates the way in which poor design and placement of street furniture can significantly reduce the unobstructed pavement width and create segments of pedestrian congestion. In this example a large glass and stainless steel bus shelter has been positioned at the kerb edge outside a supermarket entrance and beside an ATM cash machine on one of the main access routes into the city centre. The bus shelter reduces the width of the pavement from 4.35 metres to a width of 2.39 metres. The width of the pavement at this location is significantly narrower than is suggested in best practice guidance documents. It is recommended that the pavement should be a minimum width of 3000mm at bus stops and between 3500mm and 4500mm outside the entrance to shops (Dept. for Transport, 2005 p. 11).

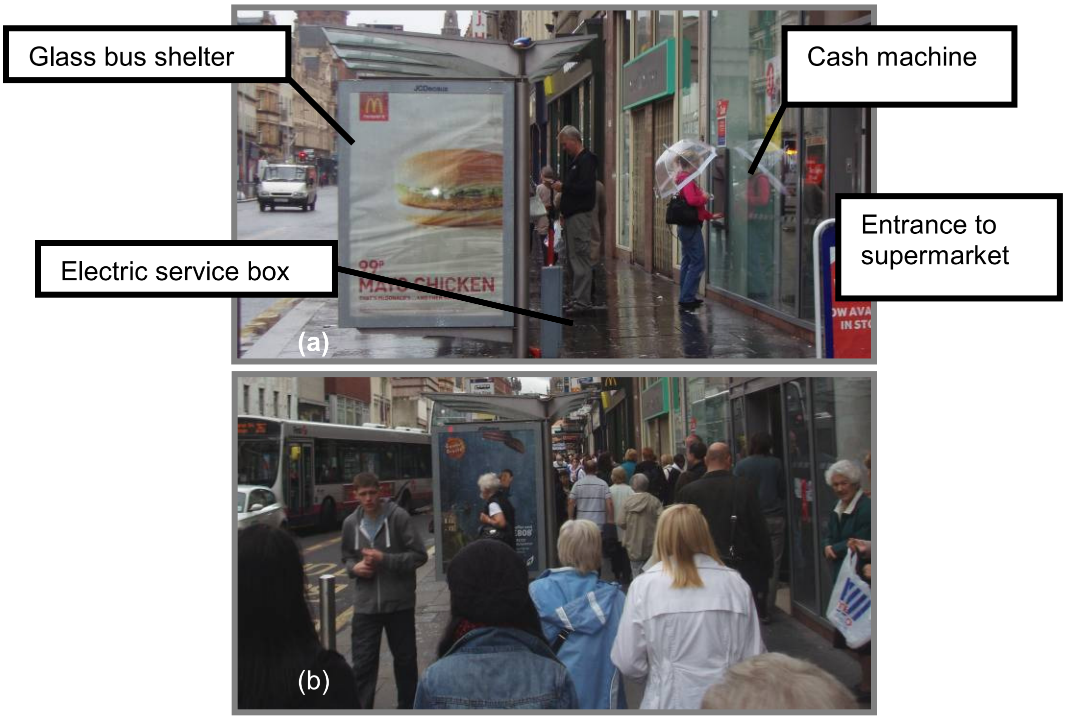
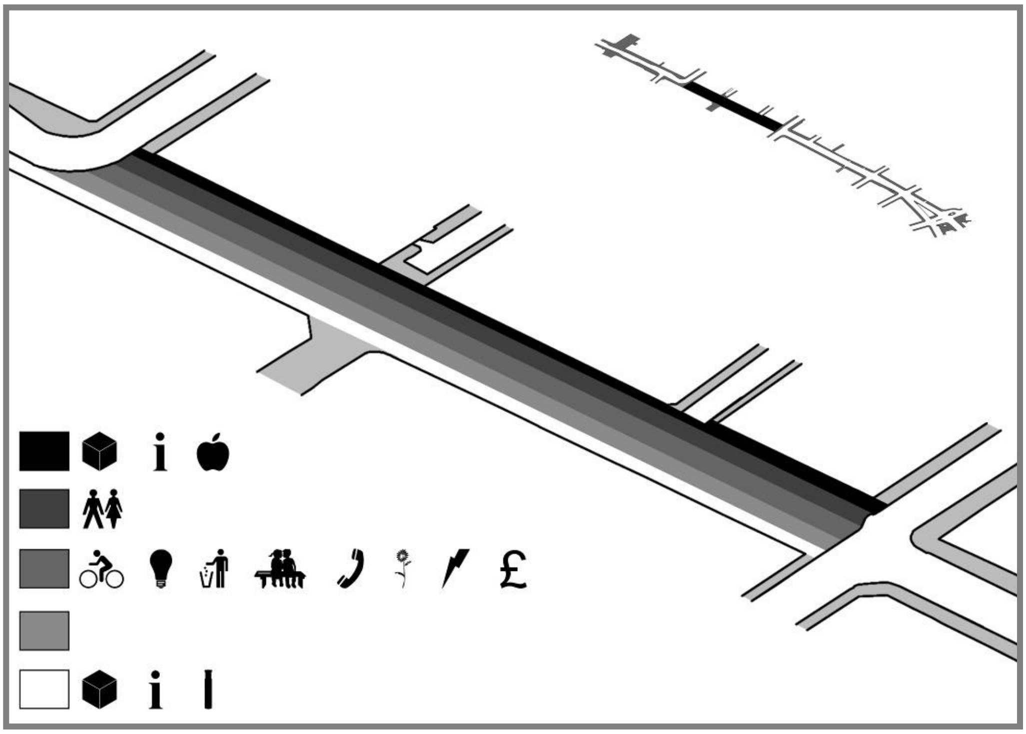


Figure 6.25: Pedestrian congestion on Trongate (a) uncrowded and (b) crowded

A sudden unexpected narrowing of the pavement can be extremely distressing and disorientating for the visually impaired pedestrian especially at locations where the volume of pedestrian traffic is high. If street furniture is to be integrated into the built environment then it should be done so in a way that does not limit movement or cause injury to pedestrians of all abilities. The positioning and zoning of street furniture within the study area was highlighted as a concern during the access audit. Figures 6.26 and 6.27 illustrate both good and bad examples of the zoning of street furniture on two of Glasgow's busiest pedestrian shopping streets.

The street furniture on Argyle Street (Figure 6.26) has been zoned in a way that creates a clear and unobstructed path for pedestrians. The pedestrian precinct has been designed to create five distinct strips, with each strip differing in colour, material and pattern. This type of design can be particularly comforting and reassuring to a visually impaired pedestrian who is able to walk safely along a particular strip in the knowledge that they are not about to collide with an item of street furniture.

Buchanan Street has been designed in a similar manner with five distinct paving strips, however there is not one strip which is completely free of street furniture (Figure 6.27). This is particularly evident at the four locations on the street where road intersections occur. Items of street furniture such as bollards are in particularly high density at these locations to prevent the movement of vehicles onto the pedestrian precinct. Furthermore the high pedestrian flow on both of these streets can often camouflage the presence of street furniture increasing the hazardous and disabling nature of the street. The following two pages contain images and schematic diagrams indicating good and bad examples of the zoning of street furniture.



Cube | Signage | Vendor's Stall | Public WC
Bicycle Rack | Lighting | Litterbin | Seating
Service Box | Telephone Box | Flower Boxes | ATM
Bollard

Figure 6.26: Clear zones on Argyle St (a) photography (b) schematic diagram illustrating zoning of street furniture

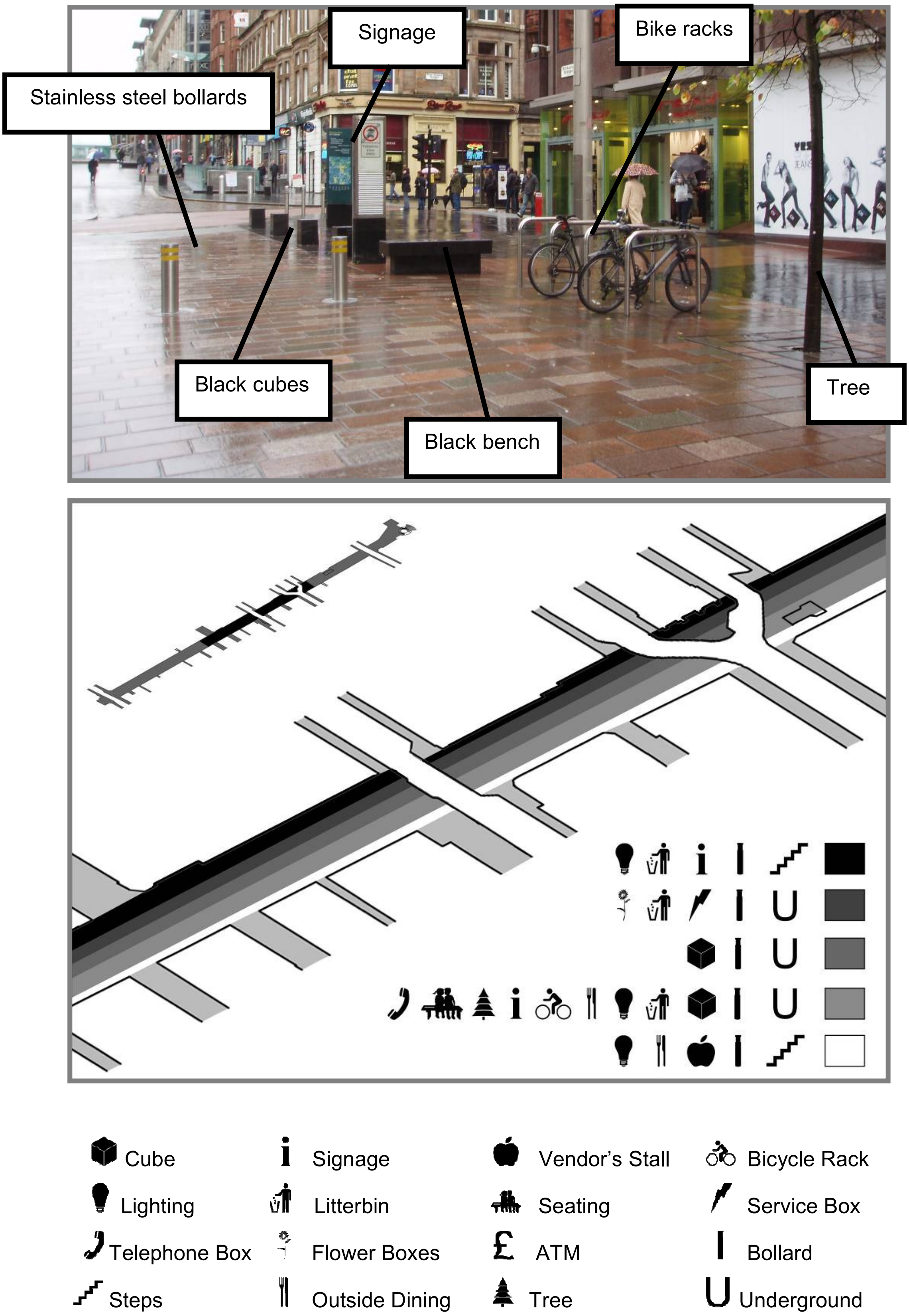


Figure 6.27: Poor zoning of Buchanan St (a) Photograph of cluttered section and (b) schematic diagram illustrating zoning of street furniture

6.7.9. Maintenance

The maintenance of street furniture within the city centre was highlighted as a concern at several locations within the study area. Figure 6.28 illustrates two examples of damaged and poorly maintained items of street furniture. This type of occurrence can be extremely hazardous for the visually impaired pedestrian as it may not be possible for this population to foresee the object and alter their course in order to avoid a collision.

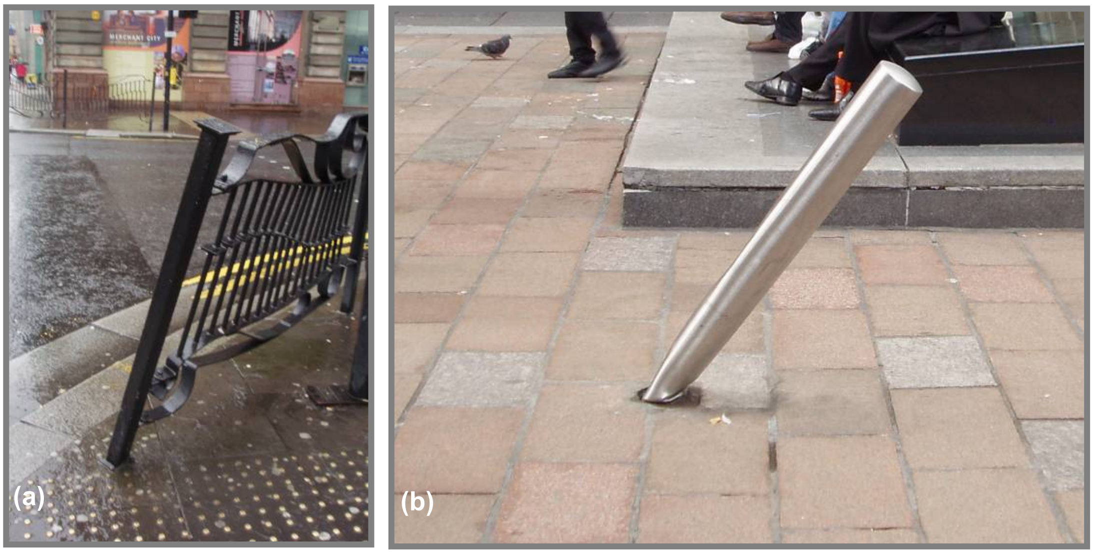


Figure 6.28: Damaged items of street furniture (a) railing on Trongate and (b) bollard on Buchanan St

6.8. Road Crossings

Controlled pedestrian crossing points facilitate the movement of pedestrians between locations within a town or city. The design, layout and general condition of a controlled crossing point can have a significant impact on the movement patterns and hence the ease with which a visually impaired pedestrian is able to access goods facilities and services. A controlled crossing which has not been designed with the needs of visually impaired people in mind can limit movement, evoke a sense of fear and stress and cause accidents and injuries of a significantly more serious nature due to the interaction with moving vehicles. Pey *et al.* (2007) reported that 80% of visually impaired pedestrians experienced difficulties when crossing roads, the majority of which fear for their personal safety and lack confidence when navigating within the built environment (Pey *et al.*, 2007). For this reason it was necessary to investigate and document the presence and location of controlled crossings within the study area in order to assess the level of provision currently available.

There are a number of design elements which can be implemented within a controlled crossing which may enable a visually impaired pedestrian to move around the built environment with greater ease and with less risk to their personal safety. Figure 6.29 illustrates an example of a controlled pedestrian crossing point equipped with a number of assistive features including, (i) tactile warning paving, (ii) tactile spinning cone, (iii) audio signal, (iv) wait light, (v) reflector studs and (vi) dropped kerb. The inclusion of diagrams and images are presented here to further assist in illustrating the features responsible for creating an environment that is either disabling or enabling.

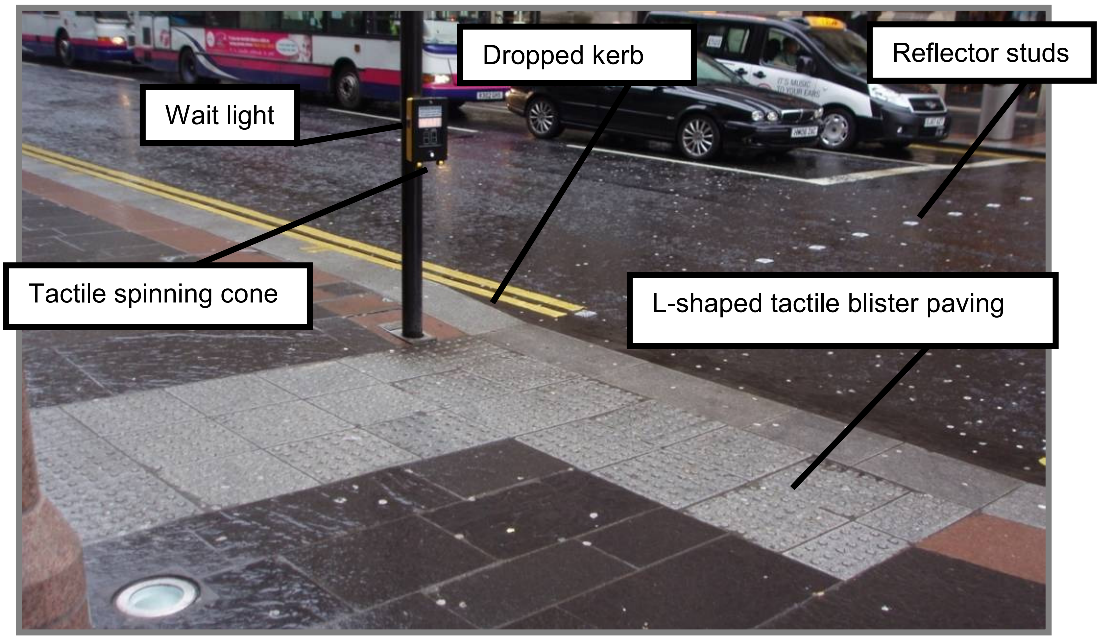


Figure 6.29: Accessible controlled crossing point on Ingram St

6.8.1. Tactile Blister Paving

Tactile blister paving is specifically designed to signify the presence and location of a crossing point across a road. This type of paving can be used at both controlled and uncontrolled crossings. This form of tactile paving consists of parallel rows of flat topped blisters 5mm (± 0.5mm) high, 25mm in diameter, pitch 64 – 67mm (Dept. for Transport, 2002, pp. 9-11). The surface should be laid to a depth of 1200mm in cases where the crossing is in the direct line of travel. At all other crossings, a depth of 800mm should be provided and should extend across the full length of the dropped kerb (Dept. for Transport, 2002, p. 14). A second row of blister paving should extend from the kerb edge and crossing pole at a right angle to a depth 1200mm in the direction of travel across the road (Dept. for Transport, 2002, p. 16). It is the recommendation that red blister paving should be used exclusively at controlled crossing points (Dept. for Transport, 2002, p. 10) in order to avoid confusion with regards to the status of the crossing. This practice was found not to be adhered to at several locations within the study area, including the crossing illustrated in Figure 6.29. Figure 6.30 illustrates three examples of different coloured tactile blister paving recorded during the access audit, (a) red, (b) brass and (c) grey. The presence of different coloured paving types can be extremely confusing to a visually impaired pedestrian as it is contradictory to what many have been taught through mobility training. In addition to providing a tactile warning surface, it is also important that there is a good colour contrast with the surrounding paving in order to provide a visual cue to assist the visually impaired pedestrian in finding the wait button and location of the dropped kerb (Dept. for Transport, 2002, p. 19). The presence of contrasting tactile paving within the study area was found to be sporadic and generally limited to pavements within areas of regeneration. Figure 6.30(d) highlights an occasion where tactile paving is bound by two different coloured paving types, one providing a good colour contrast and the other a poor contrast. Finally it is also important to consider the way in which tactile paving responds under different weather conditions, for example the brass tactile paving (Figure 6.30b) becomes extremely slippery when wet, which may be hazardous to pedestrians of all abilities.

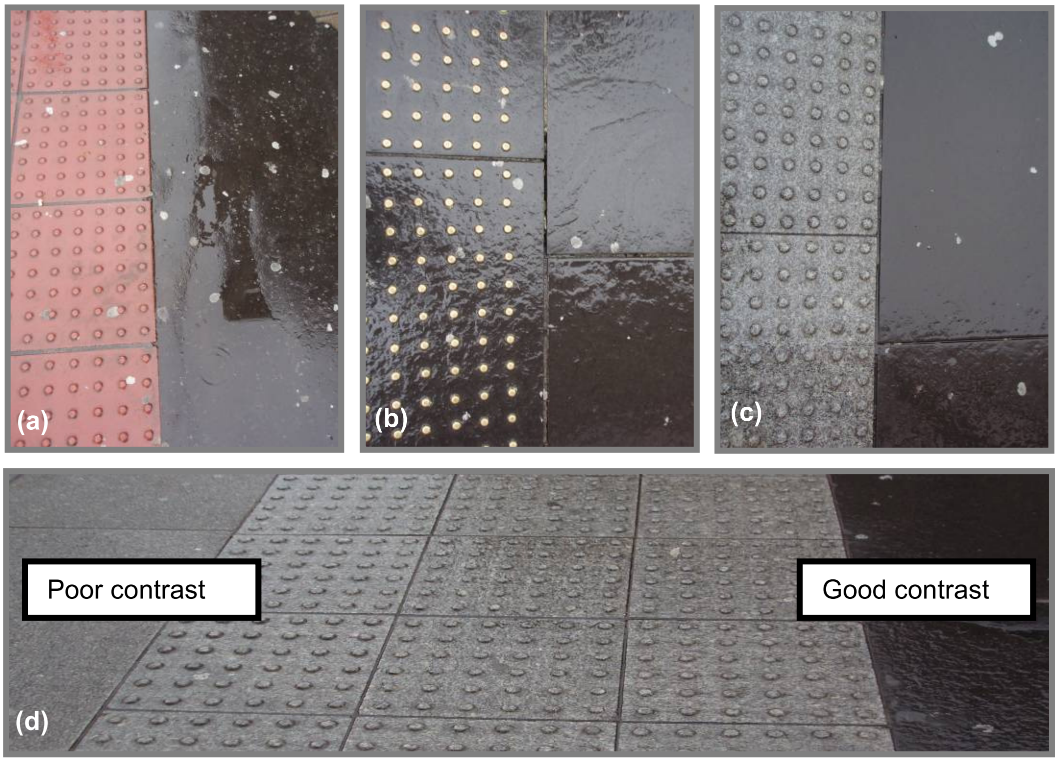


Figure 6.30: Different coloured tactile blister paving, (a) red, (b) brass and (c) grey.

6.8.2. Tactile & Audible Cues

It may often be the case that the visually impaired pedestrian is unable to see the red or green man on the opposite side of the road, indicating whether or not it is safe to cross. The presence of an audio signal or a tactile spinning cone on the underside of the control box (positioned in the bottom right-hand corner) alerts a visually impaired pedestrian when it is safe to cross without the need for relying on visual cues or sighted assistance. The spinning cone rotates when it is safe to cross and when unsafe the cone stops turning. This relatively unknown device can have significant benefits for the visually impaired pedestrian reducing stress associated with crossing a road, increasing independence by reducing the need for sighted assistance and extending the range of travel within the urban environment. However the spinning cone is not without its problems. It was noted that spinning cones may stop working due to maintenance issues, effectively rendering the crossing inaccessible. In this circumstance a visually impaired pedestrian may wait at the crossing for a lengthy period of time before realising that the cone is non-operational. Out of a total of 83 controlled crossings, 55 were equipped with tactile spinning cones, however on the day of the audit almost a quarter (24%) were non-operational. It was also noted that the location of the spinning cone was inconsistent at several locations within the study area. It is recommended that the cone should be located on the right hand side of the bottom of the control box as illustrated in Figure 6.31 (Dept. for Transport, 2005a, p. 17). As these recommendations were not adhered to at all locations, the non-standard positioning of the cone could lead to confusion or the belief that an assistive feature is not present.

An audible signal should also be provided to indicate to visually impaired pedestrians when it is safe to cross the road (Dept. for Transport, 2005a, p. 17). However in the study area this assistive feature was not as widely used as the spinning cone, present at only three controlled crossings and not featuring at junctions. The failure to provide both audible and tactile cues at every pedestrian crossing is contradictory to current advisory guidelines published in Inclusive Mobility. The advice states that *"Tactile indicators should not be considered as a substitute for audible signals as they are required by different people"* (Dept. for Transport, 2005a, p. 17).

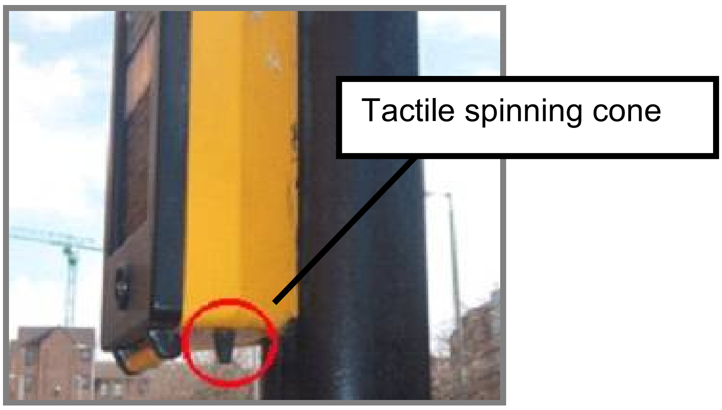


Figure 6.31: Tactile spinning cone located on the underside of the control box

6.8.3. Wait Light

If a visually impaired pedestrian cannot see the red or green man across the road and there is no tactile spinning cone or audible cue present at the crossing, a last option may be to use the wait light in the control box to determine the moment at which it is safe to cross. However, this option may be dependent not only on the amount of useful residual vision of the individual but also the condition of the control box and outside lighting levels. For example on a bright sunny day it may be very difficult to detect the wait light whereas on a dark night it may be easier to identify (Figure 6.32a). It was noted that a large number of wait lights were not working (27%). Furthermore many were covered by stickers and flyers, or had been vandalised (Figure 6.32b). Therefore this method cannot be treated as a reliable assistive feature when crossing roads.

Figure 6.32: Wait light (a) on a dark night and (b) covered over with a sticker

6.8.4. Additional Features

Additional features such as reflector studs and dropped kerbs also assist pedestrians when crossing the road. As illustrated in Figure 6.31, reflector studs located on the road can act as a guide, directing pedestrians to the boundary they should keep within when crossing the road. This boundary can also be marked out using different paving methods, such as brick, bitumen or stone, however it should be noted that none of these paving types featured in the study area.

The presence of dropped kerbs can assist pedestrians by eliminating the additional stress associated with negotiating a level change, benefiting not only individuals with a visual impairment but those with mobility impairments and parents with pushchairs. Although dropped kerbs may be beneficial their presence was not found to be consistent throughout the study area, in turn leading to a level of uncertainty as to the kerb height present when stepping off the pavement onto the road. Indeed it was noted that in several locations a dropped kerb was only present at one side of the crossing which can lead the pedestrian to believe there will not be a level change at the opposite side. This may be particularly hazardous to individuals negotiating the environment without the use of a mobility aid.

6.8.5. Audit of Crossings

The presence of accessible pedestrian crossings or lack thereof can have a significant effect on the way in which a visually impaired individual is able to move between different locations within a town or city. For this reason, a comprehensive audit was conducted, extending the original boundaries of the access audit up until the M8 motorway at Charing Cross (see Figure 6.33). Each controlled crossing point was marked on a map of the city centre and was assigned one of three symbols to indicate whether it was (i) accessible, (ii) inaccessible or (iii) had maintenance issues affecting the tactile spinning cone or audible signal. A controlled crossing was accessible if it was equipped with either a functional tactile spinning cone or an audible signal.

At each controlled crossing it was also recorded if tactile paving and dropped kerbs were present. If there was an issue relating to maintenance, then the nature of the problem was recorded, (for example vandalism). Finally, when a controlled crossing point was not present but it was felt that the area would benefit from one being placed there, this was also noted.

A total number of 83 controlled pedestrian crossings (Figure 6.33a) were located within the study area, out of which 66% were accessible (Figure 6.33b) and 34% were inaccessible (Figure 6.33c) of which 18% had no tactile spinning cone or audible signal, and 16% had maintenance issues which effectively resulted in them being classified as inaccessible at the time that the audit was carried out. This is a significant finding which suggests that if problems with maintenance were addressed regularly, the number of accessible controlled crossings in the study area could be as high as 82%.

The importance of accessible pedestrian crossings in facilitating movement within the city centre is further highlighted in Figure 6.34, which illustrates areas which may be reached by visually impaired individuals if only using accessible controlled crossings (equipped with a functional spinning cone or an audible signal). Starting from Central Station (Figure 6.34a) the provision of accessible crossings allows for large areas of the city to be reached safely and independently by the visually impaired pedestrian. However when starting a journey from either Charing Cross Station in the West (Figure 6.34b) or High St Station in the East (Figure 6.34c) the reachable area is significantly reduced. If however all maintenance issues were resolved, the reachable area, starting from High St Station would significantly expand (Figure 6.34d). This further highlights the importance of implementing a regular maintenance programme.

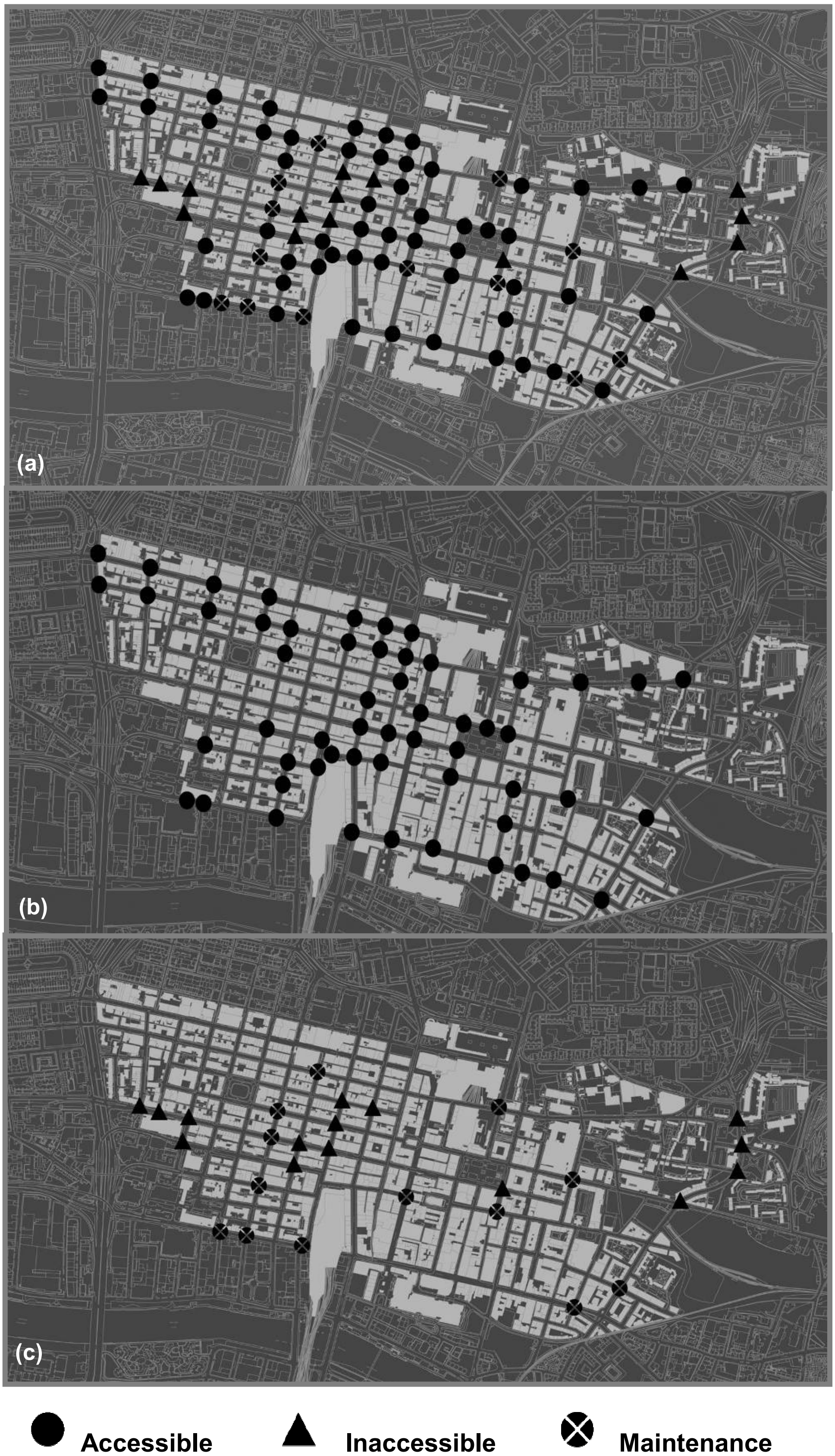


Figure 6.33: Maps of (a) all controlled crossings, (b) all accessible controlled crossings and (c) all inaccessible controlled crossings found within the Study Area

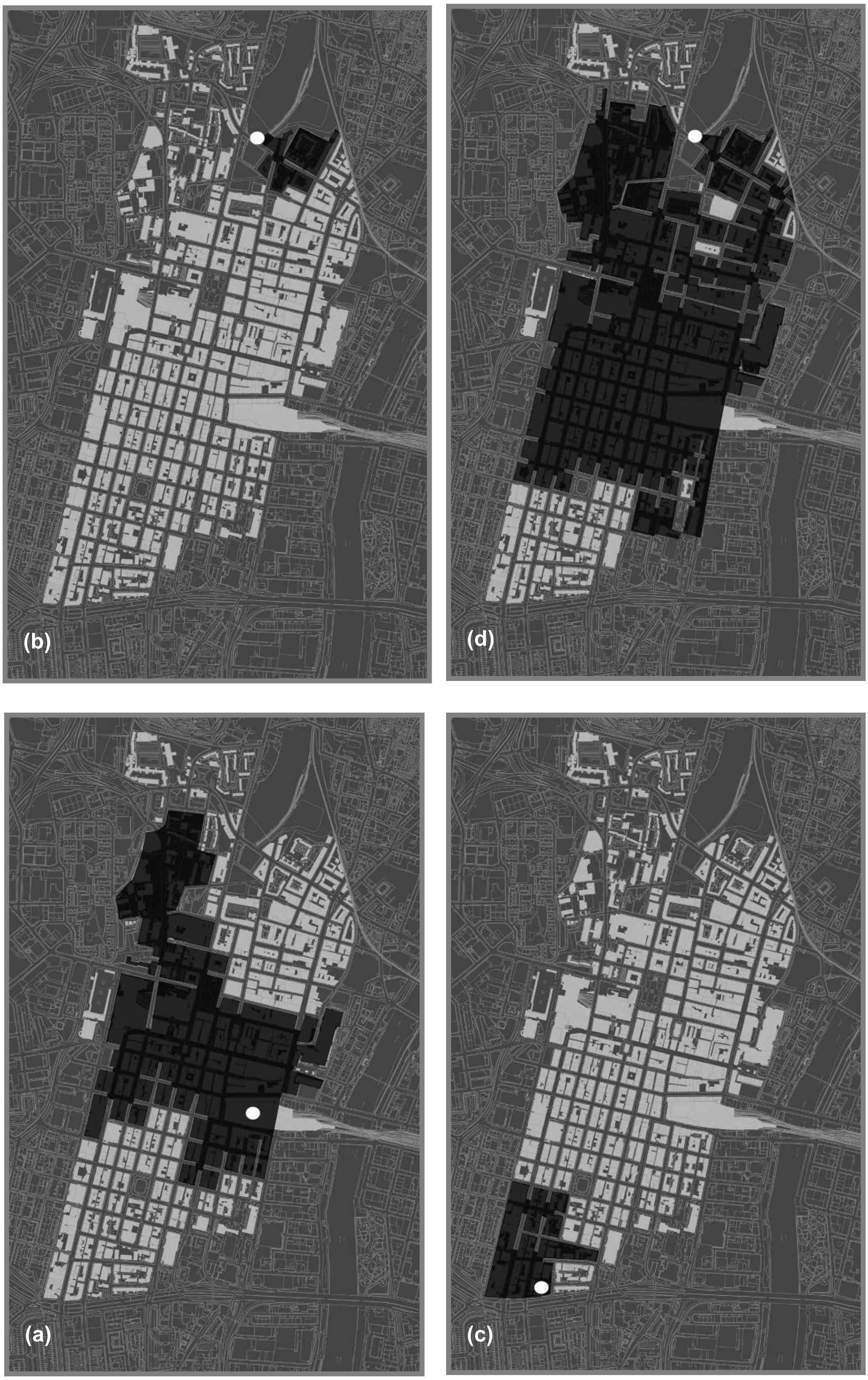


Figure 6.34: Areas which can be accessed using accessible pedestrian crossings starting from (a) Central Station, (b) Charing Cross Station, (c) High St Station and (d) the area which could be accessed from High St Station, if all maintenance issues were resolved

In order for a visually impaired pedestrian to cross a road where there are no accessible crossings present or there are unresolved maintenance issues, they must rely on help from the general public, try and guess when it is safe to cross or ultimately turn around in defeat. This is clearly a worrying and dangerous situation which is unacceptable in this modern age especially when the technology is available to facilitate the movement of individuals with impaired vision. The findings highlight the emergence of a postcode lottery whereby in this example, a person's home address and the train line which they use to enter a town or city can determine the extent to which a visually impaired person is able to participate in even the most basic of activities.

6.9. Conclusion

The access audit formed an important part of the research by expanding on the many themes explored within the survey presented in Chapter 5, through quantifying the number and type of hazards present within a typical external built environment. A total of 35 streets and 2 squares were audited within the boundaries of Glasgow city centre, encompassing shared-space zones, public squares, pedestrian areas and streets of varying vehicular and pedestrian traffic flow. The analysis of everyday spaces within the study area highlights the problematic nature of street design to the disadvantage of not only the visually impaired pedestrian but individuals of all abilities.

One of the main areas of concern relates to the lack of mandatory building regulations and comprehensive guidance documents in place to assist the design of urban streets, particularly taking into account the needs of the visually impaired population. The absence of such regulations and guidance create a situation whereby the treatment of town and city centre streets are dependent on the attitudes and design briefs of local authorities, resulting in a non-standard approach to street design.

It was evident throughout the audit that the dominance of the car disadvantaged pedestrians on a number of levels. The main effect was the high frequency of road signage positioned on pavements, often poorly zoned in the centre of the pavement and badly contrasting with the surrounding environment. The second effect relates to pavements breaking unnecessarily to allow vehicular access into lanes and car parks creating unexpected level changes, as opposed to a design solution whereby the pedestrian has priority over the vehicle as illustrated in Figure 6.14. Finally, the third effect relates to the high frequency of street furniture implemented as a means of controlling vehicular movement, such as bollards and protective barriers.

The audit found several areas of concern in relation to the design and appearance of pavements, the first being the role that utility companies play in shaping the appearance of the urban environment. In areas where paving has been excavated in order to install or maintain services, it was found to be inadequately replaced creating a patchwork, non-uniform appearance often accompanied by uneven surfaces. This change in colour and material is particularly confusing to visually impaired pedestrians as the sudden change in appearance may appear to signify a change in the use or function of the pavement. Within the study area a large number of different paving types were found to be in use, creating an environment of contrasting patterns and colours. Some were found to be beneficial in providing cues to the pedestrian and others detrimental causing confusion due to choice of colour and material, particularly highly patterned paving. Certain materials were found to react and alter in appearance under varying weather conditions, often resulting in shiny, glossy surfaces with glare and reflection, further contributing to the disabling nature of the environment. There was also found to be a large variation in kerb heights across the study area which can lead to uncertainty over the difference in height between the pavement and road at any two given points along the same street. This was particularly the case in parts of the city that had not undergone regeneration. Understandably the pavement widths varied significantly between different streets within the study area. However at several locations the pavement width reduced significantly as a result of the poor zoning of street furniture and subway entrances, resulting in pedestrian congestion.

There was found to be a strong presence of street furniture within the study area, with the most prevalent being the bollard. Notably this was cited as the most hazardous type of street furniture by the visually impaired survey participants. There was a clear difference between the design of old and new street furniture. The majority of modern street furniture was silver / stainless steel, which was highlighted in the survey as being the least visible colour among all types of visual field loss. Older street furniture was generally black, which was rated as more visible in the survey. The zoning of street furniture was also noted as a concern, with many items poorly positioned and obstructing pedestrian flow. Examples included the placement of trees, bollards, bins and lampposts in the centre of the pavement, creating a collision hazard and the potential for accidents and injuries.

The review of road crossings within the study area found that almost one third of controlled crossing points were not equipped with assistive features such as a tactile spinning cone or an audio signal, resulting in them being inaccessible to the visually impaired pedestrian. This creates a situation whereby large areas of the city are effectively transformed into unreachable islands, placing the lives of visually impaired people at risk and severely limiting their movement, preventing them from accessing goods, facilities and services. Furthermore the design and layout of pedestrian crossings varied considerably. In cases where tactile paving was used there was found to be a variety of colours and materials. Additionally, the location of tactile spinning cones was inconsistent at numerous crossing points. This non-standardised design approach further complicates the visually impaired pedestrian's ability to navigate the city.

Maintenance was a recurring issue which was found to affect all aspects of the built environment. Paving materials, kerb edges and drain covers were found to be cracked and missing, items of street furniture were broken and positioned at dangerous angles and pedestrian crossings suffered from vandalism and the breakdown of tactile spinning cones and wait light bulbs. Although these instances may not seem to pose a serious problem to the fully sighted pedestrian, the effect this has on the visually impaired individual can be significant. Repairing all of the broken and damaged elements within the city is a simple, straightforward measure which would bring instant benefits to visually impaired pedestrians. This would suggest that a structured maintenance programme should be developed in order to resolve issues as quickly as possible and eliminate unnecessary barriers.

The overall findings of the audit generally demonstrate a lack of consistency with regards to design features, street layouts and the presence of assistive cues to aid navigation, such as tactile paving and spinning cones. This can be considerably confusing to a visually impaired pedestrian as there is no logic to a particular space. It can also affect a person's ability to reference and associate specific features and situations with relation to a particular standardised material.

Despite the existence of best practice guidance documents it was apparent throughout the access audit that minimal attempts have been made to conform to best practice standards. This was particularly evident with respect to design specifications such as dimensions and materiality, zoning and layout, colour and contrast, presence of assistive features, and general maintenance. This is of great concern as it suggests that local authorities are designing and constructing disabling environments as a result of the lack of mandatory regulations and failure to implement best practice design solutions. It is therefore recommended that additional mandatory regulations are enforced in order to create safer, accessible environments that are sympathetic to the needs of the visually impaired user.

In order to investigate how the many features identified within the survey and access audit affect the movement of the visually impaired pedestrian, a series of navigational experiments were undertaken to examine the movements of this population between two specified locations within the study area, details of which are presented in Chapter 7.

Chapter 7: The Disabling Nature of the City – Navigational Experiment

7.1. Introduction

The external built environment can vary significantly between locations within a city, region or country and as such, the unpredictable topography can either be a challenging or assistive platform when designing and implementing features and facilities within the public realm. In order that our public streets, squares, parks and approaches to buildings are designed in a way that does not discriminate against or compromise the safety of the end user, it is important that designers, architects and policy makers have an understanding of the possible impact that their design decisions may have, as it is often the case that the most vulnerable citizens within society are also the most likely to suffer from poorly designed spaces. Everyday elements within the built environment can present significant problems for the visually impaired pedestrian as outlined by Golledge:

> "…gutters become chasms, sidewalks and streets become treacherous paths, stairs may be impossible cliffs, distinctive sizes, shapes or colors may lose their significance, layout becomes a maze, maps and models may be uninterpretable…"
>
> (Golledge, 1993, p. 64)

The navigational experiments provide a platform for examining the extent to which everyday elements previously outlined in the questionnaire and access audit, disable the visually impaired pedestrian. In order to achieve this aim, a series of navigational experiments were conducted within the boundary of the study area previously defined in Section 6.4. In more detail, the experiments will be used to assess the navigational behaviour with respect to the type of visual field loss, the age of diagnosis of visual Impairment, the type of mobility aid used and to a lesser extent, the age and gender of participants. The inclusion of a sighted control group enables a comparison between both groups in terms of the overall time taken and distance travelled.

Furthermore, the experiments will test the theories relating to cognitive mapping abilities and spatial awareness of the visually impaired population as previously outlined in Section 4.2.3. It should be noted that the navigational experiments are designed to be complementary to the survey and access audit and not representative of the abilities and performance of the general visually impaired population.

7.2. Previous Experiments in External Environments

As highlighted in Chapter 4, a number of studies have been conducted involving blind, visually impaired and fully sighted participants both in familiar and unfamiliar external environments. The location for such studies has ranged from University campuses and suburban settings to complex urban areas (Blades *et al.*, 2002; Espinosa *et al.*, 1998; Jacobson *et al.*, 1998). The main aim of these studies was specifically related to the investigation of the learning capabilities of the visually impaired population, some by comparing direct experience with learning via tactile maps. All of these studies provide evidence which suggests that visually impaired people are capable of learning external routes successfully. However, Golledge, (1993), Kitchin *et al.*, (1997) and Golledge *et al.*, (1999) have all highlighted the lack of previous research carried out in large-scale urban environments and have stressed the practical importance of such studies. Moreover with the knowledge that the visually impaired population are able to learn new routes successfully using cognitive mapping abilities, further investigation is required to observe this population during navigation to identify which features inherent within the built environment have an influence on their independent travel behaviour. Kitchin & Jacobson (1997) and Ungar (2000) highlight the need for more research to be carried out specifically focusing on visually impaired people with varying degrees and types of vision loss. Studies have indicated that prior visual experience, particularly with peripheral vision, is important in the development of spatial cognition (Rieser *et al.*, 1982), thus it is also important to analyse navigational behaviour of visually impaired people taking into account the age of onset and type of visual field loss.

Although much research has focused on the spatio-cognitive abilities of blind and visually impaired people, little information has been obtained as to the environmental cues which are used by this population during independent navigation (Golledge, 1993). Given that it is now generally accepted that visually impaired people do have spatio-cognitive abilities sufficient to learn unfamiliar environments and to navigate with efficiency, the navigational experiment presented in this chapter was designed to observe the independent navigational behaviour of visually impaired individuals within a familiar complex urban environment, thus removing the debate / questions over the spatio-cognitive abilities of the visually impaired population. Instead the analysis will focus on observing the main features or factors influencing, aiding or having a detrimental effect on travel.

7.3. Objectives

The main objectives of the navigational task are:

- To compare time taken, distance travelled and route selected during the navigational task between visually impaired and sighted participants.
- To compare similarities and differences between route, time and distance recorded between the different types of visual impairments.
- To compare similarities and differences between route time and distance recorded between the congenitally and adventitiously blind groups.
- To compare the independent navigational behaviour between participants who make use of different mobility aids.
- To investigate the level of spatio-cognitive abilities between the fully sighted and visually impaired groups.

- To investigate the level of spatio-cognitive abilities between participants with different types of vision loss, age and gender.

- To investigate the level of spatio-cognitive abilities between the congenitally and adventitiously blind groups.

- To identify common verbal utterances between groups of different vision loss.

- To identify problematic features within the built environment.

With these in mind, the following Sections will present the methodology adopted to address the objectives and the analysis of the findings.

7.4. Methodology

7.4.1. Ethical Considerations

Full ethical considerations were taken into account prior to the design of the navigational experiment in accordance with the regulations set out by the Research and Consultancy Services at the University of Strathclyde (University of Strathclyde, 2009). Informed consent was a prerequisite for participation in the experiment, participants were provided with an information pack (see Appendix C) explaining the nature, purpose and aims of the experiment. Furthermore, prior to participation, participants were required to accept or decline the terms and conditions detailed within the project disclaimer. Participation was entirely voluntary and participants were permitted to cease participation at any time during the experiment without giving a reason. Participants were required to provide details of any other medical conditions other than their visual impairment which may affect their performance during the navigational experiment. If any medical conditions were disclosed which were believed to incur significant risk to an individual's mental or physical health then they were not chosen to take part in the experiment. Finally, participants were accompanied by a sighted assistant throughout all stages of the experiment to further reduce any risk to their wellbeing.

7.4.2. Recruitment

In order for comparisons to be made between the travel behaviour of individuals with different types and degree of vision loss, it was necessary to source an even number of participants who are affected by central, peripheral and mixed vision loss. The involvement of fully sighted individuals also allows for a detailed comparison to be made in terms of the time, distance and route taken between individuals with a visual impairment and those not affected by visual field loss. All of the visually impaired participants involved in the navigational experiment were recruited directly through an invitation located in the final section of the survey (Chapter 5), where involvement in the experiment was entirely voluntary. Participation was encouraged from individuals of all ages, gender, type of vision loss, age of onset of vision loss, type of mobility aid (if any used) and level of independence and confidence. However the experiment was restricted to individuals who were familiar with the city centre of Glasgow. Although this decision limited the number of potential volunteers, it reduced the number of variables and helped to focus the investigation away from testing theories relating spatio-cognitive abilities to the architectural features within the built environment which may have an influence on travel behaviour. The fully sighted volunteers were recruited through an advertisement placed within the University of Strathclyde electronic notice board, known as Pegasus. As with the visually impaired participants, each volunteer was required to have knowledge of Glasgow city centre and were selected to reflect a varied range of age and gender.

7.4.3. Experimental Location

The navigational experiment was conducted in the same location covered by the access audit. By selecting this location it would be possible to identify which features highlighted within the questionnaire and later identified during the access audit present the greatest difficulty to visually impaired pedestrians and which may have a potential influence on the choice of route taken. As was described in section 6.4 of Chapter 6, the study area is located within the grid pattern of Glasgow city centre and contains a large variety of land use types, including several major transportation hubs, a University campus, numerous public squares, pedestrian shopping streets, shared space zones and various intersections with busy roads. Figure 7.1 illustrates the start and end points for the navigational experiment. The route was chosen in order to reflect a typical journey that may be made between two locations within the city centre. For this reason, Dundas Street was chosen as the start point as it is surrounded by a large number of transportation links including national and regional rail services, Glasgow underground network, taxi rank and regional and national bus services including the airport bus link. The end point for the experiment was the Tron Theatre, a recreational and leisure destination located approximately 1.1Km in a south easterly direction from the starting point of Dundas Street. The location of the theatre provides the opportunity for a number of different routes to be selected passing through pedestrian zones, public squares, shared space zones and pavements and roads of varying width and traffic flow.

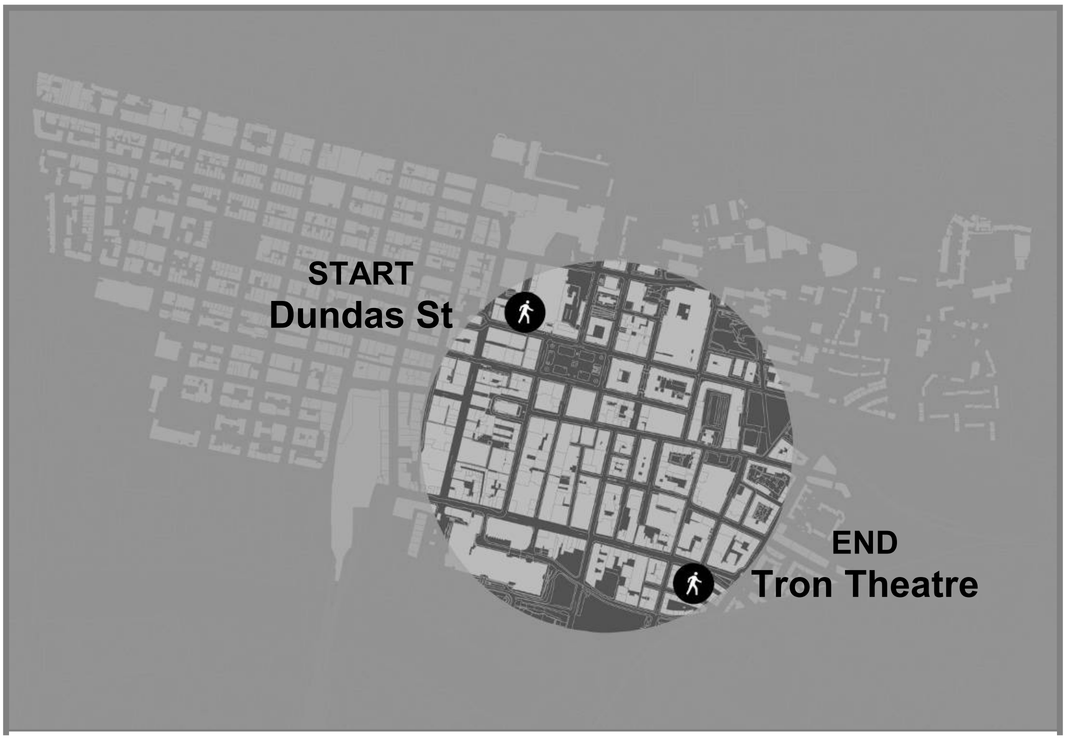


Figure 7.1: Location of navigational experiment indicating start and end point

7.4.4. What was Recorded

The navigational experiments were performed on an individual basis and were designed to replicate as much as is reasonably possible a normal unaccompanied journey within a city centre environment. Each participant was allocated a day and time for the experiment, all of which were scheduled for a week day either in the morning at 10am or in the afternoon at 2pm. The timeslots were chosen in order to avoid the peak times of the morning, lunchtime and early evening when the pavements and roads would have higher levels of pedestrian and vehicular traffic. This decision also reduced the number of variables under investigation such as the possible influence that increased pedestrian and vehicular traffic may have on the performance of the participants, possibly affecting the time, distance and route taken between Dundas Street and the Tron Theatre. This also ensured consistency between the pavement, road and light conditions during each separate experiment.

Prior to the experiment, participants were unaware of the full details of the task requirements, apart from a basic understanding that they would be involved in a navigational experiment between two locations within Glasgow city centre. This was a conscious decision as it removed any possibilities of the participants planning their route before the commencement of the task. On arrival at Dundas Street, participants were greeted and given details of the planned experiment. Each participant was given the same scenario whereby they have just arrived into Glasgow city centre either by bus, taxi, train or underground and are travelling to the Tron Theatre to watch a performance. They were then asked to plan their route and provide reasons for their decision. The planned route was then compared with the actual route taken at the end of the journey and if the two routes differed this was discussed in the post-experiment interview. The route of each participant was recorded in terms of the route chosen (represented on a large scale map), the time taken (using a digital stopwatch), the distance travelled (using a pedometer) and any verbal utterances made during the journey (using a digital recorder). The weather conditions were also recorded in the event that they may influence the performance of a participant. For example, snow and ice may reduce the walking speed and result in a change to the planned route in order to avoid smaller side streets which have not undergone treatment to remove ice patches. Similarly, strong sunlight and rain may cause glare, shadows and reflection, in turn increasing the time taken to complete the experiment. Where applicable, any influence the weather has had on a participant's performance is taken into account when analysing the results.

On completion of the experiment, each participant was required to participate in a task to assess their level of spatial awareness and cognitive mapping abilities. While at the Tron Theatre location, each participant was asked to imagine that they were standing at the starting point on Dundas Street facing in a southerly direction. They were then asked to point towards the location of the Tron Theatre using a high contrast tactile pointer made from a compass and protractor. The second phase involved repeating the pointing task, this time facing north and pointing to the direction of the starting point (Dundas Street). The results from this stage of the research are used to identify whether a relationship exists between the level of spatial awareness and cognitive mapping abilities and the age of onset of an individual's visual impairment or the type of vision loss.

After completing the final pointing task, participants were invited to take part in a post discussion interview lasting approximately 30 minutes. This provided them with the opportunity to discuss any issues relating to the navigational experiment, such as any problematic features encountered along the route and the use of any environmental cues. The interview also provided participants with the opportunity to expand on any issues relating to themes contained within the questionnaire. The deliberations from the interviews are further discussed in Section 7.9.

7.5. Demographics

7.5.1. Gender

A total of twenty individuals participated in the navigational experiment, out of which fifteen were visually impaired or blind and five were fully sighted. Table 7.1 details the gender division of the participants. The visually impaired group consisted of ten females and five males and the sighted control group contained three females and two males.

Table 7.1: Gender of participants

Gender (number)	Male	Female
Visually impaired	5	15
Fully sighted	2	3

7.5.2. Age Group

Participation in the navigational experiment was restricted to individuals over the age of 16 however no upper age limit was enforced. This resulted in a test sample of participants covering a broad spectrum of ages, with the youngest aged 22 and the oldest aged 83. The age distribution of visually impaired participants within the experiment is therefore representative of the many views, experiences and abilities spanning several generations within society. This ensured that the results are not biased towards the views of any one particular age group. The age distributions of participants within the visually impaired and sighted control group are presented in Table 7.2.

Table 7.2: Number of participants according to age group

Age Group (number)	16-24	25-34	35-44	45-54	55-64	65+
Visually impaired	1	5	4	1	2	2
Fully sighted		3	1			1

7.5.3. Type of Vision Loss

Table 7.3 details the type of vision loss including the many eye pathologies experienced by the visually impaired individuals participating in the experiment. Eye conditions involving visual field loss had the highest prevelence, with a total of 12 out of 15 participants reporting either central vision loss (4), peripheral vision loss (4) or mixed vision loss (4). Two participants were blind and one participant had a condition not responsible for affecting visual field loss, but rather in this case, visual acuity. A total of 14 different eye conditions were listed as responsible for causing the reduction / loss in vision and are listed in Table 7.3.

Table 7.3: Number of participants according to vision loss group & eye pathology

Type of vision loss	Central loss	Peripheral loss	Mixed loss	Blind	Other
Number	**4**	**4**	**4**	**2**	**1**
Eye pathology	AMD (2)	Retinitis Pigmentosa	Aniridia	Micro ophthalmia	Nystagmus
	Macular disease	Periventric-ular leukomalac-ia	Congenital Cataracts	Retinobla-stoma	
	Lebers Disease	Glaucoma	Premature birth		
		Accident	Cataract		

7.5.4. Age of Diagnosis

Table 7.4 presents the distribution of respondents according to the age at which they were diagnosed with their eye condition. There is a broad distribution of ages at which partcipants were diagnosed, allowing for an almost equal division between those clasified as early blind (7) and those classified as late blind (8).

Table 7.4: Number of participants according to age of diagnosis of eye condition

	Early blind			Late blind			
Age of diagnosis	**Birth**	**0-3**	**4-12**	**13-21**	**22- 40**	**41-59**	**60+**
	4	1	2	2	1	3	2
Overall		**7**			**8**		

7.5.5. Mobility Aid

A total of 7 participants made use of a mobility aid during the experiment. This included the use of a long cane (three users of which two had peripheral vision loss and one was blind), guide dog (two users of which one had peripheral vision loss and one was blind) and symbol cane (two users of which both had central vision loss). A significant proportion of participants (8) completed the experiment without the use of a mobility aid (see Table 7.5).

Table 7.5: Number of participants making use of a mobility aid during experiment

Mobility Aid	None	Guide dog	Symbol cane	Long cane
Number of participants	8	2	2	3

7.6. Time Taken & Distance Travelled

The time and distance taken to complete the journey from Dundas Street to the Tron theatre was recorded and analysed in terms of (i) the age of participants, (ii) the differences between fully sighted and visually impaired individuals, (iii) differences / similarities between the journey times of the various vision loss groups, (iv) the age of diagnosis and (v) the use of a mobility aid. Results of which are given below.

7.6.1. Age Group

The average time and distance taken to complete the experiment according to the age group of participants are listed in Table 7.6. It may have been perceived that the journey time would lengthen in response to an increase in age and associated age related health conditions; however there appears to be no relationship between the age of an individual and the time taken to complete the route. The average time for the youngest age group (16 - 24) was 19:09, compared with 16:44 for the oldest age group (65+). These findings would suggest that the time taken to complete the experiment and overall distance travelled are influenced more by the type of visual impairment, degree of vision loss and level of confidence during independent travel, rather than the age of participants.

Table 7.6: Average time and distance according to age group

Age Group	16-24	25-34	35-44	45-54	55-64	65+
Avg. Time (mins)	**19:09**	15:02	15:04	19:17	16:29	16:44
Avg. steps	**1751**	1367	1364	1332	1574	1216
Avg. Distance (km)	**1.33**	1.04	1.04	1.01	1.20	0.96

7.6.2. Type of Vision Loss

There was found to be a significant difference between the average journey times recorded for the visually impaired and fully sighted participants. The fully sighted group took an average time of 8:54, while the visually impaired participants delivered an average time of 17:07, equating to a completion time over twice that of their sighted counterparts (see Table 7.7). There was also a notable difference with regards to the number of steps taken and average distance travelled between the visually impaired and fully sighted control group. An average distance of 1411 steps (1.07km) was recorded for the visually impaired group compared to an average of 999 steps (0.76km) for the fully sighted group; equating to a difference of 412 steps (0.31km). For full details see Table 7.8.

Table 7.7: Average completion time according to type of vision loss

Type of vision loss	Central loss	Peripheral loss	Mixed loss	Blind	Other	Fully sighted
Avg. time (mins)	16:25	**18:01**	16.57	17:57	16:16	8:54
Total Avg. time (mins)	**17:07**					**8:54**

Table 7.8: Average distance travelled according to type of vision loss

Type of vision loss	Central loss	Peripheral loss	Mixed loss	Blind	Other	Fully sighted
Avg. steps	1321	**1519**	1443	1423	1185	999
Avg. distance (km)	1.01	**1.15**	1.11	1.08	0.90	0.76
Avg. total distance	**(1411 steps) (1.07 km)**					**999 steps 0.76 km**

Within the visually impaired group there was a time difference of 2:15 between the fastest and slowest walking speeds. The fastest time was completed by an individual with Nystagmus, a condition affecting visual acuity. Within the visual field loss categories, the fastest average time was for individuals with central vision loss, followed by mixed vision loss and total blindness. Individuals with peripheral vision loss took the longest time to complete the experiment and also travelled a greater distance then any of the other visual field loss categories (see tables 7.7 and 7.8). This finding is significant as it builds upon the results from the survey (presented in Chapter 5) which found that individuals with peripheral vision loss rated physical pavement features and items of street furniture as more hazardous than any other visual field loss category. Furthermore the results reflect those from Marron and Bailey, (1982) and Rieser *et al.*, (1992) who found that individuals with peripheral vision loss perform significantly worse than other vision loss categories, including the congenitally blind (see Section 4.5.2).

7.6.3. Age of Diagnosis

There were clear distinctions with regards to the time taken and distance travelled between individuals diagnosed before the age of twelve (early blind) and individuals diagnosed from the age of thirteen onwards (late blind). In particular, the early blind group took less time to complete the experiment and travelled a shorter overall distance than the late blind group (see tables 7.9 and 7.10). These findings support the view that prior visual experience is not necessary in order to use spatio cognitive skills effectively (Passini *et al.*,1990). Furthermore the results build upon findings from the survey (Chapter 5) which found that the early blind category rated factors and features associated with the design of the built environment as less influential, problematic and hazardous than those in the late blind group. This suggests that this population (early blind) are more confident independent travellers, perhaps due to the increased time spent navigating in a world with low vision (see Section 4.5.1).

Table 7.9: Average completion time according to age of diagnosis

Age of diagnosis	Early blind			Late blind			
	Birth	0-3	4-12	13-21	22-40	41-59	60+
Avg time (mins)	16:29	15:01	18:45	18:14	16:28	17:22	16:44
Total avg time (mins)	**16:45**			**17:12**			

Table 7.10: Average distance travelled according to age of diagnosis

Age of diagnosis	Early blind			Late blind			
	Birth	0-3	4-12	13-21	22-40	41-59	60+
Avg distance (steps)	1464	1388	1307	1519	1403	1478	1216
Avg distance (km)	1.12	1.06	1.00	1.16	1.10	1.13	0.93
Total avg distance	**(1382 steps) (1.06 km)**			**(1404 steps) (1.08 km)**			

7.6.4. Mobility Aid

There was found to be a link with regards to the time taken and distance travelled between individuals who use a mobility aid and those who do not. Individuals, who made use of a mobility aid, in particular a guide dog or long cane, took more time to complete the experiment and walked a greater distance than individuals who travel without the use of an aid (see Table 7.11). This finding is however perhaps more related to the type and degree of visual field loss and not the influence of a specific mobility aid. The two participants who used a guide dog and three users of a long cane all had a severe reduction in their visual field and were either fully blind or affected by peripheral vision loss.

Table 7.11: Average time and distance according to type of mobility aid

Mobility Aid	None	Guide dog	Symbol cane	Long cane
Avg total time (mins)	16:33	**19:52**	16:44	17:07
Avg distance (steps)	1427	1456	1216	**1469**
Avg distance (km)	1.10	1.11	0.93	**1.12**

7.7. Route Chosen

The routes traversed by the fifteen visually impaired and five sighted participants are presented by means of a colour coded diagram in Figure 7.2. There were found to be significant variations between the different route strategies adopted by the visually impaired and fully sighted participants. These strategic choices are perhaps responsible for the notable differences between the time taken and distance travelled between the two groups. All of the visually impaired participants with the exception of one, made a conscious decision to avoid traversing the most direct route in a south east direction via George Square and the Merchant City in favour of a route which incorporated minimal streets and road crossings, even if it involved walking in the opposite direction from the end destination for part of

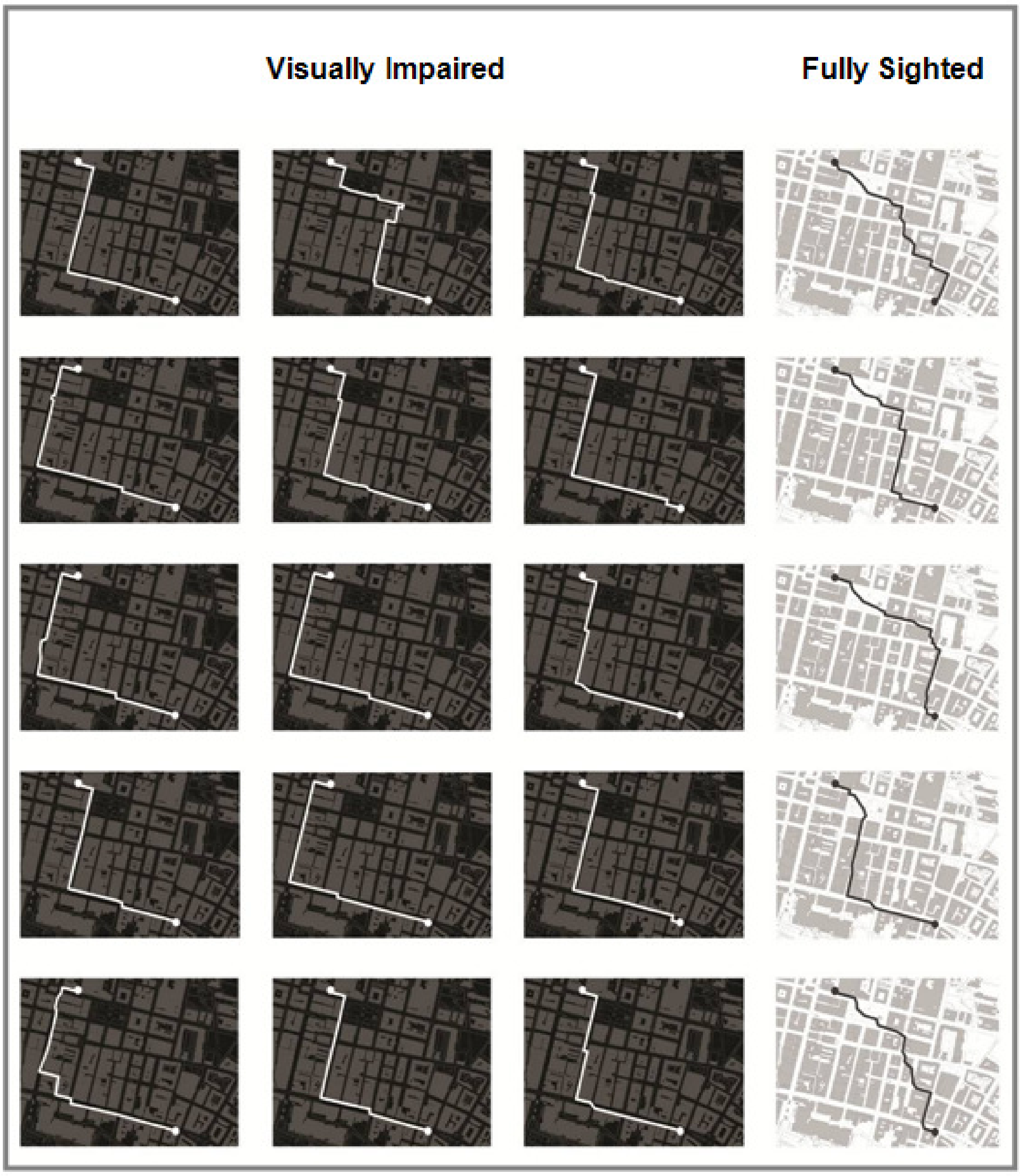


Figure 7.2: Routes taken by visually impaired (black background) and fully sighted (white background)

the journey. The routes chosen by the fully sighted participants incorporated many more streets, and changes of direction, with a typical route encompassing an average of ten streets, compared to an average of four for the visually impaired group. Problems were experienced by all visually impaired participants regardless of their age, gender, type of visual field loss, age of diagnosis or use of a mobility aid. However a significantly higher number of incidents were recorded involving individuals with peripheral vision loss and those who are fully blind, all of whom used either a guide dog or a long cane during the experiment. The three main strategies adopted by the visually impaired participants are described in separate narratives below. Reference is made as to the main hazards present within each route and the degree to which they influence the movement of individuals with different types and degree of visual field loss.

7.7.1. Strategy A

The most popular strategy among the visually impaired participants was the Queen Street – Argyle Street option (as illustrated in Figure 7.3). A total of nine visually impaired participants traversed this route, all of whom were able to successfully complete their planned route, albeit encountering problems during their journey. This strategy involved the participation of three individuals with peripheral vision loss, two with mixed vision loss, two with central vision loss, one blind and one with another condition not affecting visual field loss but rather a reduction in visual acuity.

The route covered five streets of varying pavement width, pedestrian and vehicular flow and function as well as the necessity to cross five roads all of which were equipped with controlled pedestrian crossing points. Problems were experienced by all participants along the route with relation to pavement design, street furniture and road crossings. Details of hazardous features are provided below on a street by street basis and are further highlighted in Figure 7.3 by means of an annotated map.

Stage 1 - West George Street

From the starting point at the end of Dundas Street, participants walked east along West George Street for a distance of 76 metres until reaching the first controlled pedestrian crossing point. This stage of the route caused few problems for the participants; however the positioning of a bus shelter, telephone boxes and an ATM cash machine on the kerb edge reduced the width of the pavement creating pedestrian congestion requiring additional concentration and a reduction in walking speed (see Figure 7.3 location A). Participants made use of the tactile paving to locate the pedestrian crossing. The majority used the tactile spinning cone to determine the time at which it was safe to cross, however one participant with central vision loss stated that she preferred not to rely on the spinning cone as in her experience the cones are often not operational; therefore she made use of sighted assistance at every controlled pedestrian crossing along the route.

Stage 2 - George Square

Participants then walked south along the western perimeter of George Square for a distance of 96 metres until reaching the second controlled crossing point. No problems were reported with the design and condition of the pavement however the presence of scaffolding created problems for individuals with all types and degree of visual field loss, (see Figure 7.3 location B). The scaffolding was very difficult to detect and many were unaware of its presence due to the absence of a protective barrier or high visibility markings. The scaffolding also caused many to significantly reduce their walking speed. Once again the pedestrian crossing was equipped with tactile paving and a spinning cone and all were able to cross with ease with the exception of one participant who walked into a stationary car in the centre of the crossing point.

Stage 3 - Queen Street

Participants then walked south on Queen Street for a distance of 0.3km. A number of problems were encountered along this stretch of pavement with relation to the design and layout of the pavement, the positioning of unexpected obstacles and the zoning and design of pedestrian crossing points. The first potentially hazardous feature to be encountered were unmarked tapered steps outside of the entrance to the Gallery of Modern Art and marking the boundary of Royal Exchange Square (see Figure 7.3 location C). The participants were unaware of the level change on their right hand side, three accidentally walked onto the steps at which point sighted assistance was required to help the participants negotiate the level change.

The second feature to cause confusion relates to the design, colour and pattern of the paving material. Problems were experienced with a double banded strip at the kerb edge which to many appeared as if it was a level change (Figure 7.3 location D). The type of paving in use to denote the presence of a vehicular entrance caused confusion among a participant with central vision loss, as the same paving is also used to signify the entrance to an important building (Figure 7.3 location E).

The presence of white bags filled with refuge also caused problems (Figure 7.3 location F). The rubbish bags are not a permanent feature on the pavement and are only present on collection day. They were positioned at the kerb edge and centre of the pavement and caused alarm among many upon contact.

The pedestrian crossing at the junction of Queen Street and Argyle Street caused problems for all nine participants due to the non-standard zoning and design. Unlike other pedestrian crossings where the crossing pole and tactile cone are positioned to the top right corner of the tactile paving and bottom right of the control box respectively, the opposite applies here. All of the participants experienced difficulty finding the crossing pole, including two users of a guide dog. It should be noted that guide dogs are trained to find a crossing pole on the right hand side of a crossing; therefore a situation of this nature will be confusing for the guide dog who may believe that no pole is present. As the spinning cone was not in the location where many were expecting to find it, all of the participants believed that the crossing was not equipped with any assistive features and requested sighted assistance to enable them to cross the road safely (see Figure 7.3 location G).

Stage 4 - Argyle Street

Participants then walked east along Argyle Street for a distance of 0.2km until reaching the next pedestrian crossing. This section of the route was fully pedestrianised and at the time of the experiment the pedestrian flow was fairly low. The main problems were caused by the irregular zoning and poor colour contrast of many items of street furniture. One participant collided with a newspaper kiosk (Figure 7.3 location H) and five participants avoided a near collision with a series of decorative cubes due to their poor colour contrast with the surrounding paving (Figure 7.3 location I). There were also numerous collisions with advertisement A-boards outside shop entrances (Figure 7.3 location J). A particularly hazardous feature in the form of a stainless steel bollard (Figure 7.3 location K) caused problems for six participants. The bollard is located in the close vicinity to the pedestrian crossing at the end of the pedestrian area and is situated in the direct line of pedestrian traffic. The poor colour contrast made this feature extremely hazardous for all participants.

Stage 5 - Trongate

After leaving the wide expanse of Argyle Street, participants continued their journey along Trongate for 0.2km before reaching their destination of the Tron Theatre. The pavement width was significantly narrower than at previous sections along the route. This created moderate to high levels of pedestrian congestion which had an effect on walking speed, concentration, confidence and stress levels. Several participants collided with other pedestrians on numerous occasions along this section. The pavement further reduced in width as a result from a large glass and stainless steel bus shelter outside the entrance to a supermarket (Figure 7.3 location L). The presence of scaffolding narrowed the pavement further and three participants commented on the difficulties they experience coping with sudden changes in light levels from bright to dark to bright again, as they walked underneath (Figure 7.3 location M).

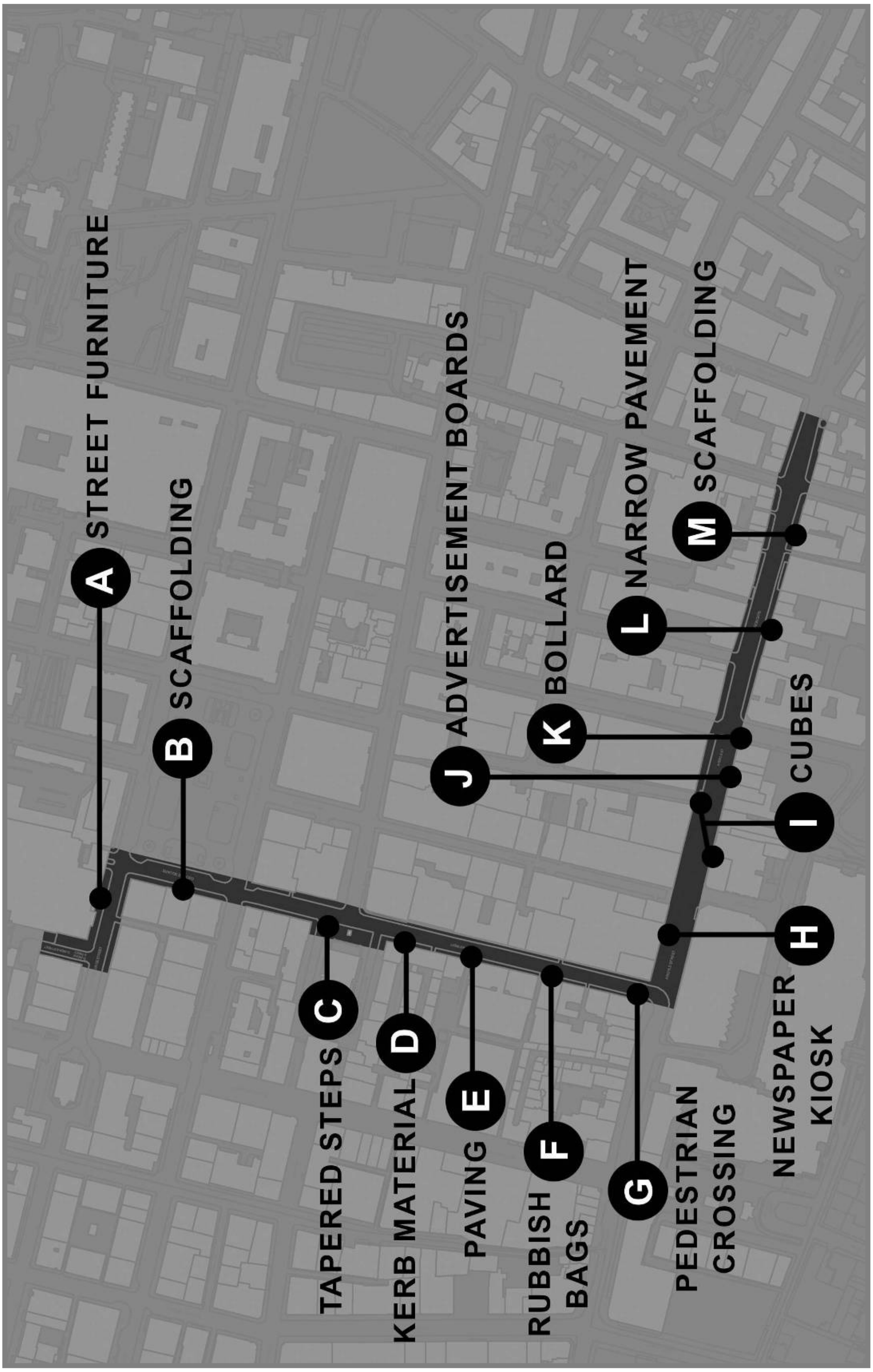


Figure 7.3: Strategy A, Queen Street – Argyle Street

7.7.2. Strategy B

The next most popular strategy was the Buchanan Street – Argyle Street option, (as illustrated in Figure 7.4). A total of five visually impaired participants traversed this route, all of whom were able to successfully complete their planned route, albeit encountering problems during their journey. This strategy was adopted by two individuals with mixed vision loss, one with central vision loss, one with peripheral vision loss and one who was fully blind.

The route covered four streets of varying pavement width, pedestrian and vehicular flow and function as well as the necessity to cross six roads, five of which were equipped with controlled pedestrian crossing points. As with Route A, problems were experienced by all participants along the route with relation to pavement design, street furniture and road crossings. Details of hazardous features are provided below on a street by street basis and are further highlighted in Figure 7.4 by means of an annotated map.

Stage 1 – West George Street

Upon commencing the journey, participants were required to cross Dundas Street at an uncontrolled and unmarked crossing point (see Figure 7.4 location A). Problems were experienced by all five participants, primarily due to the absence of assistive features such as tactile paving, spinning cone and dropped kerb. This resulted in a situation whereby participants had to guess (after a long period of hesitation) when it was safe to cross a section of road heavily used by taxis in addition to negotiating unknown level changes in the absence of dropped kerbs. After crossing the road, participants walked west along West George Street for a distance of 83 metres, until reaching the next pedestrian crossing point. Along this short section of the route, various problems were experienced with pavement design, street furniture and road crossings. One blind participant using a long cane collided with a set of protruding steps forming the entrance to a hotel (see Figure 7.4 location B). The same participant was then involved in a collision with a telephone box while trying to the find the location of the controlled pedestrian crossing at the junction of West George St and Buchanan St (see Figure 7.4 location C). After several failed attempts to locate the crossing pole and control box, the participant proceeded to cross at a time when vehicles were still moving, clearly putting himself in a dangerous situation (see Figure 7.4 location D).

Stage 2 – Buchanan Street

Participants then walked south down the pedestrian precinct of Buchanan Street for a distance of 0.4km, negotiating a further road crossing before reaching Argyle Street. No significant problems were found with pavement design and road crossings however incidents involving street furniture were numerous. The first incident involved a collision between a blind participant and a newspaper kiosk, positioned against the wall of a building (see Figure 7.4 location E). The same participant was then involved in several collisions with advertisement A-boards outside the entrances to various shops (see Figure 7.4 location F). All five participants experienced difficulty negotiating construction works towards the bottom section of the street (see Figure 7.4 location G). Participants could either walk underneath a narrow section of dark unlit scaffolding or walk around the obstacle. Upon reaching the entrance to the scaffolding the guide dog of a participant with peripheral vision loss stopped and hesitated, creating anxiety for the owner, after a lengthy period of hesitation sighted assistance was required to facilitate movement through the passage. In an attempt to negotiate his way around the construction works, a blind participant using a long cane, collided with a black granite bench occupied by three workmen (see Figure 7.4 location H). One participant deviated from the route and took a short cut through a busy shopping precinct (see Figure 7.4 location I) in order to avoid street furniture on the southern section of the street, particularly bollards which had previously caused injury (see Figure 7.4 location J). The remaining four participants continued their journey south towards Argyle Street with minimal problems.

Stage 3 – Argyle Street

Participants walked along the non-pedestrian section of Argyle St for a distance of 0.1km until reaching the pedestrian crossing at the junction of Queen Street (see Figure 7.4 location K). There were no significant incidents with relation to pavement design, or street furniture along this section, however all participants experienced difficulty due to the non-standard positioning and location of the crossing pole and tactile spinning cone. During this time, participants used a number of different strategies including guessing when it was safe to cross, following other pedestrians, and using sighted assistance.

Following section of the route involved walking east along the pedestrian section of Argyle Street for a distance of 0.2km. On this occasion the main problems experienced by participants were caused by the paving surface and maintenance issues. Two participants tripped on a section of cracked and uneven paving (see Figure 7.4 location L). On two separate experiment dates the wet weather conditions caused the paving surface to change from dry matt into a glossy, reflective appearance resulting in a large degree of glare and reflection. This led to confusion and disorientation for the participants involved and led to a reduction in walking speed (see Figure 7.4 location M). The same weather conditions were also responsible for making the brass tactile paving extremely slippery and dangerous to walk on (see Figure 7.4 location N). This sudden change in surface friction was unexpected and had the same effect as if it were black ice. Participants then used the spinning cone to cross onto the next section of the route.

Stage 5 - Trongate

After crossing from the pedestrian section of Argyle Street participants continued walking east along Trongate for a distance of 0.2km, negotiating a further road crossing before reaching the final destination of the Tron Theatre. There were a number of collisions between the participants and other pedestrians, due to high volumes of pedestrian traffic stemming from a sudden reduction in the pavement width. This was particularly apparent at sections where street furniture is inappropriately zoned (see Figure 7.4 location O). One guide dog owner encountered problems on approaching a change in the type and pattern of the paving. The change in paving was intended to mark the entrance to a building; however the guide dog was under the belief that the paving was intended to signify a vehicular access point or change in level, as is the case at other locations within the experiment area. The guide dog therefore stopped abruptly leaving the participant quite stressed and confused as to why her dog had stopped so suddenly (see Figure 7.4 location P). Finally one blind, long cane user experienced difficulty locating the crossing pole at the junction of King Street and had to ask for sighted assistance. While crossing the road the participant tripped over a raised island in the centre of the crossing and collided with signage poles upon reaching the other side of the crossing (see Figure 7.4 location Q).

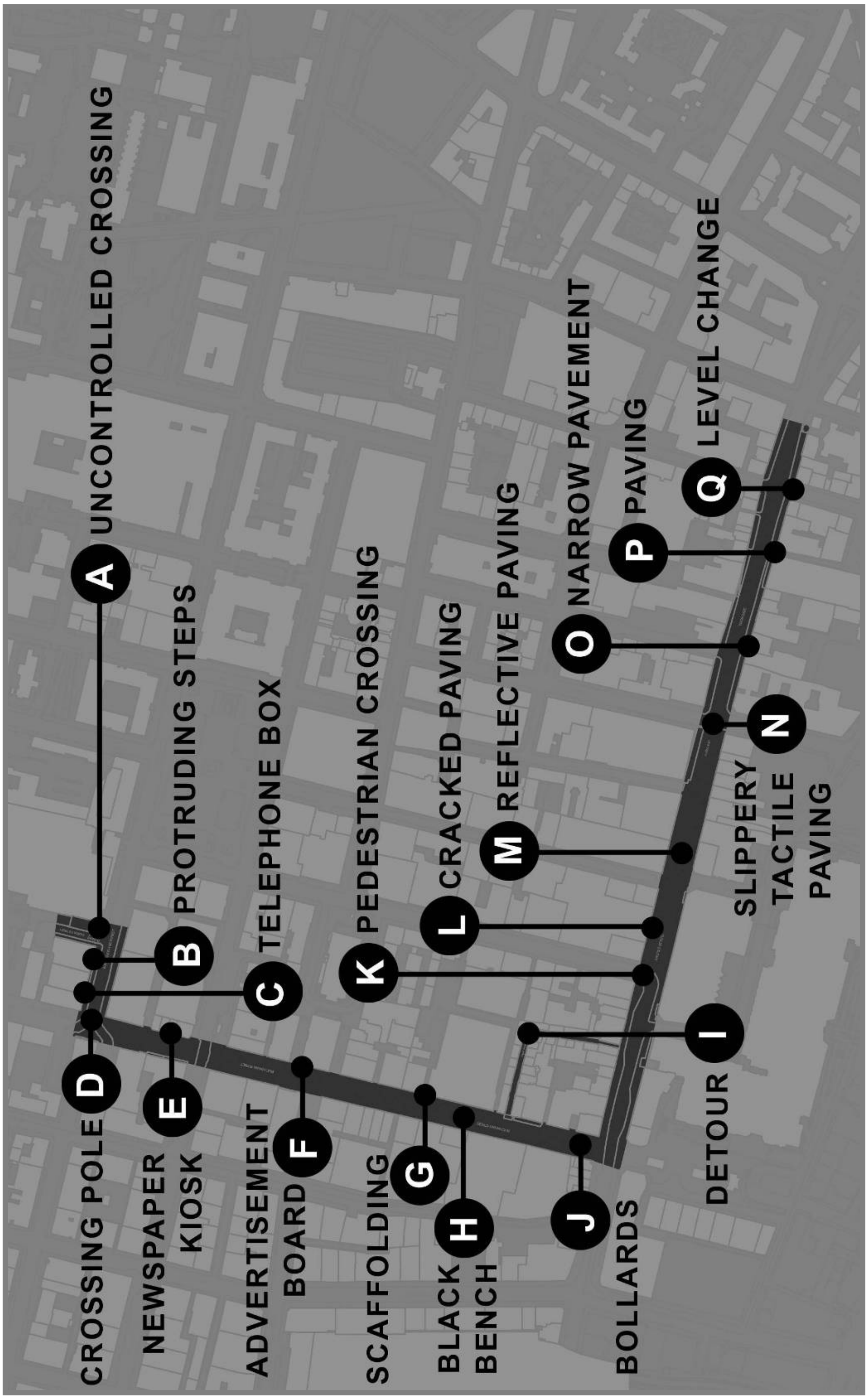


Figure 7.4: Strategy B, Buchanan Street – Argyle Street

7.7.3. Strategy C

One participant with central vision loss, opted for an alternative route strategy compared to that of the other fourteen participants (see Figure 7.5). As the participant was familiar with the area they were aware that by taking a more diagonal route they would experience less interaction with street furniture and other pedestrians by avoiding the populated pedestrian precincts. This strategy incorporated twice the number of streets than routes A or B which inevitably resulted in increased interaction with road crossings. The route covered eight streets of varying pavement width, pedestrian and vehicular flow and function, as well as the necessity to cross nine roads. On this occasion, the planned route was unable to be completed due to the absence of accessible pedestrian crossings. Problems also occurred due to the presence and zoning of street furniture. Figure 7.5 illustrates both the planned and actual route taken, accompanied by an annotated map detailing particular problematic features along the route.

The participant walked east along West George Street for a distance of 76 metres until reaching the first pedestrian crossing point. Although this crossing was equipped with accessible features such as tactile spinning cone, tactile paving and a dropped kerb the participant still required sighted assistance, as they did not feel comfortable relying on such features to judge at which point it was safe to cross (see Figure 7.5, Location A). The participant then walked south along the western pavement of George Square for a distance of 96 metres before reaching the next pedestrian crossing. Once again sighted assistance was required due to the wish not to rely on assistive features (see Figure 7.5, Location A). After traversing the southern perimeter of George Square for a distance of 0.2km, significant problems were experienced when trying to cross onto Cochrane Street (see Figure 7.5, Location B). Although a controlled pedestrian crossing point was present at this location, it was not equipped with a tactile spinning cone, audio signal, tactile paving or dropped kerb. On this occasion sighted help was not available and the participant had to guess the time at which it was safe to cross by relying on the movement patterns of a pedestrian on the opposite side of the road. After crossing the road the participant then walked east on Cochrane Street for a distance of 95 metres with the intention of crossing onto Montrose Street, however this option was unavailable due to the lack of a controlled crossing point (see Figure 7.5, Location C). The participant then had to walk back towards George Square at which point she became disorientated and visibly distressed and required sighted assistance to continue the journey on a different path, via John Street (see Figure 7.5, Location D). From this point onwards a new route was devised which incorporated known accessible crossing points in order to reach the end location. A number of hazardous features were encountered when walking down the pedestrian precinct in John Street. The first of which was an outside dining area which although was zoned by a protective barrier, it narrowed the pavement and encroached with the intended path of travel (see Figure 7.5, Location E). In an attempt to negotiate the outside dining area the participant collided with a stainless steel bollard (see Figure 7.5, Location F) and a stainless steel bench (see Figure 7.5, Location G) both of which were positioned in the centre of the pedestrian path. The participant then turned right onto Ingram Street walking west in the direction of Queen Street for a distance of 41 metres in order to use an accessible pedestrian crossing at the junction of Glassford Street and Ingram Street. The participant then continued down Glassford Street for a distance of 0.3km, crossing a further two roads on the way. Once again, problems were experienced with an uncontrolled road crossing (see Figure 7.5, Location H). However on this occasion the road was quiet and the participant was able to guess the point at which it was safe to cross. Upon reaching the bottom section of Glassford Street the participant experienced difficulties when the pavement narrowed due to the presence of a large glass and stainless steel bus shelter. Thereafter no further significant problems were encountered and the participant was able to use accessible pedestrian crossing points until reaching the final destination of the Tron Theatre.

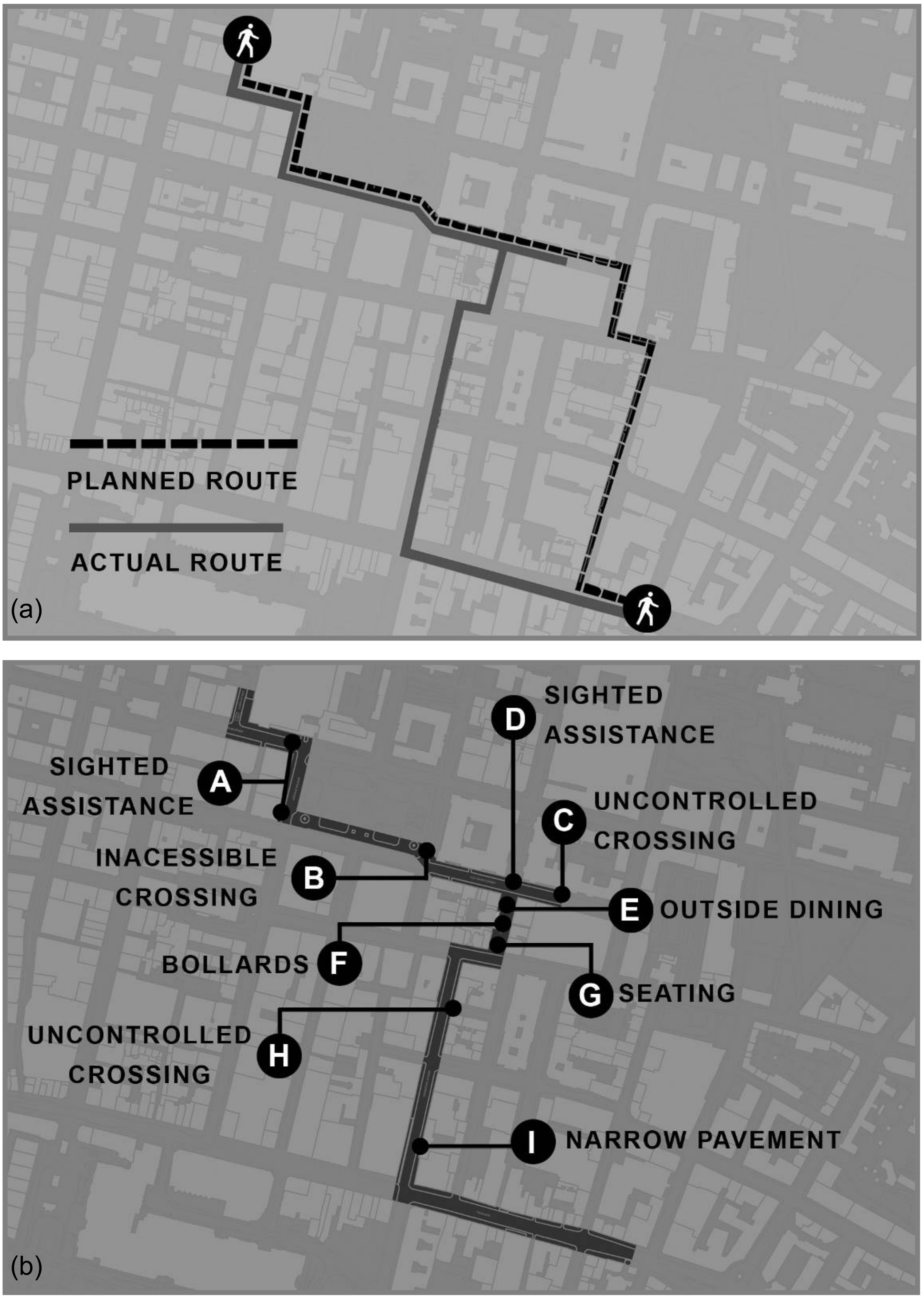


Figure 7.5: (a) planned and actual route taken, (b) annotated map detailing hazardous features located along the route

7.7.4. Strategy D

The fully sighted participants all adopted a similar strategy during the navigational experiment. In particular, none of the fully sighted participants planned their route prior to commencing the journey. Instead the strategy was based on a spontaneous decision-making process whereby decisions were made and executed in rapid progression. The routes chosen by the fully sighted were more diagonal in nature and were angled in the compass direction of the end location of the experiment. All five fully sighted participants chose to walk diagonally across George Square and thereafter weave through the streetscape of the Merchant City. It was noted that unlike the visually impaired participants, the fully sighted did not restrict their path across roads to designated controlled pedestrian crossing points. Instead they were able to use their vision to judge a time at which it was safe to cross. Furthermore, the fully sighted control group did not encounter any problems with the street design or layout while navigating through the city as they were able to use their vision to avoid potential obstacles and hazards and alter their course accordingly. Figure 7.6 provides an example of a typical route strategy adopted by the sighted participants.

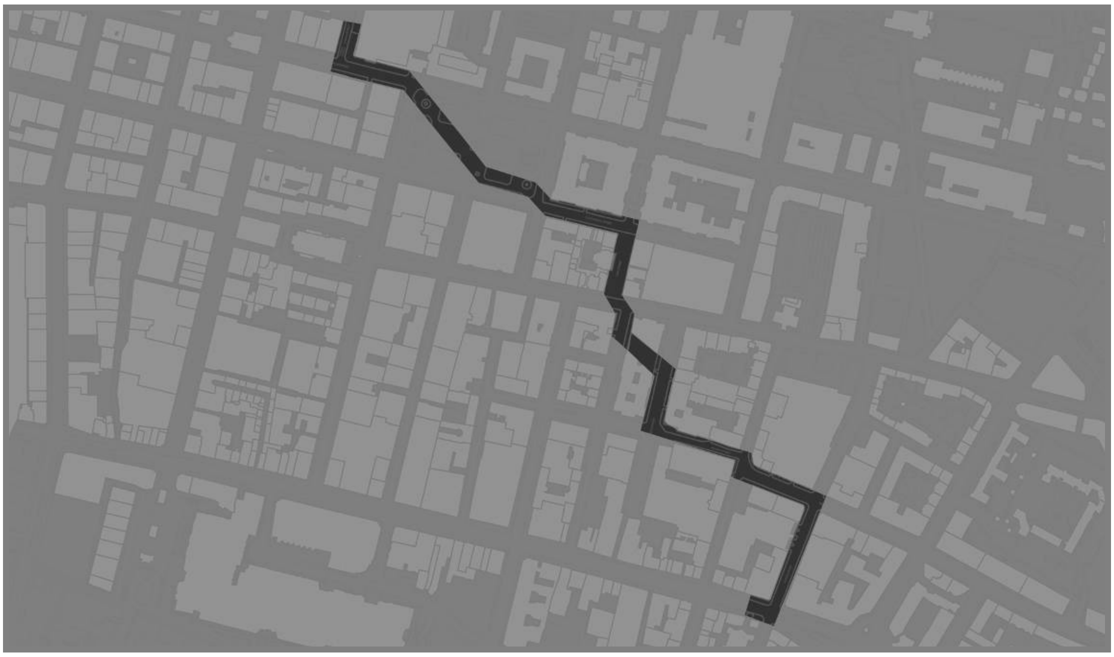


Figure 7.6: Example of a strategy adopted by a fully sighted participant

7.8. Cognitive Mapping

After the completion of the navigational experiment, both the fully sighted and visually impaired participants were required to participate in a further task in order to assess their level of spatial awareness and cognitive mapping abilities (see Section 4.2.3). The pointing task consisted of two stages, both of which were completed at the entrance to the Tron Theatre.

The first stage of the experiment was designed to test the level of spatial awareness among the participants. This required each participant to face north and move the pointer in the direction of where they believed the starting point of the experiment to be. The correct angle for the start point was 324º, located in the North West quadrant of the pointer (Figure 7.7). The second stage of the experiment was designed to determine the presence and validity of a cognitive map. This required each participant to face south and imagine that they were standing back at the start point of the experiment. They were then asked to move the pointer in the direction of the Tron Theatre. The correct angle was 324º, located in the South East quadrant of the pointer (Figure 7.8).

7.8.1. Spatial Awareness

Figure 7.7 illustrates the recorded angles for both the visually impaired and fully sighted participants. In this part of the task, participants were asked to move the pointer towards the start location of the experiment (Dundas Street). Participants were deemed to be spatially aware of their surroundings if they were able to move the pointer within the boundary of the North West quadrant, between the angles of 270º and 360º. All of the fully sighted participants pointed in the direction of the North West quadrant, with measurements ranging from 310º to 328º, a range of between 14º and 4º either side of the correct angle (see Figure 7.7a). The visually impaired participants also completed this part of the task with minimal difficulties. Fourteen out of fifteen (93%) were able to point towards the starting location of the experiment by indicating that Dundas Street was located within the

North West quadrant. The measurements ranged from 290º - 340º, resulting in a range of between 34º and 16º either side of the actual measured angle. The only participant not to accurately identify the direction of the start location was a blind participant who moved the pointer within the North East quadrant at an angle of 40º (see Figure 7.7b). Although one participant failed to accurately locate the starting point of the experiment, the findings still provide strong evidence to suggest that the vast majority of the visually impaired participants have a level of spatial awareness that is similar if not the same to that of their sighted counterparts.

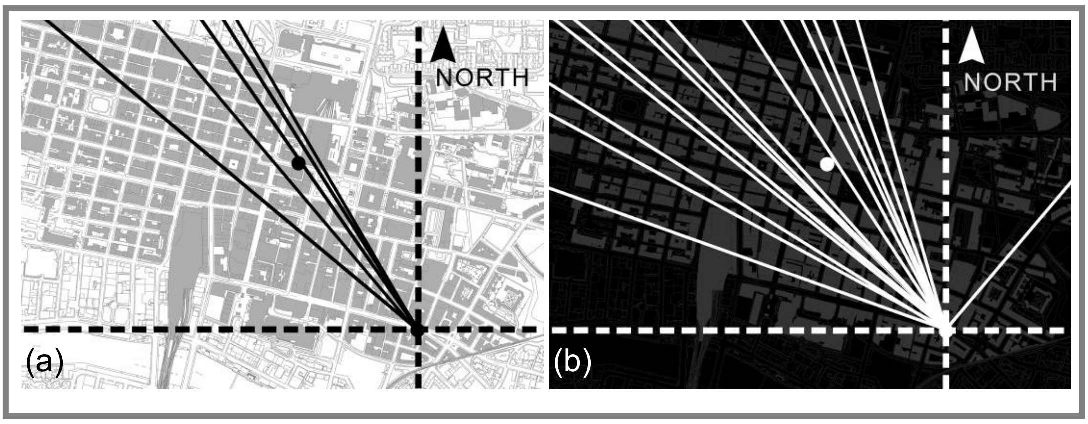


Figure 7.7: Angle measurements (a) fully sighted and (b) visually impaired, indicating level of spatial awareness

7.8.2. Cognitive Mapping Abilities

For this part of the experiment, participants were asked to imagine that they were standing at the starting point of the experiment (Dundas Street) and point towards the end location (Tron theatre). Participants were deemed to have a cognitive map if they were able to move the pointer within the boundary of the South East quadrant, between the angles of 270º and 360º. All of the fully sighted participants were able to move the pointer in the direction of the Tron Theatre with measurements ranging from 305º – 325º, a range of between 19º and 1º either side of the actual angle (see Figure 7.8 a). Ten out of the fifteen visually impaired participants (67%) were able to imagine that they were standing at the start location and point in the correct direction of the Tron Theatre (Figure 7.8b). The recorded angles ranged from 285º - 331º, a range of 39º and 7º either side of the actual angle.

Due to the small sample size it is not possible to establish firm conclusions as to the impact that other variables may have on the presence and validity of the cognitive map. There did not appear to be a relationship between the age of participants, the type of visual field loss or the age at which the visual impairment was diagnosed. There was however a relationship with regards to the gender of participants and the use of a mobility aid. All of the participants who pointed outside of the South East quadrant were women, of which four made use of a mobility aid during the experiment, including a guide dog, long cane and two symbol canes. Further details regarding the presence and validity of the cognitive map are presented within the post task discussion in section 7.9.2.

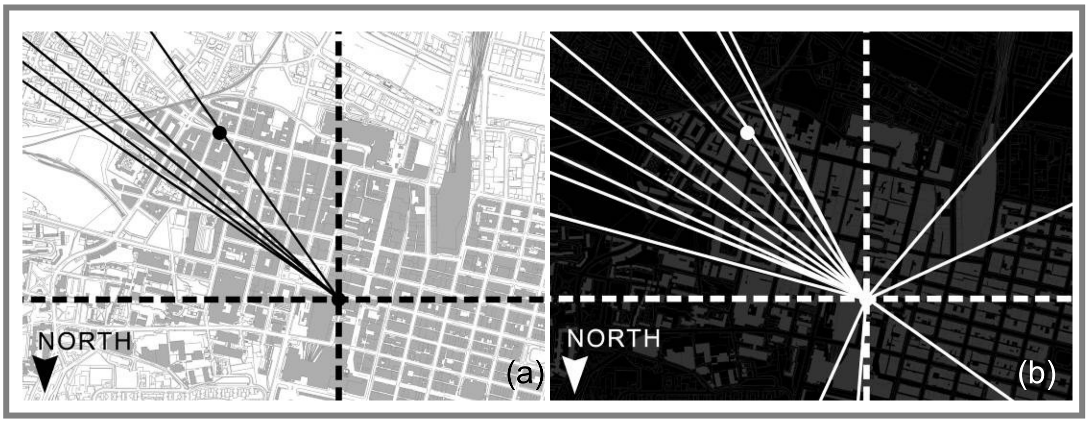


Figure 7.8: Angle measurements (a) fully sighted and (b) visually impaired, indicating the presence & validity of the cognitive map

7.9. Post Task Discussion

In order to gain a better understanding of why there were such big differences in terms of the time, distance and route choice between the visually impaired and fully sighted participants, a series of post task discussions were held immediately after the completion of each experiment. The discussions were scheduled to last for thirty minutes and covered topics including route strategies, spatial awareness and cognitive mapping abilities. Participants were given the opportunity to comment further on the disabling and enabling features associated with pavement design, street furniture and pedestrian crossings. Finally, an insight will be given into some of the many accidents and injuries experienced by the visually impaired participants during their time navigating within everyday spaces.

7.9.1. Route Planning

Unlike their fully sighted counterparts, all of the visually impaired participants made a route plan before commencing their journey. The main features to influence a route include (i) the location of controlled pedestrian crossings, (ii) the presence of street furniture and (iii) the level of pedestrian flow, particularly at busy times of the day. All of the participants were aware that they could have taken a more direct route from Dundas Street to the Tron theatre, similar to that of the fully sighted control group; however by doing this they were aware that they would encounter many more intersections with roads, not all of which were equipped with accessible pedestrian crossings. This indicates that they are capable of employing both route knowledge and configurational knowledge (see Section 4.2.3), but are limited in doing so due the inaccessible nature of the built environment. There was a general consensus that by choosing a more straight forward route they would be able to concentrate more on obstacles such as street furniture instead of focusing on decision making with regards to route choice. Figure 7.9 provides examples of some of the quotations from the post task discussion regarding route planning.

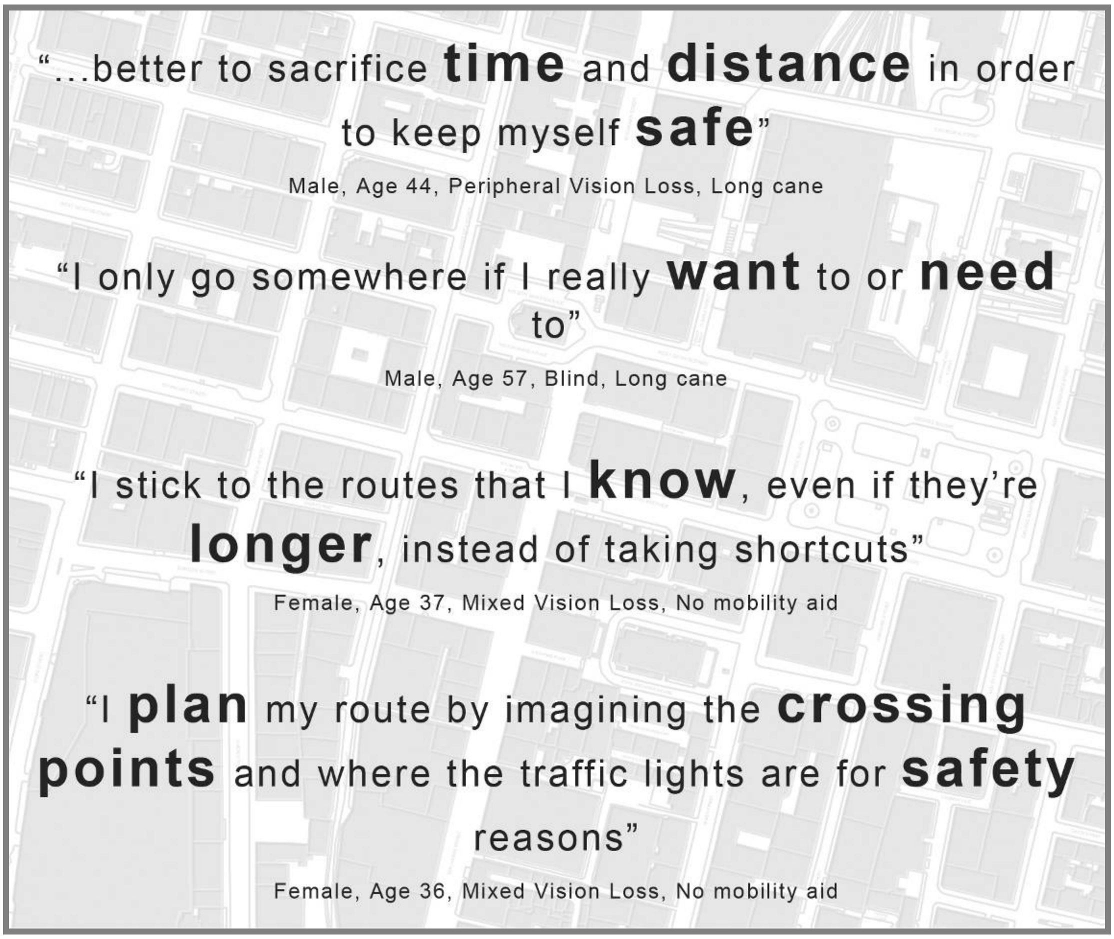


Figure 7.9: Quotations from post task discussion regarding route planning

7.9.2. The Cognitive Map

All of the participants made reference to their cognitive map and the way in which it enables them to plan a route within a familiar location. Participants stated that they map out and memorise the location of street furniture on frequently used routes, a process which gradually builds up the accuracy and detail of their cognitive map. Participants remarked that they prefer to adhere to known routes within the boundary of their cognitive map as they know the location of obstacles, and where to walk in order to avoid collision with street furniture.

When asked if their cognitive map was picture like, the majority of participants remarked that they have a map like image of the city centre; however one blind participant stated that although he has a very good cognitive map he was unsure if the map was visual. Many participants remarked that their cognitive mapping abilities would enable them to take shortcuts and plan alternative routes in the event of encountering obstacles along the original route. Many also commented that the grid pattern of Glasgow city centre further facilitates the ability to take a diversion without becoming lost or disorientated (see Figure 7.10 for a list of quotations from the post task discussion regarding spatial awareness and cognitive mapping).

Figure 7.10: Quotations from post task discussion regarding cognitive mapping

7.9.3. Paving Type

The type and condition of the paving surface and the impact that it can have on travel behaviour was a topic raised by many participants. Individuals who use a mobility aid, particularly a long cane, commented that cobbles and uneven paving are problematic, as the long cane can often get caught in between the cobbles causing pain to the wrist and arm. One participant commented that on one occasion her stick got caught in a cobble and she ended up impaled on her own cane. The pattern of the cobbles was also commented on as being confusing and unpleasant to the eye. The condition of the paving was a factor that influenced the route choice of many participants. It was the view that side roads generally have uneven and badly maintained paving and should therefore be avoided.

The surface colour and reflectance of the paving was an issue raised by all fifteen participants. Lightly coloured surfaces such as concrete or white tiles were highlighted as bad examples due to glare and reflectance. Several participants commented on the use of Caithness stone within Glasgow city centre, remarking that it is often uneven and extremely reflective especially on wet days. Black tarmac was viewed by many as being a good paving type as it completely flat, smooth and non reflective. It also provides a good base to work on for contrast.

It was suggested that different paving types could be used to signify specific areas of the city. However another participant stated that this would be confusing, as there is already a large number of different paving types and more consistency is needed, commenting that if the type of paving is familiar there is less to worry about. All of the participants favoured consistency with relation to pavement design. However, many remarked that standardisation was perhaps not a good idea. One blind participant stated that he favours consistency, however is against total standardisation, as he uses distinguishing characteristics of particular areas to identify where he is (see

Figure 7.11 for a list of quotations from the post task discussion regarding paving type).

"Light grey coloured is the worst paving because it's very **reflective** on **wet** days"

Female, Age 36, Mixed Vision Loss, No mobility aid

"Nothing **worse** than a **shiny** pavement"

Female, Age 27, Peripheral Vision Loss, Long cane

"I prefer black **tarmac** with white speckles because it's completely **flat** and **smooth**"

Female, Age 36, Mixed Vision Loss, No mobility aid

"Motorways are **black** and **white**; why can't pavements be like that?"

Female, Age 36, Mixed Vision Loss, No mobility aid

"My **cane** jars on **cobbled** streets, the **pain** jerks right up my wrist and arm"

Male, Age 44, Peripheral Vision Loss, Long cane

"I use my **feet** to gauge the **height** and **texture** of the pavement"

Female, Age 80, Central Vision Loss, Symbol Cane

"I avoid side streets…the paving is normally **cracked** and **uneven**"

Female, Age 27, Peripheral Vision Loss, Long cane

Figure 7.11: Quotations from post task discussion regarding paving type

7.9.4. Pavement Width

The width of a pavement was viewed by many to have a crucial effect on their travel behaviour. Narrow pavements, particularly with street furniture and / or high levels of pedestrian flow were deemed to be extremely detrimental and influential with regards to their choice of route. In general, narrow streets were avoided with participants preferring to walk on wider streets as there is more room to navigate around street furniture. However one blind participant stated that if the pavement is too wide you can get lost in it, therefore there needs to be a compromise between space and orientation, he further commented that an optimum pavement width would be 2.5 metres. One guide dog owner commented that shared space zones are extremely hazardous as the guide dog is unable to tell the difference between the pavement and the road (see Figure 7.12 for a sample list of quotations taken from post task discussion regarding pavement width).

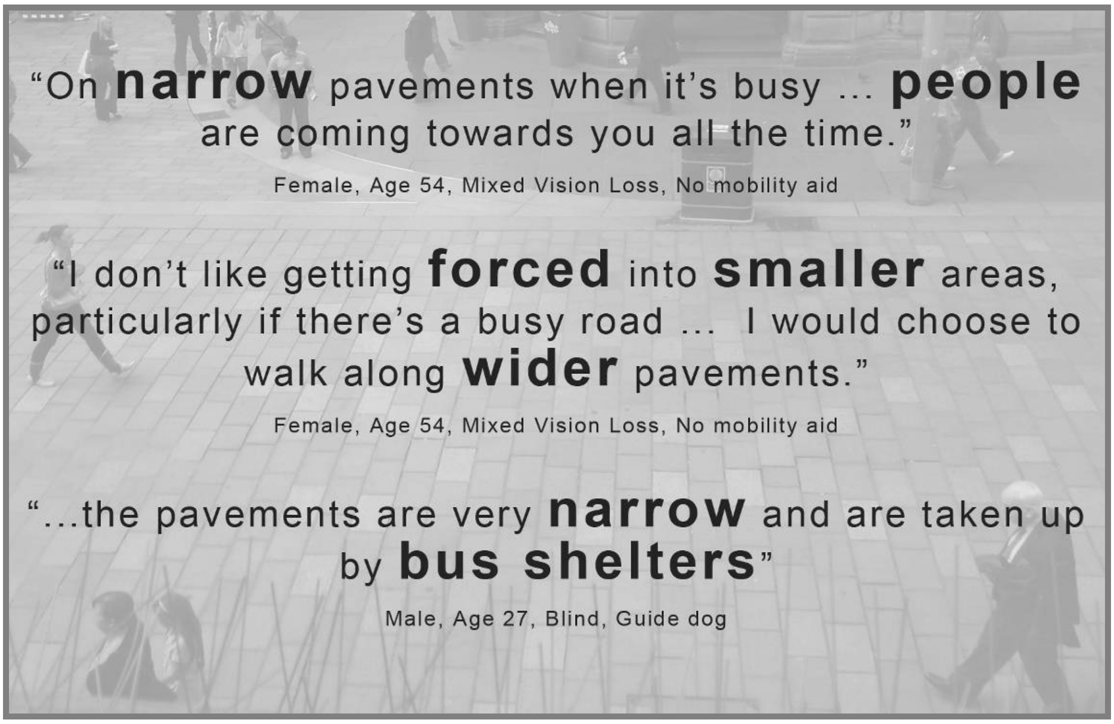


Figure 7.12: Quotations from post task discussion regarding pavement width

7.9.5. Public Squares

During the navigational experiment all of the visually impaired participants avoided travelling through public squares. Twelve participants commented that they would never consider walking diagonally through an open space such as a public square. Two stated that they would only walk around the perimeter and one participant stated that they have a mental map of the permanent obstacles within George Square which enables them to walk diagonally if no events are taking place. However it was the general agreement that due to the changeable nature of George Square and the uncertainty over the location and duration of events, they would always chose to avoid the square (see Figure 7.13 for quotations from the post task discussion regarding public squares and open spaces).

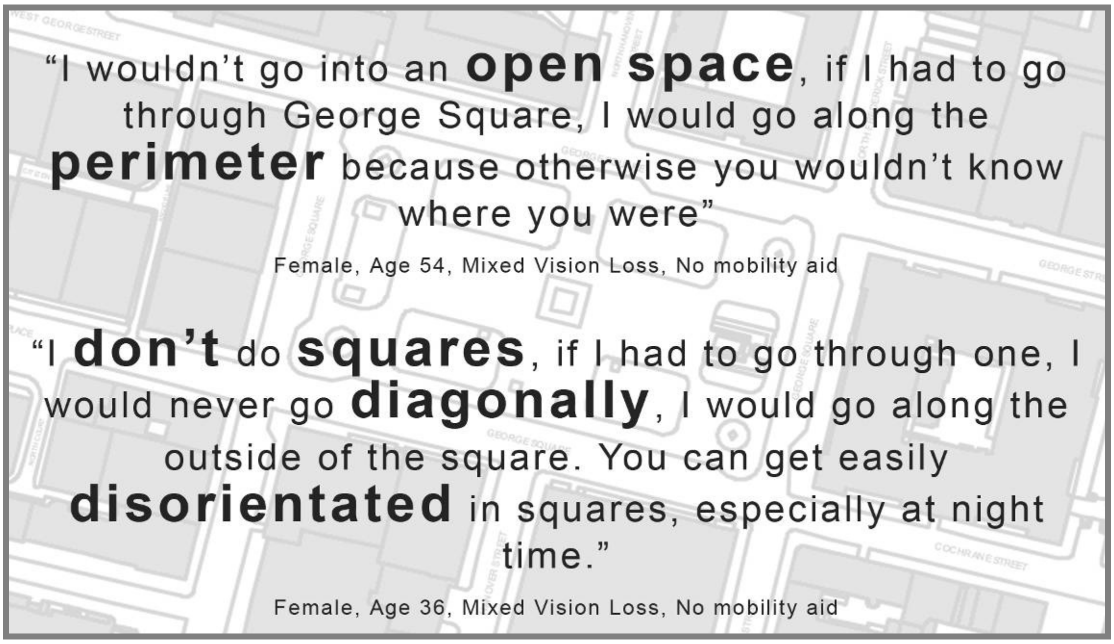


Figure 7.13: Quotations from post task discussion regarding public squares

7.9.6. Level Changes

Level changes were commented by many as being one of the most hazardous features within the built environment, especially if they are unexpected and unmarked. Participants highlighted the problematic nature of tapered steps with a number of individuals stating that they avoid certain streets within the city where tapered steps have been incorporated into the pavement design. Many expressed anxiety with regards to kerb heights. High kerbs were commented as being problematic and dangerous; however a blind guide dog user commented that kerbs which are flush with the road can cause significant problems as it may not be possible to detect when you have left the pavement and stepped onto the road. Among all participants there was a general agreement that there needs to be a consistent standard height for kerbs (see Figure 7.14 for quotations from the post task discussion regarding level changes).

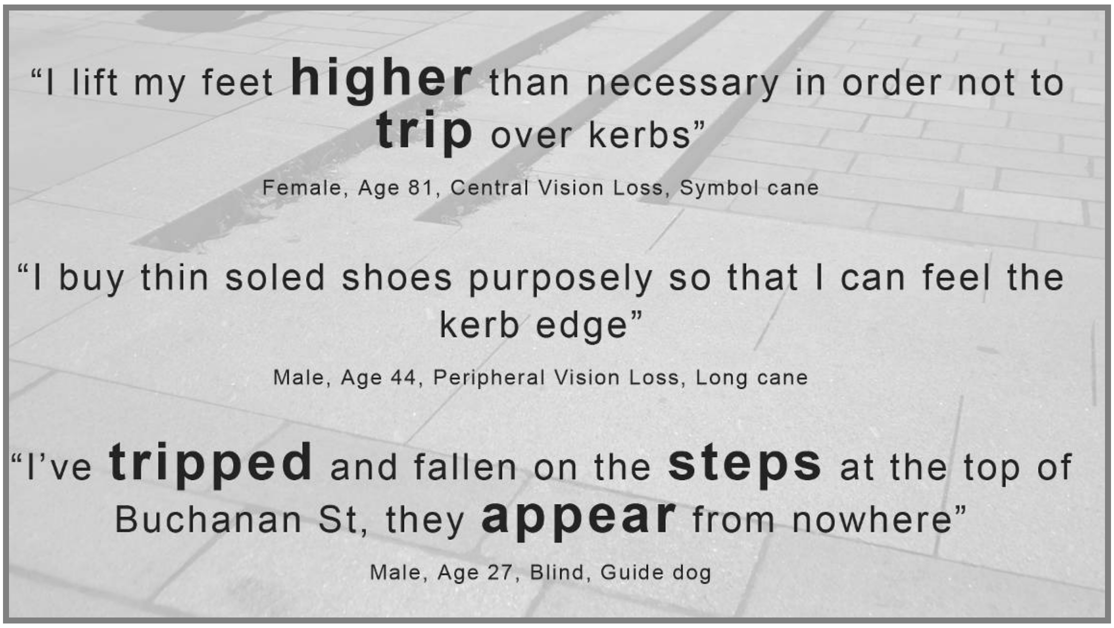


Figure 7.14: Quotations from post task discussion regarding level changes

7.9.7. Street Furniture

Many participants questioned the necessity for the large quantity and variety of street furniture present within the city centre of Glasgow, stating that there are too many unnecessary obstacles cluttering the pavements. The main pedestrian shopping street (Buchanan Street) was regarded as the worst street within the study area due to the large number of obstacles present. One participant commented that they avoid the area and feel segregated from the community, as most shops are located along Buchanan Street . All of the participants were of the same agreement that silver stainless steel bollards are the most hazardous item of street furniture (see Quotations in Figure 7.15).

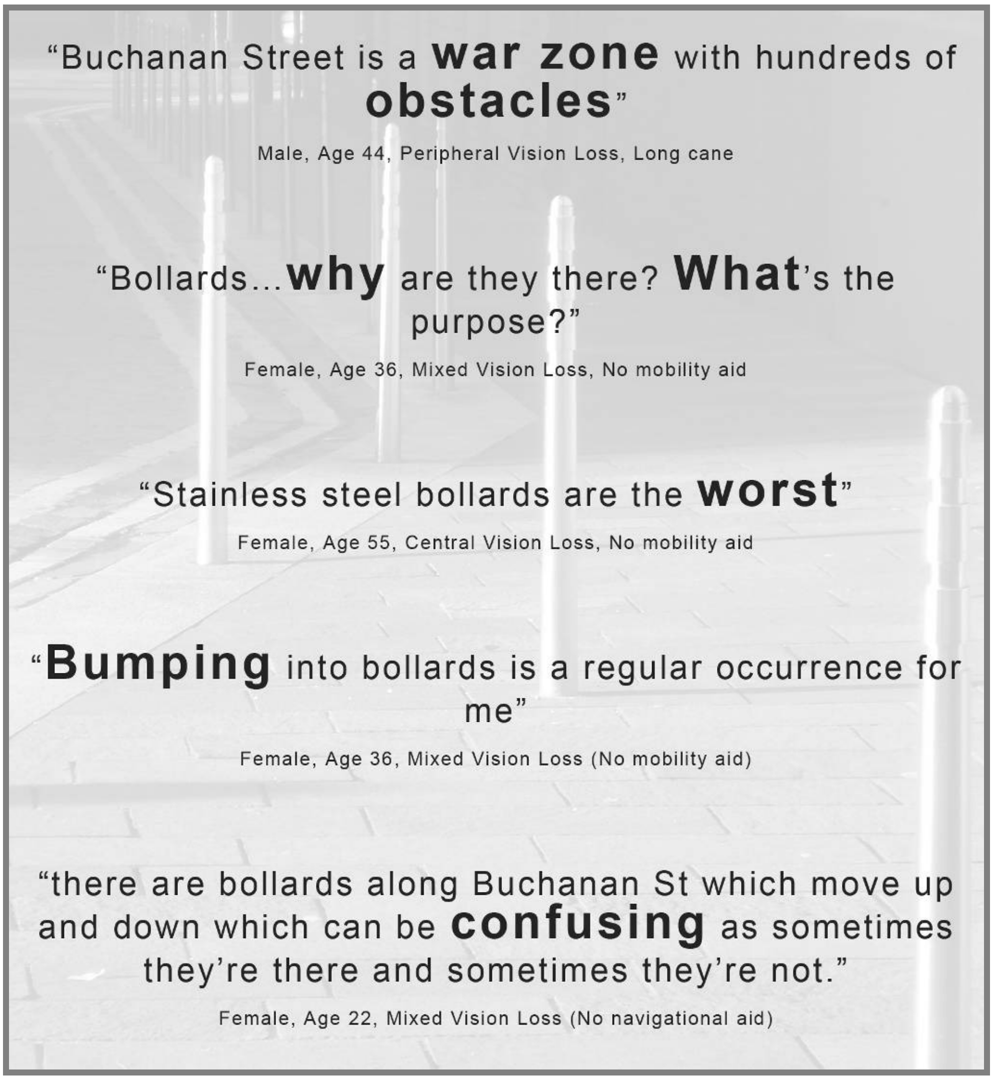


Figure 7.15: Quotations from post task discussion regarding Buchanan Street

Other highlighted items also included granite benches, outside dining areas, signage poles and bins. Three long cane users commented on the hazardous nature of items of street furniture which do not have a solid base, (such as bike racks and benches), stating that the cane can pass underneath and not always alert them to the presence of an obstacle.

Many participants raised concern over the variety and design of street furniture, particularly among items of the same use and function. One participant stated that Glasgow city council should stop rebranding and adopt a policy of standardising all street furniture within the city. He further commented that this would make items of street furniture easier to identify and distinguish from one another.

All of the participants stated that they have been involved in at least one collision with an item of street furniture, with many stating that they have lost count of the number of times they have collided and received an injury. This prompted one participant to suggest that street furniture should be made from a softer material such as polyurethane in order to reduce the level of injury in the event of a collision. Several participants have developed coping strategies in order to reduce the number of collisions. For example, two participants commented that they walk 3ft (1m) away from buildings in order to avoid signage (a-boards) and busy entranceways. Scaffolding and road works were mentioned by many as being extremely hazardous, due to the poor colour contrast and lack of protective barriers and high visibility markings. Several participants stated that they would avoid a street if it had road works (see Figure 7.16 for quotations from the post task discussion regarding street furniture).

Figure 7.16: Quotations from post task discussion regarding street furniture

7.9.8. Road Crossings

Many participants stressed the important role that accessible pedestrian crossings can have in facilitating movement between locations within the city. However there was also a general agreement that the current provision was neither an adequate nor a reliable facility to assist the movement of individuals with restricted vision between all areas of the city. All participants stated that they had made inquiries with their local council requesting that they make particularly problematic crossing points accessible – the response was unanimous in that funds were not available. This led many participants to comment that the level of provision of accessible pedestrian crossings is dependent on the attitudes and priorities of local authorities. They further commented that Glasgow in particular is less accessible than other cities. Issues relating to the maintenance of assistive features were of a concern to all participants. Many expressed the wish for a proper maintenance system to be implemented in order to resolve any problems which arise, (such as non operational spinning cone, broken wait light or stickers obscuring the wait light) as quickly and efficiently as possible. One participant stated that they would like to have access to a dedicated name and contact number to report maintenance issues.

Several participants commented on the general design of pedestrian crossings, stating that they have experienced difficulties when trying to locate the position of the crossing pole. In particular two guide dog users explained that the inconsistent positioning of poles is confusing for the dog as it is trained to find them on the right hand side of the crossing. Many participants remarked that they only allocate a set time to try and find the crossing pole, after which point they would cross anyway as they do not want to appear vulnerable and attract unwanted attention. The design and layout of tactile paving was also highlighted as a problematic feature under certain circumstances. In particular one participant with peripheral vision loss stated that tactile paving areas can often be too large and it can be easy to get lost making it difficult to find the crossing. Several participants commented on the use of brass tactile paving within the study area remarking that it can become very slippery and therefore dangerous when wet. One blind participant remarked that dropped kerbs are essential in helping to identify the location of crossing points, however inconsistency can be hazardous in situations where a dropped kerb is only present at one side of the crossing.

Several participants indicated that they have a strategy for crossing roads for example, one participant stated that they would first use the spinning cone / audio signal and if not working would then seek sighted help, failing that they would try and use the wait light and thereafter guess the time at which it is safe to cross. In instances where the tactile spinning cones are found not to be working, the majority stated that they would take a risk and try to cross anyway, especially if sighted help was not available and an alternative route would result in a significant increase to the time of their journey. A number of other strategies were described including listening out for the sequence of traffic in familiar areas or one-way streets, and following the movement of other pedestrians.

A number of participants expressed the wish for additional cues to be present at road crossings in order to supplement those currently available. There was a preference for audio signals over tactile cones as tactile cones can be difficult to find, often non-functional and the underside of the control box is often dirty and unpleasant to touch. Another suggestion was for the crossing area to be clearly distinguished from the rest of the road, using contrasting colours, patterns and materials for example black and white stripes or red monoblock. This would not only benefit the visually impaired pedestrian but also further assist in alerting the drivers that there is a change of function at this point of the road (see Figure 7.17 for quotations from the post task discussion regarding road crossings).

Figure 7.17: Quotations from post task discussion regarding crossings

7.9.9. Navigational Cues

During the post task discussion, participants mentioned a variety of cues which they use in order to assist them with the navigational process. Specific reference was made to auditory, olfactory, tactile and landmark cues as well as suggestions for additional cues to be implemented within the built environment.

Participants made use of a number of auditory cues, either during the navigational experiment or within everyday life situations. The majority stated that they use the noise of shops to establish a location within the city, particularly amusement arcades, bingo halls and music / electronic shops, which usually play music in the proximity to the entrance. Many indicated that church bells and chimes also assist them to navigate. One participant mentioned that they use the 'tick' sounds of the turnstiles to identify the entrance to underground stations, while another stated that they listen out for the humming noise of electrical cables in order to identify the location of lamp posts. Cobbles were generally viewed to be problematic and hazardous for pedestrians when they are used as a pavement surface, however a number of participants commented that they find cobbled road surfaces particularly beneficial, commenting that the surface amplifies the noise of moving vehicles. Many stated that this is particularly useful especially in circumstances where a controlled pedestrian crossing is not present, in which case they are able to listen for the presence of moving vehicles with greater accuracy. Although auditory cues can be a useful means of location finding, one participant commented that too many sound sources could be distracting and be more of a hindrance than a help.

Olfactory cues were perhaps one of the most popular and frequently used cues among the participants. Participants mentioned a large number of olfactory cues during the discussion including the smell from cosmetics shops, coffee shops, cheese shops, fishmongers, fast food outlets and the warm draft and smell from the entrance to subway stations. In particular, one participant suggested that different planting types could be used to identify specific streets such as lavender or pine. There are however certain drawbacks to relying on olfactory cues. A persons sense of smell may be absent or significantly reduced as a result of medical conditions affecting the nasal passage such as the flu or common cold. One participant commented that she is not able to rely on her sense of smell as she suffers from hay fever, stating that the increased presence of scented plants may aggravate her hay fever and act as another barrier preventing her to access the city centre. One participant remarked that olfactory cues may not be as effective or reliable on windy days, as the smell may be blown in different directions. The presence of a smell may also only be limited to certain times of the day if for example the source is restricted to the opening hours of a shop, bar or restaurant. Finally it is also important to consider that people can become used to a smell and no longer detect it.

The majority of participants remarked that they use differences in paving to orientate within the built environment. There was a wish for additional paving materials to be used on a more frequent basis in order to distinguish and separate different functions and changes in use of the pavement (such as the positioning of street furniture). Two guide dog owners remarked that a change in paving material is also beneficial to the guide dog as it enables them to orientate with greater ease. One blind participant discussed the issue of raised guidance lines, remarking that they are very useful not only for him but also the guide dog.

Many participants indicated that they use visual or landmark cues in order to assist orientation within the city. The majority stated that they follow other pedestrians in order to negotiate through or between problematic areas such as road crossings and scaffolding. In particular, one participant remarked that if she is unsure of when it is safe to cross the road, she will wait until she can find a mother with small children or a pram and follow them across the road, as she feels that a mother is less likely to take risks with moving vehicles. During evening hours a number of participants stated that they use shops with bright window displays or illuminated signage on the side of buildings. Finally, one participant remarked that she uses the double yellow lines at the edge of the road as an indicator in order to identify the location of the kerb edge (see Figure 7.18 for quotations from the post task discussion regarding navigational cues).

Figure 7.18: Quotations from post task discussion regarding cues

7.9.10. Accidents & Injuries

Participants were asked to detail and describe any accidents they have been involved with, including any injuries they have received as a result from poorly designed spaces and hazardous features within the built environment. All participants stated that they have been involved in minor incidents resulting in cuts and bruises. In particular one participant collided with a stainless steel bollard leading to a groin injury. Another participant bruised their chin and knee following a collision with a concrete cube and two participants said they have been involved in a collision with a cyclist while walking along the pavement. A number described far more serious events, many of which required hospital treatment. One participant was involved in a direct collision with a scaffolding pole, resulting in a burst lip and cut eye. Another participant tripped over a traffic cone on the pavement. The fall caused her teeth to pierce through her lip resulting in excessive bleeding and stitches. In particular, one extreme case involved a collision between a participant and a large road sign. The two metre tall sign was placed in the centre of the pavement providing directional signage for vehicles. The silver sign had a poor colour contrast with the surrounding environment and was lacking any high visibility markings or a protective foam cover. The participants legs were caught on the bottom metal bar at shin height and her throat and voice box were caught on the upper metal bar. The participant received severe bruising and was unable to speak for a number of weeks following the accident.

The absence of tactile warning paving can lead to the occurrence of a number of serious accidents and injuries. In particular, one participant fell down a flight of unmarked steps incurring head and wrist injuries and a blind participant reported falling onto a railway line due to lack of tactile warning paving at the platform edge. Both participants stated that if tactile hazard warning paving had been installed they would have been alerted to the danger and responded accordingly.

7.10. Conclusion

The principle aim of the experiment was to determine the main problems which visually impaired pedestrians encounter when navigating within the built environment. A series of navigational experiments were conducted within the boundary of Glasgow city centre involving fifteen visually impaired participants of varying age, type of vision loss and age of diagnosis alongside a control group consisting of five sighted participants. The main topics of investigation related to: (i) the time taken to complete the experiment, (ii) the number of steps taken and overall distance travelled, (iii) the route strategies adopted and (iv) the level of spatial awareness and cognitive mapping abilities.

There was a significant difference between the completion times of the visually impaired and fully sighted participants. The fully sighted group took an average time of 8:54, while the visually impaired participants delivered an average time of 17:07, resulting in a completion time over twice that of their sighted counterparts. There was also a notable difference with regards to the number of steps taken and average distance travelled between both groups, with the visually impaired participants walking an additional average of 412 steps (0.31km). With regards to visual field loss the fastest average time was for individuals with central vision loss, followed by mixed vision loss and total blindness. Individuals with peripheral vision loss took the longest time to complete the experiment and also travelled a greater distance than any of the other visual field loss categories. It was also found that individuals who were diagnosed with their visual impairment before the age of 13 (early blind) took less time and travelled a shorter distance than those diagnosed from age 13 onwards (late blind). This leads to the conclusion that this population (early blind) are more confident independent travellers, perhaps due to the increased time spent navigating in a world with low vision. Furthermore the results build upon findings from the survey (Chapter 5) which found that the early blind category rated factors and features associated with the design of the built environment as less influential, problematic and hazardous than those in the late blind group. With regards to mobility aid used, it was found that those who use a guide dog or long cane required more time and travelled a further distance than individuals who travelled without a mobility aid. However this finding is perhaps more related to the type and degree of visual field loss and not the influence of a specific mobility aid, as all those who used a long cane or a guide dog had a significant reduction in their visual field.

It was noted that the level of spatial awareness among the visually impaired participants is similar if not the same to that of their sighted counterparts. The majority of participants (67%) were able to imagine that they were standing at the start point of the route and point to the end destination giving rise to the conclusion that they have cognitive mapping abilities. Due to the small sample size it is not possible to establish firm conclusions as to the impact that other variables may have on the presence and validity of the cognitive map. There did not appear to be a relationship between the age of participants, the type of visual field loss or the age at which the visual impairment was diagnosed. There was however a relationship with regards to the gender of participants and the use of a mobility aid, as all of those who were unable to successfully complete the task were female, four of whom made use of a mobility aid during the experiment.

All of the visually impaired participants pre-planned their route, actively utilising their spatial awareness and cognitive mapping abilities. When planning their journey, participants were first influenced by the location of accessible pedestrian crossings, followed by the presence of street furniture and the level of pedestrian flow, particularly at busy times of the day. All participants were aware that they could travel along a more direct route, indicating that they are capable of executing both route knowledge and configurational knowledge. However they were limited in doing so due to the inaccessible nature of the built environment. This resulted in participants adhering to known routes, even although these routes took longer to complete, led to an increase in distance and involved walking in the opposite direction from the end destination for part of the journey. The comparison between the route choice of the visually impaired and fully sighted participants was quite striking. All of the visually impaired participants with the exception of one opted for straight line “L-shaped” routes incorporating a limited number of streets and road crossings. In particular all of the visually impaired participants avoided traversing diagonally through large open spaces such as public squares.

Numerous problems were experienced by all visually impaired participants in relation to pavement design, street furniture and road crossings, regardless of age, the type of visual field loss, the age of diagnosis or the use of a mobility aid. Due to the small sample size it was not possible to provide firm conclusions regarding a relationship between the age of diagnosis of a visual impairment and the number and type of problems encountered along the route. There were however a significantly higher number of incidents recorded involving individuals with peripheral vision loss and those who are fully blind, all of which used either a guide dog or a long cane. This finding reflects the fact that users of a mobility aid and those with peripheral vision loss or blindness, all rated factors and features associated with the design of the built environment as more influential, problematic and hazardous than others, during the survey presented in Chapter 5. This could perhaps be explained by a higher degree of vision loss in individuals who prefer to travel with a mobility aid. Alternatively it may be due to the aid alerting them to the many obstacles while navigating in the built environment. These results indicate that the use of a mobility aid alone does not eliminate the hazardous nature of the built environment as perceived by the visually impaired pedestrian.

Participants planned their routes around the positioning of known accessible pedestrian crossings. Therefore the main problems encountered during the experiment were in relation to the design of pavements, including the presence and inappropriate zoning of street furniture, often narrowing the pavement and causing pedestrian congestion. It should however be noted that problems still existed due to the non-standard design of road crossings, including irregular positioning of the crossing pole / tactile spinning cone, and lack of accessible crossing points.

The findings from the navigational experiments presented within this chapter have demonstrated that there are clear differences between the movement patterns of the visually impaired and fully sighted populations when navigating within a typical built environment. Individuals with a visual impairment took longer to complete the journey and undertook journeys of a greater distance. These differences are not due to a lack of understanding with regards to spatial orientation or cognitive mapping abilities, but are rather due to barriers inherent within the design of the built environment which restricts movement to specific pre-planned, rehearsed routes. The following chapter will build on the findings from the survey, access audit and navigational experiments by producing an evaluation tool to quantify the number and type of hazards present within the design of individual streets situated within the boundary of the study area.

Chapter 8: Street Hazard Rating Calculation

8.1. Introduction

This chapter expands on many of the themes explored within the survey, access audit and navigational experiments through the creation of an evaluation tool to represent the overall accessibility of individual streets located within the boundary of the study area. After gaining an understanding of the design features which pose a hazard to visually impaired pedestrians, the next stage of the research involves quantifying the number and type of such hazards present within the design of individual streets. This information will form the basis for a street hazard rating calculation whereby each street within the study area is awarded a percentage rating to reflect the overall accessibility for the visually impaired pedestrian. The results from the hazard rating exercise will be used to facilitate the creation of a colour coded street hazard rating map of Glasgow city centre, providing a visual representation of the current levels of accessibility with relation to specific streets and interconnections with the built environment on a wider scale.

The street hazard rating calculation will also be used as a basis for assessing the suitability and current provision of existing mandatory regulations featured in the Scottish Building Regulations (Section 2.3.2) in addition to best practice guidance contained in British Standards BS 8300 (Section 2.3.3), Inclusive Mobility (Section 2.3.4) and Guidance on the use of tactile paving (Section 2.3.5). This exercise will assist in identifying possible shortages with relation to the current provision of mandatory regulations and advisory guidelines by examining the relationship between the percentage ratings and design features, fixtures and fittings incorporated into the design of streets.

8.2. Street Hazard Rating calculation

The street hazard rating is a formula based calculation which provides a percentage rating relating to the accessibility of each individual street within the study area. The areas of investigation are categorised into three main sections focusing on (i) pavement characteristics, (ii) street furniture and (iii) pedestrian crossings. Each design category has been assigned a separate percentage rating based on the hazardous nature and disabling effect it can have on the visually impaired pedestrian. The rating scores for each category were determined from a number of sources. The main source being the feedback given by the visually impaired survey participants when asked to rate the influential factors preventing independent travel in addition to the problematic and hazardous features associated with pavement design and street furniture. This created a rating system whereby pavement characteristics and street furniture were each awarded a potential percentage rating of 30% and pedestrian crossings a potential total rating of 40%. Each design category was divided into separate sections and thereafter awarded a rating score in relation to specific features. Full details of the breakdown within each individual category are presented below. The calculations required to facilitate the creation of the individual ratings within each design category are provided in Appendix D.

8.2.1. Pavement Characteristics

The pavement characteristics were categorised into six main sections and awarded a rating score for each particular design element. This process provided the basis for an overall average rating for the pavement characteristics for each particular street. Each design element was allocated one of three rating scores. A rating score of 1 was given if a design element was deemed to be hazardous or cause significant problems for a visually impaired pedestrian. A rating score of 2 was awarded if a design element was deemed to cause potential problems at certain locations along a street. Finally, a rating score of 3 was given if a design feature was deemed to be of benefit to the visually impaired pedestrian. For further details see Table 8.1.

Table 8.1: Percentage rating awarded to specific pavement characteristics

Score	1	2	3
General Condition	Consistently bad	Sporadic patches	Consistently good
Paving Type	Patterned	Mixed	Plain
Surface Reflectance when wet	Reflective	Mixed	Non-reflective
Width	Consistently very narrow / very wide	Inconsistent	Adequate
Kerb Height	Highly variable	Variable	Consistent
Level Changes	Present without assistive features	Present with assistive features	Not present
Potential Total		**18**	
Weighting		**30%**	

8.2.1.1. General Pavement Condition

Streets with uneven, broken or missing paving can pose a significant hazard to pedestrians of all abilities (see Section 6.6.2, Figure 6.4). For this reason, streets with a consistently bad paving surface were awarded a score of 1. In cases where a small section of the paving requires maintenance a score of 2 was given and in circumstances where a street has a consistently level and smooth paving surface, a score of 3 was given.

8.2.1.2. Paving Type

Streets with patterned paving were deemed to be detrimental to the visually impaired pedestrian (see Section 6.6.3, Figure 6.6). For this reason streets with paving of varying colour, size, shape and pattern (including cobbles) were awarded a rating score of 1. A score of 2 was given for pavements with sections of both patterned and plain paving and a score of 3 was allocated for pavements with a plain consistent and non patterned appearance.

8.2.1.3. Surface Reflectance

Certain paving types can become reflective when wet, causing confusion, disorientation and anxiety (see Section 6.6.3, Figure 6.7). For this reason, a street with a reflective paving surface was awarded a low rating of 1. A rating of 2 was awarded in circumstances where a street has different paving types, one of which is reflective. Finally, a rating score of 3 was given to streets with non reflective matt paving surfaces.

8.2.1.4. Pavement Widths

A pavement which is consistently narrow along the full length of the street can be undesirable for the visually impaired pedestrian due to the close proximity to the kerb edge and lack of space to negotiate items of street furniture and other pedestrians, particularly in circumstances where the use of a sighted companion or guide dog is required. Similarly, a very wide street, pedestrian precinct or public square can be difficult to navigate, way find and orientate within due to the lack of available cues (see Section 6.6.4, Figure 6.9). For this reason, both a very narrow and very wide pavement have been awarded a low score of 1. In circumstances where a pavement significantly reduces in width at a specific location, predominantly as a result from the placement of street furniture, a score of 2 was given. Finally, a rating score of 3 was awarded to pavements with an adequate space to negotiate street furniture and other pedestrians and still maintain spatial awareness and orientation.

8.2.1.5. Kerb Height

A pavement with varying kerb heights can be a hazardous and confusing environment for the visually impaired pedestrian, due to a lack of uncertainty over the vertical distance between the footpath and road along the length of the pavement (see Section 6.6.5, Figure 6.13). For this reason, pavements with a significant variation in kerb heights along the entire length of the pavement were awarded a low rating of 1. In cases where the height of the kerbs varied slightly, a rating score of 2 was awarded and in cases where the kerb height was consistent along both sections of the pavement, a high score of 3 was allocated.

8.2.1.6. Level Changes

An unmarked level change can be extremely hazardous for a visually impaired pedestrian (see Section 6.6.6). For this reason where a level change is present with no assistive features such as corduroy hazard warning paving, continuous handrail and stair edge strips, a low rating score of 1 was allocated. In cases where a level change equipped with assistive features was present, a score of 2 was awarded. Streets with no level changes were rewarded with a high rating of 3.

8.2.2. Street Furniture

The street furniture category represents 30% of the street rating total and has been divided into three sections (i) presence, (ii) colour and (iii) zoning, each representing 10% of the street furniture total. See Table 8.2 for details.

Table 8.2: Percentage rating awarded to specific street furniture characteristics

Weighting	Presence	Colour	Zoning
Weighting within street furniture	33.33%	33.33%	33.33%
Total Weighting within hazard rating		30%	

8.2.2.1. Presence

Each item of street furniture was awarded a rating score from 1 to 10. The scoring system was determined from the ratings provided by the visually impaired survey participants when asked to rate the most hazardous items of street furniture (see Section 5.5.12, Table 5.22). As bollards were deemed to be the most hazardous item of street furniture, they were awarded a score of 1, followed by bins which received a rating score of 2. The least hazardous item (telephone box) was awarded a score of 10. If an item of street furniture was not present then it was allocated a score of 11 to acknowledge the absence of a potential hazard. Table 8.3 details each item of street furniture against the allocated rating score.

Table 8.3: Percentage rating awarded to specific items of street furniture

Item of street furniture	Rating	Item of street furniture	Rating
Bollards	1	**Bus stops**	7
Bins	2	**Railings**	8
Outside dining areas	3	**Trees**	9
Signage	4	**Telephone boxes**	10
Lampposts	5	**Not present**	11
Seating	6		
Potential Total		**110**	
Weighting within street furniture		**33.3 %**	

8.2.2.2. Colour

Each item of street furniture was awarded a score in relation to a particular colour from 1 to 8. The scoring system for the colours was determined from the ratings provided by the visually impaired survey participants when asked to select the most visible colours within the built environment (see Section 5.5.13, Figure 5.14). If items of the same type of street furniture were present in different colours, then the rating score for the most dominant colour would be chosen. The rating score applies the same logic to that used in Table 8.3, where a low rating of 1 equals the least visible colour (silver) and a high rating of 8 equals the most visible colour (yellow).

Table 8.4: Percentage rating awarded in accordance to colour of street furniture

Colour	Rating	Item of street furniture	Rating
Silver	1	**White**	5
Green	2	**Orange**	6
Blue	3	**Red**	7
Black	4	**Yellow**	8
Potential Total		**64**	
Weighting within street furniture		**33.3 %**	

8.2.2.3. Zoning

Finally, each type of street furniture was awarded one of three rating scores relating to its positioning and zoning on the pavement. If an item or items were consistently poorly zoned then they would be awarded a low rating score of 1. If a street furniture category was well zoned with the exception of one item then it was awarded a score of 2 and if all items of the same type of street furniture were zoned in a way that did not significantly reduce the pavement width or pose a collision hazard for pedestrians, it was awarded a rating score of 3. For further details see Table 8.5.

Table 8.5: Percentage rating awarded in accordance to the zoning of street furniture

Rating	1	2	3
Item of street furniture	Poor zoning	Inconsistent Zoning	Good zoning
Potential Total		**30**	
Weighting within street furniture		**33.3 %**	

8.2.3. Pedestrian Crossings

The design of pedestrian crossings accounted for 40% of the overall percentage rating for each street. This category was awarded a higher percentage than the other two categories due to the important role that accessible pedestrian crossings play in the planning and successful completion of a route (see Sections 6.8.5 and 7.9.1). A street can have an exemplar design, free from obstacles but if the pedestrian is unable to traverse the full length of the street due to a lack of controlled crossings or inaccessible pedestrian crossings, then the street becomes extremely hazardous and potentially unusable for pedestrians with a visual impairment.

The number of road intersections along the entire length of a street was recorded. This was then compared against the number of accessible crossing points. A crossing was classified as accessible if it was equipped with a tactile spinning cone or audible signal (see Section 6.8.2). A pedestrian crossing was allocated additional points if the design incorporated tactile blister paving (Section 6.8.1) and a dropped kerb (Section 6.8.4). Further information can be obtained from Table 8.6 on the following page and Appendix D.

Table 8.6: Percentage rating awarded in accordance to road crossing design

Criteria	Rating System
No. of crossing points	**x** = No of road intersections along length of street
Accessible Crossings	No. of controlled crossing points with tactile cone or audio signal
Dropped Kerb	No. of controlled crossings with dropped kerb
Tactile Paving	No. of controlled crossings with tactile paving
Potential Total	**3x**
Weighting	**40%**

8.2.4. Sample Hazard Rating

An example of a completed hazard rating form has been provided in Table 8.7. For a full account detailing the hazard rating scores on a street by street basis, see Appendix D. This example details the rating scores for a principle street within the city centre. Ingram Street has recently undergone major modern aesthetic alterations as part of the city centre public realm works. Despite the installation of new paving materials and street furniture, the street only managed to obtain an overall rating score of 58%, suggesting that by simply modernising a space, the overall accessibility may actually decrease rather than improve. Pavement characteristics were awarded a score of 21.67% out of a potential 30% due to the presence of an unmarked level change and highly reflective paving when wet. Street furniture only received half of its potential total due to the irregular zoning and hazardous positioning of certain items. The majority of the street furniture present on the street was also of the new slim line stainless steel variety making it hard to detect for the visually impaired pedestrian. Finally, road crossings were awarded a total of 21.67% out of a potential 40%, as only four out of eight crossing points were equipped with a tactile spinning cone or audio signal, making it extremely dangerous to walk along the full length of the street (see Table 8.7 for details).

Table 8.7: Example of street rating system for Ingram Street

Ingram Street			
Pavements (30%)		**21.67**	
General condition		3	
Paving Type		2	
Surface Reflectance when wet		1	
Width		3	
Kerb height		3	
Level changes		1	
Street Furniture (30%)		**14.69**	
	Presence	Colour	Zoning
Bollards	1	1	1
Bins	2	1	3
Outside dining areas	3	1	2
Signage	4	1	3
Lampposts	5	1	1
Seating	11		
Bus stops	7	1	3
Railings	11		
Trees	9	2	1
Telephone Boxes	10	4	3
Subtotal (10%)	5.73	1.88	7.08
Road Crossings (40%)		**21.67**	
No. of crossing points		8	
Accessible crossings		4	
Dropped kerb		5	
Tactile Paving		4	
TOTAL RATING (%)		**58.02**	

8.3. Results and Interpretation

A total of 38 streets were audited as part of the hazard rating exercise. The rating scores were found to vary significantly across the study area from a low percentage rating of 25.7% to a high percentage rating of 80.7%. Table 8.8 details the number of streets located within each rating score category, exactly one half of all streets received a rating score below 50%.

Table 8.8: Number of streets within each percentage rating category

0 – 24%	25 – 34%	35 – 44%	45 – 54%	55 – 64%	65 – 74%	75 – 84%	85 – 100%
0	6	9	8	7	7	1	0

The findings highlight a considerable lack of consistency with regards to the design and treatment of the streets within the study area. This in turn further emphasises the hazardous and restrictive nature of the built environment for persons with a visual impairment. Interestingly, the three streets to be rated in first, second and third place; Argyle Street (80.7%), Queen Street (73.9%) and Buchanan Street (70.4%), were all selected as the preferred route choice among the visually impaired participants during the navigational experiment (see Section 7.7). This indicates that the visually impaired population have instinctively developed their own street hazard rating map for frequently used areas of the city, providing further evidence to suggest that this population actively use cognitive mapping techniques to pre-plan their route to include streets with higher accessibility ratings therefore avoiding more hazardous corridors of the city.

The results from the hazard rating were used to facilitate the creation of a street hazard rating map of Glasgow city centre (see Figure 8.1). Each street has been categorised into a particular percentage rating group as defined in Table 8.8 and thereafter represented on the map using one of six colours.

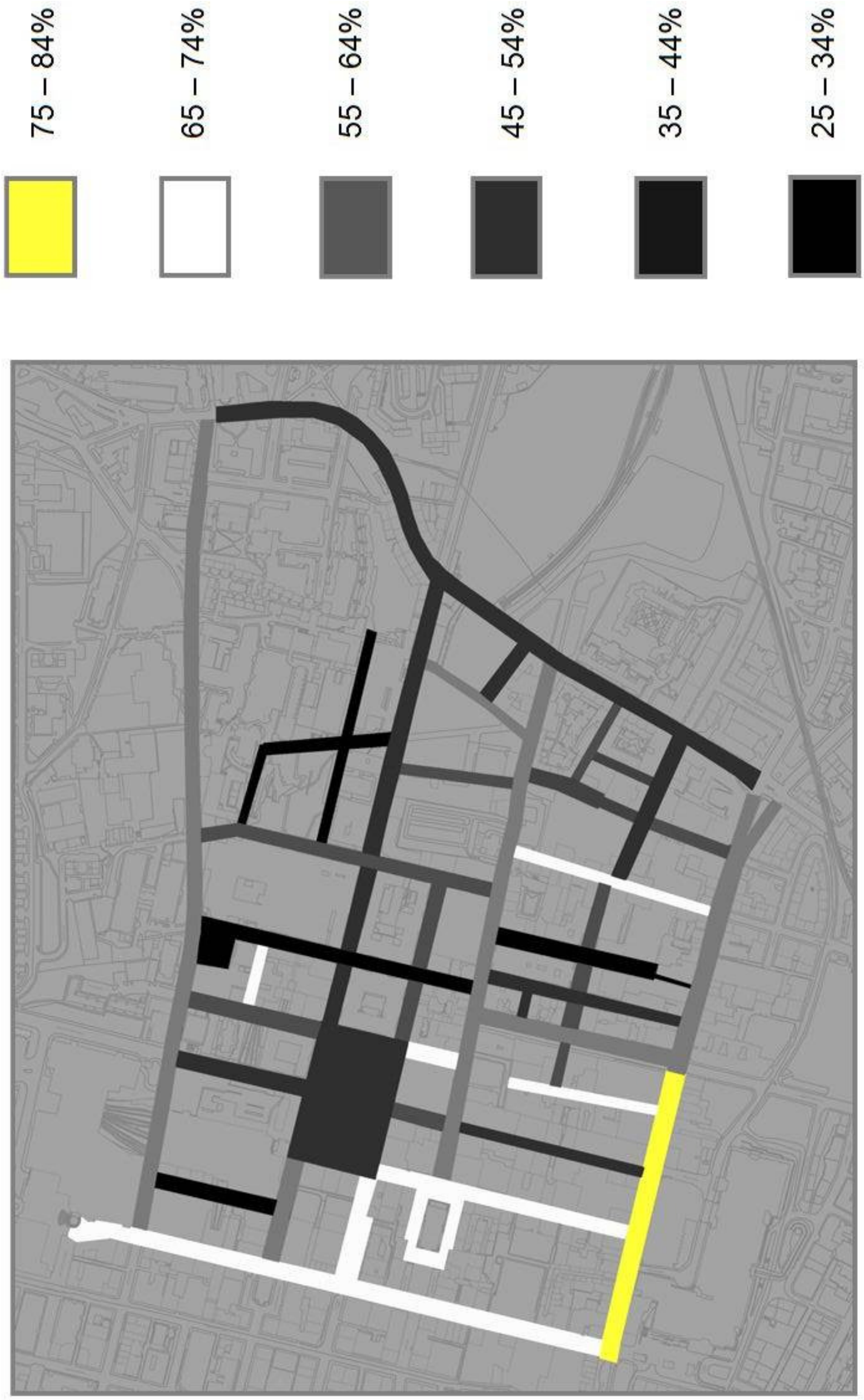


Figure 8.1: Hazard rating map of Glasgow city centre

The Street hazard rating map clearly demonstrates the patchwork nature of the city centre, with hazardous streets intertwined among more accessible strips. There also appears to be a division between areas of low, moderate and high accessibility. Streets located within the south west quadrant generally have a higher percentage score compared to those located within the north and east of the city. As a general rule, the streets with the highest rating scores were all equipped with accessible pedestrian crossings allowing for a safe passage along the full length of the street. The high number of streets with low ratings is a direct reflection towards the insufficient provision of accessible pedestrian crossing points along a street or between connecting streets. This is evident at several principle locations within the study area including the main public square (George Square), which received a rating of 44.3% (see Appendix D). This low rating reflects the absence of tactile paving, dropped kerbs, inconsistent positioning of tactile spinning cones and lack of accessible pedestrian crossings at two locations.

The irregular positioning, poor colour contrast and inconsistent zoning of street furniture also had a major impact on the overall percentage rating for areas where street furniture was widely used. In particular the choice of colour and material had a significant impact on the percentage rating within the street furniture category. This reflects the fact that silver and stainless steel (identified in the survey and post task discussion as low visibility colours), had a high prominence among all types of street furniture present within the study area. Finally, pavement characteristics also had an impact on the overall percentage rating although to a lesser extent than that of road crossings and street furniture. The main elements responsible for reducing the percentage rating were inconsistent kerb heights, reflective paving surfaces and significant variations in pavement width predominantly due to the inappropriate positioning of street furniture.

Figure 8.2 details the streets with the lowest and highest percentage ratings. The most hazardous street within the study area was John Street with an overall rating score of 25.7%, while Argyle Street received the highest rating with a score of 80.7%. In order to understand the reasons why these two streets differ so much in terms of accessibility, they will be examined in detail in sections 8.3.1 (most hazardous street) and 8.3.2 (most accessible street) through the use of tables and annotated street maps.

Figure 8.2: Map indicating most accessible street and most hazardous street

8.3.1. Most Hazardous Street

John Street is located in the centre of the study area and has a north – south orientation stretching for a distance of 0.4km. The street is intersected by two principle roads creating three distinct sections under the same street name. The northern section is 200 metres in length and follows a steep gradient downwards until the intersection of the first main road. This section contains University accommodation, including the sports centre and student union. The middle section of the street is 80 metres in length and follows a level gradient between several archways of the city chambers building until reaching the second road intersection. The southern section runs for a distance of 70 metres forming a pedestrian precinct containing bars, restaurants and residential accommodation. The street will be analysed in detail in terms of pavement characteristics, street furniture and road crossings in order to identify the main factors contributing to the low accessibility rating awarded to the overall design of the street. An annotated map of John Street is provided at the end of this section (Figure 8.3) in order to illustrate the exact locations of hazardous features along the full length of the street.

8.3.1.1. Pavement Characteristics

The pavement characteristics of John Street were assessed and awarded rating scores in terms of (i) the general condition of the paving, (ii) the type of paving used, (iii) the level of reflectance when wet, (iv) the width of the pavement, (v) the consistency of kerb heights and (vi) the presence and treatment of level changes. Taking all these factors into account, a low score of 8 out of 18 was awarded, equating to 13.3% out of a potential 30% (see Table 8.9 for full details).

The three separated sections of John Street exhibit extreme differences in terms of the overall treatment to the paving surface and material. The north and middle sections are predominantly paved in concrete which is of overall poor quality, condition and appearance. In addition to concrete, other materials used as paving surfaces include tarmac, brick, cobbles, gravel and plastic gridding at car parking areas. In contrast, the southern section of the street has recently been modernised and repaved to include Caithness stone as the base material. Although the condition of the newly paved section was considerably better than the north and middle sections, the patterned design and reflective nature of the surface under wet conditions had a detrimental effect to the rating scores in relation to the type of paving and reflectance levels. There is a large variation in the pavement width along the entire length of the street. Starting at the northern most section, there is a pedestrian square containing a sequence of level changes, trees and planted areas. The footpath then significantly narrows at the point at which the square meets the road and car park (see 8.3) and thereafter separates into two pavements on either side of the road. The pavement in the middle section of the street narrows in width at the two locations where the stone arches of the city council building meet the ground. On the southern section the width of the pedestrian area reduces considerably as a result of outside dining areas, seating, bollards, bins and trees. In addition to a variable pavement width, the kerb heights vary considerably, particularly in the northern section of the street.

A substantial number of level changes were present in the northern section, both in terms of pavement breaks to facilitate vehicular access and steps to negotiate the sloping gradient. At the beginning of the northern section the pedestrian is required to negotiate several level changes. At this point there is no clear path to follow and a number of different routes are possible between trees and planted areas. A low rating score was awarded to level changes primarily due to the lack of accessible features incorporated within the design of steps. In particular, corduroy hazard warning paving was absent from the top and bottom of each flight of steps making the detection of a level change extremely difficult and potentially dangerous. Furthermore, the majority of steps were not fitted with a handrail and in cases where a handrail was present; the design did not comply with design regulations (see Section 6.6.6). Finally, the steps did not incorporate high contrasting stair edge strips to help differentiate the end of each stair tread. Another area of concern related to the high frequency of pavement breaks to allow vehicular access to buildings. A total of ten unmarked level changes were observed on the east pavement with a total of four on the west pavement, creating a treacherous environment for the visually impaired pedestrian (see Table 8.9).

Table 8.9: Rating scores awarded for pavement characteristics

Score	1	2	3
General Condition	✓		
Paving Type		✓	
Surface Reflectance when wet		✓	
Width	✓		
Kerb Height	✓		
Level Changes	✓		
Total score / potential		**8 / 18**	
Percentage rating / potential		**13.3% / 30%**	

8.3.1.2. Street Furniture

The overall percentage rating awarded to street furniture was 12.4% out of a potential 30%. Table 8.10 details the rating scores allocated for the presence, colour and zoning of items of street furniture located on John Street. Both old and new styles of street furniture were present on the street, ranging from older style black furniture in the less developed north and middle sections to modern stainless steel items in the recently developed southern section. As opposed to pavement characteristics where the north and middle sections received a lower rating than the south, the street furniture in the less developed north and middle sections were deemed to be less hazardous due to the better zoning, larger size and more visible colours (black). The southern section however was dominated by street furniture in the form of bollards, litter bins, seating and outside dining areas. All of the items were in a slender stainless steel design making their detection extremely difficult to the visually impaired pedestrian. The street furniture is zoned into two strips running the length of the pedestrian section. The first strip is positioned 2 metres from the building edge and the second is parallel to the protective barrier of the outside dining area. If a pedestrian were to veer to the left or right of the clear zone to access a bar or restaurant they face a high risk of colliding with a low visibility bollard, litter bin or bench.

Table 8.10: Rating scores awarded for the presence, colour, zoning of street furniture

Item	Presence	Colour	Zoning
Bollards	1	**1**	**1**
Bins	2	1	1
Outside dining	3	1	3
Signage	4	1	1
Lamp posts	11		
Seating	6	**1**	**1**
Bus stops	11		
Railings	11		
Trees	9	2	2
Telephone boxes	10	1	1
Percentage rating / Potential (%)	**12.4 / 30**		

8.3.1.3. Road Crossings

John Street is intersected by two principle roads, none of which are equipped with controlled or accessible pedestrian crossing points. The lack of accessible pedestrian crossings resulted in a percentage rating of 0% out of a potential 40% (see Table 8.11). The absence of accessible crossing points had a significant effect on the overall percentage rating for the street. It is apparent in this case that John Street has not been treated as a single uniform street but rather three separate entities, creating difficulties for pedestrians of all abilities but posing a significant risk to the visually impaired pedestrian. Independent travel along the full length of the street is an extremely dangerous activity as the visually impaired pedestrian is required to guess the point at which it is safe to cross the road, incurring significant risks to their health and safety. It should be noted that if both crossing points were equipped with accessible pedestrian crossings, the overall street rating would increase by 40% to produce a new overall accessibility rating of 65.7%.

Table 8.11: Rating scores awarded for the provision and accessibility of road crossings

Criteria	Rating System
No. of crossing points	**2**
Accessible Crossings	0
Dropped Kerb	0
Tactile Paving	0
Percentage rating / Potential (%)	**0 / 40**

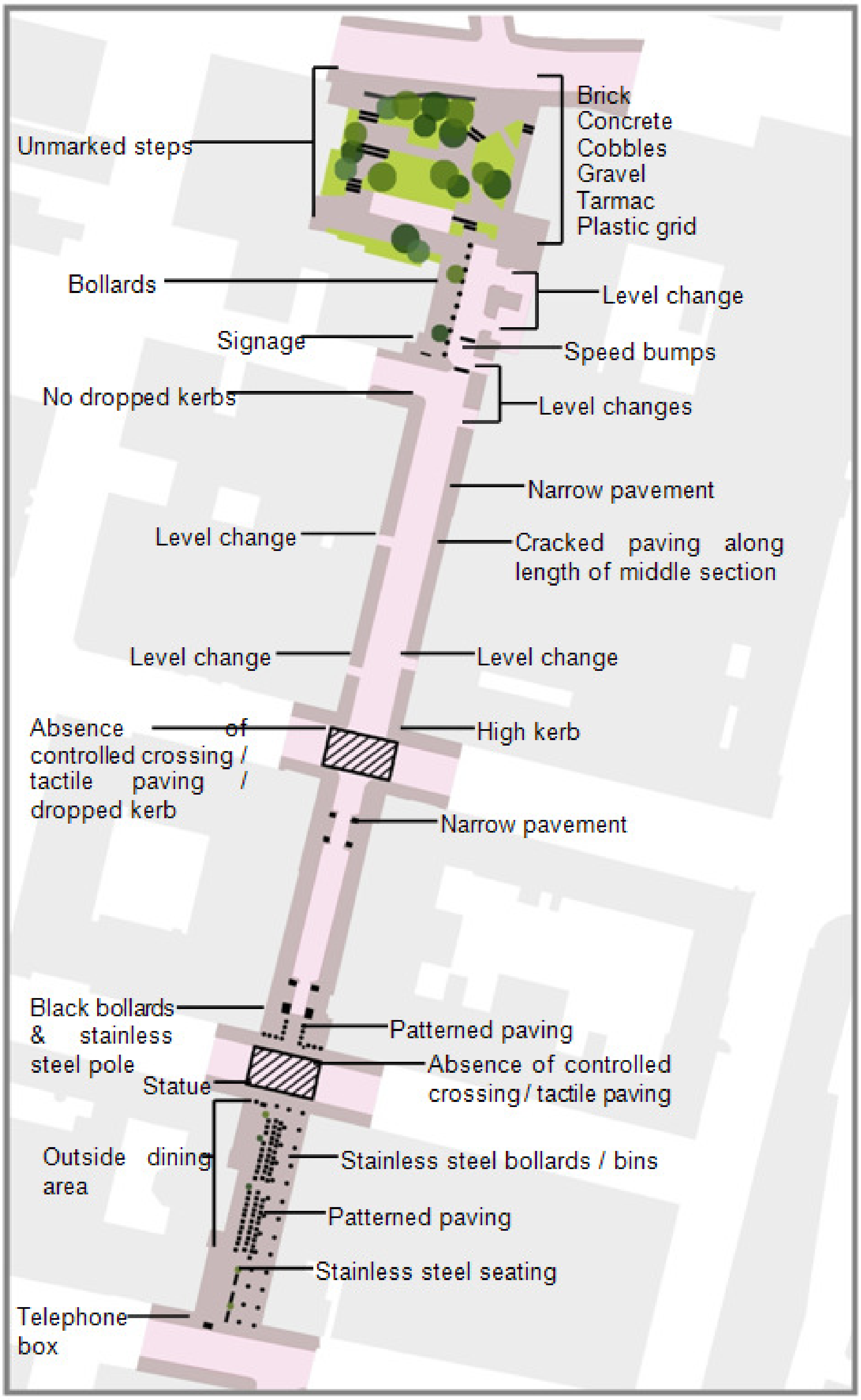


Figure 8.3: Annotated map of John Street indicating hazardous features

8.3.2. Most Accessible Street

The most accessible street within the study area was Argyle Street with a rating score of 85.7%. The street has an east – west orientation and stretches for a distance of 0.3km, two thirds of which are pedestrianised. As with John Street, an annotated street map (Figure 8.4) is provided to indicate the location of accessible and potentially hazardous features associated with the design of the street.

8.3.2.1. Pavement Characteristics

Pavement characteristics were awarded a percentage rating of 23.3% out of a potential 30%. This score reflects the fact that the pavement surface is in a good smooth level condition with no level changes and consistent kerb heights. Points were deducted due to the highly reflective properties of the paving surface under wet conditions in addition to the patterned paving surface present throughout the pedestrian area (see Table 8.12).

Table 8.12: Rating scores awarded for pavement characteristics

Score	1	2	3
General Condition			✓
Paving Type		✓	
Surface Reflectance when wet	✓		
Width		✓	
Kerb Height			✓
Level Changes			✓
Total score / potential		**14 / 18**	
Percentage rating / potential (%)		**23.3 / 30**	

8.3.2.2. Street Furniture

Street furniture was awarded a percentage score of 17.4% out of 30%. The poor zoning and colour contrast of concrete cubes, signage and a stainless steel bollard resulted in a reduction to the rating score (see 8.4 for exact locations). The zoning of all other items of street furniture was however clear and consistent, with minimal risk to the visually impaired pedestrian. The zoning and colour contrast was particularly good in the pedestrian section as the furniture is contained within a single strip in the centre of the pavement, defined by a change in the paving material.

Table 8.13: Rating scores awarded for the presence, colour, zoning of street furniture

Score	Presence	Colour	Zoning
Bollards	1	**1**	**1**
Bins	2	4	3
Outside dining	11		
Signage	4	1	1
Lamp posts	11		
Seating	6	**4**	**3**
Bus stops	7	**1**	**3**
Railings	8	4	3
Trees	11		
Telephone boxes	10	1	3
Percentage rating / potential (%)	**17.4 / 30**		

8.3.2.3. Road Crossings

Argyle Street has three road crossings, one connecting the non pedestrian area to the pedestrian precinct and two at either end of the street (see 8.4). All three crossings are fully accessible incorporating spinning cones, tactile paving and dropped kerbs. The provision of accessible crossings enables the visually impaired pedestrian to traverse the full length of the street in a safe and efficient manner. For this reason, road crossings were awarded a top score of 40% (Table 8.14). Although road crossings received full marks for accessibility, two features were highlighted as potential hazards. Firstly, the brass tactile paving in use at all three crossing points was extremely slippery when wet and has the potential to cause injury to pedestrians of all abilities. Secondly, the crossing pole and location of the tactile spinning cone at two crossing points were positioned in a non standard location which could mislead the visually impaired pedestrian into thinking that a controlled crossing or spinning cone is not present.

Table 8.14: Rating scores awarded for the provision and accessibility of road crossings

Criteria	Rating System
No. of crossing points	**3**
Accessible Crossings	3
Dropped Kerb	3
Tactile Paving	3
Percentage rating / Potential (%)	**40 / 40**

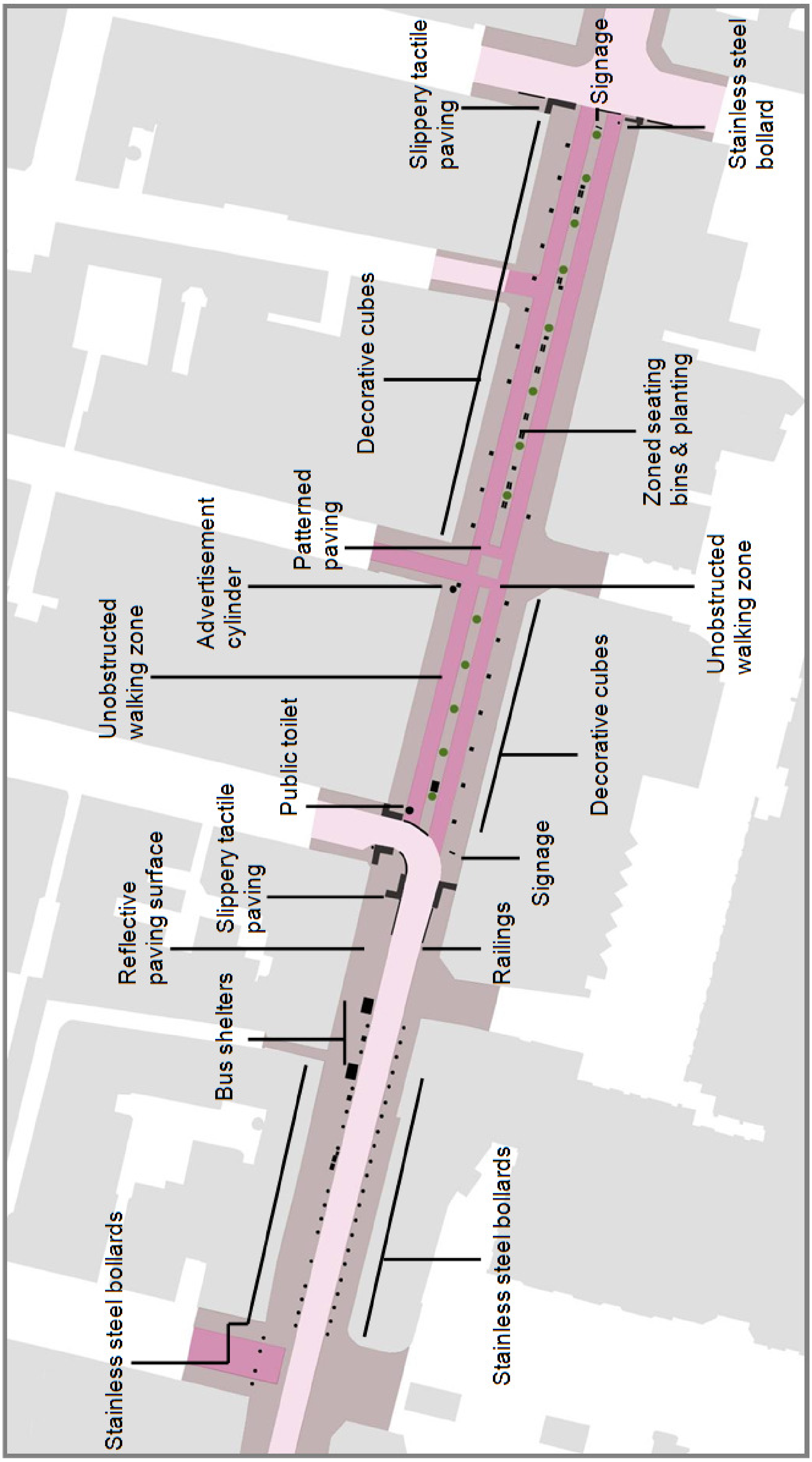


Figure 8.4: Annotated map of Argyle Street indicating hazardous features

8.4. Conclusion

The street hazard rating calculation has, for the first time, provided an account of the current status of the accessibility of the external built environment with particular reference to the visually impaired pedestrian. The distinct lack of mandatory regulations available to designers, planners and local authorities is perhaps a major contributor to the disabling nature of the built environment and hence the low percentage ratings achieved. Furthermore, the quantity and variety of hazards present within the design of streets suggests that local authorities have a disregard to the current best practice guidelines, instead opting for architectural fashion trends over safe and accessible inclusive design solutions. This is further emphasised when examining the percentage rating scores for streets which have recently been redeveloped. It may perhaps be perceived that modernised areas of the city would provide more accessible environments for the visually impaired pedestrian; however in reality the opposite is true in many cases. It was evident that by simply redeveloping and upgrading a street with new paving and street furniture, the end result would not necessarily produce a more accessible street environment but rather introduce additional barriers hence reducing the overall accessibility. This is particularly applicable to the main pedestrian shopping areas of the city, both of which have new paving, street furniture and fully accessible pedestrian crossings. The choice of materials, fixtures and fittings has led to the creation of an environment with glare, reflection and dangerously positioned low visibility street furniture, which paradoxically are implemented with the intention of improving the pedestrian environment. Less developed streets of the city were generally absent from glare, reflection and obstacles; however the percentage ratings were significantly reduced due to the sporadic nature of accessible pedestrian crossings.

It was interesting to note that the three streets to receive the highest accessibility ratings also featured as the preferred route choice for the visually impaired participants during the navigational experiments. This suggests that individuals who are familiar with an area instinctively develop their own street hazard rating map of the city. This provides further evidence to support the view that the visually impaired population actively use cognitive mapping abilities prior to and during a journey in order to negotiate the built environment with ease and efficiency through the avoidance of inaccessible sectors of the city. This finding only reinforces the urgent need for additional mandatory regulations to be enforced in order to remove barriers to access and create more user friendly environments. Not only will this increase independence but will also enable the visually impaired pedestrian to expand and make more efficient use of the cognitive map by increasing the scope of available route choices. It is for this reason that the following chapter will focus on the development of an enhanced set of design guidelines to eliminate unnecessary barriers and deliver more enabling environments for the benefit of the visually impaired pedestrian.

Chapter 9: Design Guidelines

9.1. Introduction

Throughout the research, information has been acquired as to the main hazards present to visually impaired individuals when traversing within the built environment. In particular, the hazard rating calculation highlighted the relationship between the quantity and variety of hazards and the distinct lack of mandatory regulations available that specifically address the navigational needs of the visually impaired pedestrian beyond the curtilage of a building. This chapter therefore aims to address many of the problematic elements identified in the survey, access audit, navigational experiments and post task discussions, through a critique and comparison of existing mandatory regulations and best practice guidelines. This information is used to suggest enhancements to existing guidelines focusing specifically on characteristics associated with the design of pavements, level changes, street furniture and pedestrian crossings. It is envisaged that the introduction of additional mandatory regulations imposed on designers and planners will assist in eliminating architectural barriers to create a safer, more visible streetscape for visually impaired users of the built environment.

This chapter commences with a reiteration of the remit and intended coverage of the current mandatory regulations contained within the Scottish Building Regulations 2009 (SBSA, 2009) and best practice guidance documents, British Standards BS 8300 (BSI, 2009), Inclusive Mobility (Dept. for Transport, 2005a) and Guidance on the use of tactile paving surfaces Mobility (Dept. for Transport, 2002). The focus then shifts to a critique of these existing provisions, which derives from comparative tables between regulations and guidelines. The comparisons reveal the content of the enhanced guidelines and the extent to which amendments are necessary to improve access within the built environment for visually impaired pedestrians.

9.2. Critique of Current Regulations & Guidelines

9.2.1. Mandatory Regulations

The Scottish Building Regulations provide mandatory standards that must be adhered to during the design, construction and conversion of both domestic and non domestic buildings (see Section 2.3.2). The mandatory regulations contained within Section 4 of the document, *Safety*, generally focus on the access needs and usability of interior spaces within buildings. Where reference is made to the external environment, the regulations only cater for the access needs within the curtilage of a building, taking into account the access route between the road or accessible car parking space to the building entrance (see Figure 9.1). The guidelines available for the design of an accessible route are limited to outlining acceptable route widths, surface material and placement of street furniture. Furthermore, the Standards predominantly focus on the access needs of individuals with mobility impairments with little reference being made to the specific needs of visually impaired users of the building / access route.

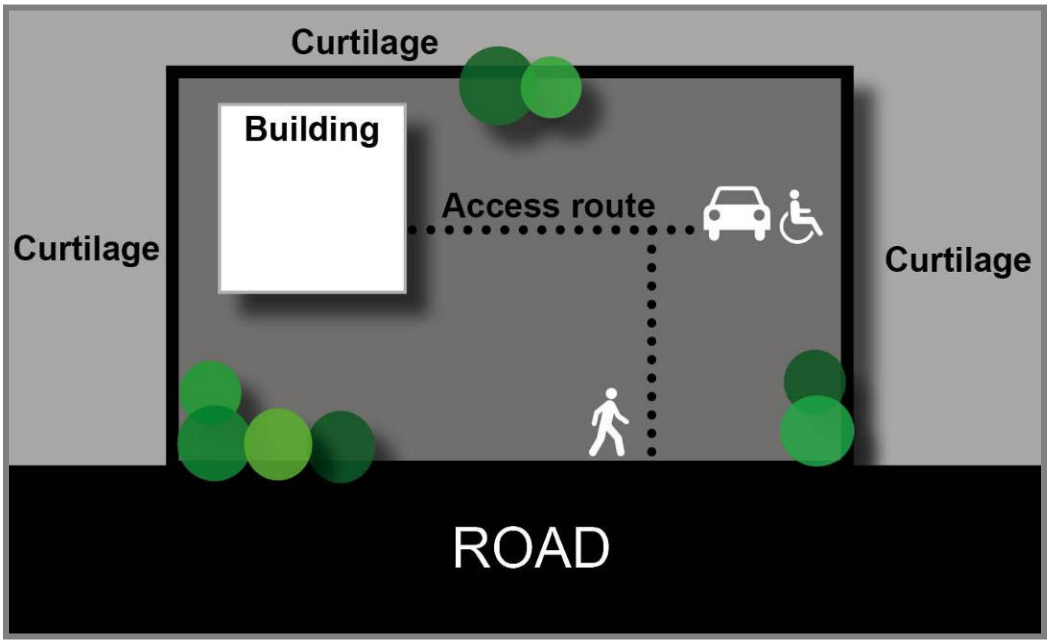


Figure 9.1: Current area covered by the Scottish Building Regulations 2009

There are currently no mandatory regulations within the current Scottish Building Regulations catering for the design of external environments outwith the curtilage of a building. The limitations of the Building Regulations are explicitly stated in the introduction to Section 4 of the document, where the reader is advised to refer to additional documentation for information regarding inclusive design solutions for the external built environment:

> Whilst the guidance to this standard reflects general good practice, certain issues remain outwith the scope of the building regulations. There are numerous publications offering additional guidance on accessibility and inclusive design […]
>
> (SBSA, 2009, p. 8)

As the design standards for external environments relate specifically to the design of an access route within the curtilage of a building, this will be taken into account during the comparison and critique process for pavement design, level changes, street furniture and pedestrian crossings (Sections 9.4 to 9.7) and only included where appropriate.

9.2.2. Advisory Guidelines

The two main guidance documents, BS 8300:2009 and Inclusive Mobility 2005, provide advisory best practice guidance and recommendations for the design of exterior and interior spaces. British Standards BS 8300 augment the Building Regulations by extending the remit outwith the curtilage of the building to include accessible routes from the building entrance to public transport stops and designated car parking spaces (see Section 2.3.3). However the exact remit of the guidelines is uncertain due to the lack of clarity over the definition and distance of the accessible route between the curtilage and public transport stop or designated car parking space. It is for this reason that it is unclear whether these guidelines are applicable to the design of pavements beyond the immediate vicinity of the building and more specifically beyond the boundary of the closest transport stop (see Figure 9.2). Inclusive Mobility as defined in Section 2.3.4 is the only document in this review to specifically provide guidelines for the design of pavements outwith the curtilage of a building and beyond the transport terminal or designated car parking space (see Figure 9.2). In particular the document provides information regarding (i) pavement characteristics such as width, use of material and treatment of level changes, (ii) the design and placement of street furniture, and (iii) the design of pedestrian crossings.

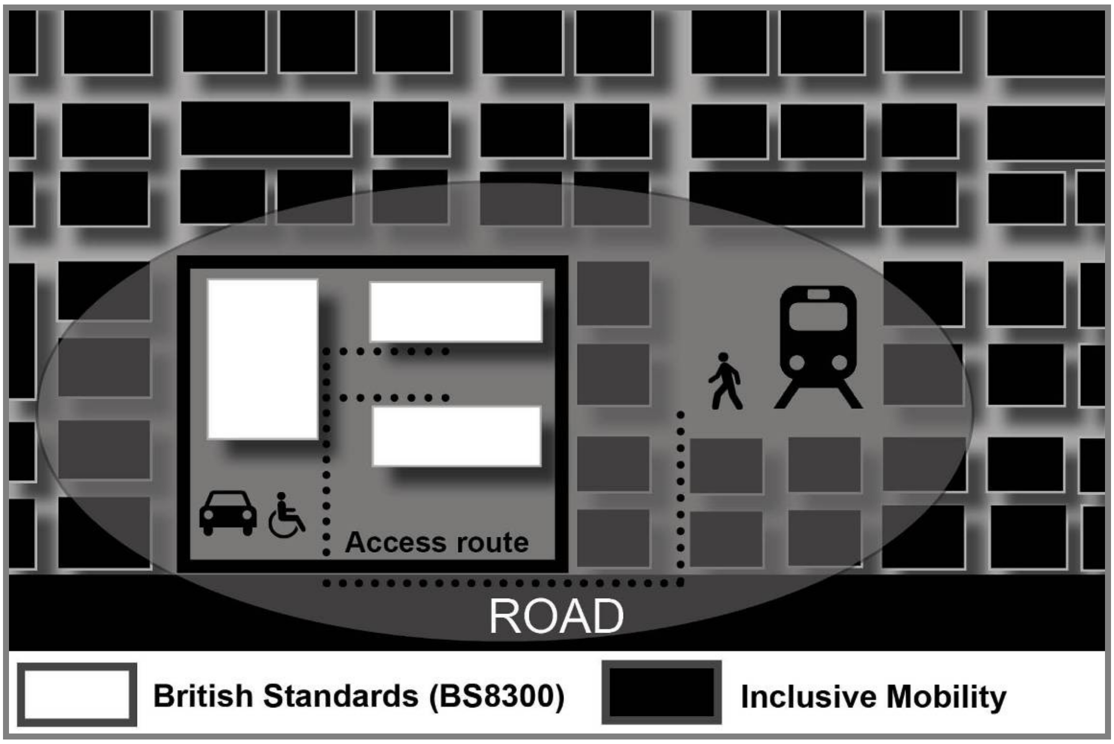


Figure 9.2: Current area covered by British Standards BS 8300 & Inclusive Mobility

9.3. Design Guidelines

The design guidelines focus on the three main themes explored throughout this thesis; specifically, (i) pavement characteristics and level changes, (ii) street furniture and (iii) pedestrian crossings. Each design category is divided into specific elements and presented in tabular format. The tables have been separated into three columns to facilitate the comparison and critique of the mandatory regulations and advisory guidelines. The first column details the current mandatory regulations featured in the Scottish Building Regulations 2009. The second column details the best practice design guidelines contained within British Standards BS 8300, 2009, Inclusive Mobility 2005 and Guidance on the use of tactile paving surfaces 2005. The third column provides an enhanced set of design guidelines which incorporate the research results presented in the previous chapters of this thesis. This review highlights areas where no guidance is available (marked by a large cross) as well as circumstances where conflicting information is contained between mandatory regulations and best practice guidance documents. Recommended regulations and guidance are denoted by a small tick and a small cross is used to represent inadvisable actions.

The enhanced guidelines provide a universal approach, tailored in a way that is sympathetic to the requirements of the visually impaired community as a whole, by taking into account the needs of individuals with varying types and degree of visual field loss. In order for the design guidelines to be effective, it is essential that they are not treated as an optional extra but rather incorporated into the mandatory regulations and hence the standard design practice. This will ensure that elements of the same type and function will have the same treatment, creating a built environment with structure and a sense of familiarity. By adopting this approach the visually impaired pedestrian is equipped with specific knowledge regarding the design and appearance of particular commonly placed objects and elements within the built environment, therefore creating more confidence, independence and fewer restrictions to movement. In the following sections, these issues are investigated through a detailed review, organised into the following categories of; pavement characteristics, level changes, street furniture and pedestrian crossings.

9.4. Pavement Characteristics

This section has been subdivided into four main categories, namely (i) paving material, (ii) paving design and appearance, (iii) pavement width and (iv) kerb design. Each category includes a complete listing of the current mandatory regulations and advisory guidelines where applicable. The enhanced recommendations are intended to supplement the existing regulations and guidelines as well as introduce new recommendations in cases where no previous guidance has been published.

9.4.1. Paving Material

As the Scottish Building Regulations 2009 do not include any reference to mandatory paving material types, the analysis has considered only the recommendations in the best practice guidelines (Table 9.1). Specifically, existing guidelines suggest that a firm and slip resistant material should be used, which should retain these properties under both dry and wet conditions. This research has shown that explicit reference to a *matt* paving material must also be made. By this it is understood that the material should have a dull, lustreless surface that reacts better when wet, but also does not reflect light in both dry and wet conditions. The guidelines do specify the avoidance of reflective materials, but it is suggested here that these should also reduce the effects of glare as detailed in Section 5.5.15. In this manner harsh, dazzling lights – particularly from sunlight or street lighting – can also be avoided. The specifications in the guideline documents regarding uneven surfaces, gaps and cobbles accord with the findings of this research. Particular attention should be paid to the recommendations regarding the avoidance of grates and covers, as these might be mistaken for tactile paving surfaces. Hence, it is suggested here that the material of these features should be as uniform with the surrounding pavement as possible.

In addition to the above, a regular maintenance programme should be adopted. Specifically, utility companies must replace the paving material with an exact match to return the pavement to a uniform design. Although this is not a design specification as such, it reflects the issues discussed in Section 6.2 regarding the intrusive manner that utility companies influence the appearance of street paving (CABE *et al.*, 2002). Building regulations should therefore explicitly situate the problem and attach conditions in the paving restoration process, so that it retains any accessibility features included in the initial design.

Table 9.1: Existing Regulations & Guidance for paving materials alongside with Enhanced recommendations

Paving Material (pavements)		
Mandatory Regulations	Best Practice Guidelines	**Enhanced Recommendations**
	✓ Firm & slip resistant in wet & dry conditions (Dept. for Transport, 2005a, p.16)	✓ Use materials with non reflective properties under both wet and dry conditions
✗	✗ Avoid reflective materials (Dept. for Transport, 2005a, p.16)	✓ Use materials that minimise the effects of glare
	✗ Avoid uneven surfaces, gaps between paving slabs & cobbles (Dept. for Transport, 2005a, p. 16)	
	✗ Avoid covers & gratings (Dept. for Transport, 2005a, p. 16)	

9.4.2. Paving Surface Design & Appearance

There are currently no mandatory standards for the design and appearance of paving surfaces outwith the curtilage of a building. The recommendations featured in advisory guidelines are also limited in nature. The findings specific to this research recommend that the principle paving surface should be of a uniform appearance and be formed from one continuous material such as precast concrete, tarmac or bitumen (see Table 9.2). A smooth pattern free surface will reduce / eliminate possible confusion regarding the presence of obstacles or features at ground level as detailed in Section 6.6.3). The use of highly patterned surfaces should be avoided under all circumstances except to identify the presence of an obstacle such as an item or items of street furniture (Dept. for Transport, 2005a). The surface material should be in greyscale tones as outlined in Section 5.5.14 of this thesis. Grey is preferable however black is also recommended. Finally it is important to re- emphasise the importance of selecting a material that is non-reflective under both wet and dry conditions. Materials such as Caithness stone are not suitable due to their highly reflective properties (see Section 6.6.3).

Table 9.2: Existing Regulations & Guidance for Paving surface design & appearance alongside Enhanced recommendations

Paving surface design & appearance		
Mandatory Regulations	Best Practice Guidelines	**Enhanced Guidelines**
✘	✓ Consideration should be given to use of different paving texture or colour to distinguish obstacles (Dept. for Transport, 2005a, p. 17)	✓ Uniform appearance such as tarmac or pre-cast concrete ✓ Use materials with grey scale tones ✘ Non reflective, non glare when wet and dry ✘ Avoid highly patterned surfaces consisting of many small parts e.g., mosaics / tiles

9.4.3. Pavement Width

The Building Regulations do not contain mandatory standards for the minimum acceptable pavement width beyond the curtilage of a building. Best practice guidelines provide several recommendations for the suitable pavement width under specific circumstances (see Table 9.3). However these measurements vary and are often site specific. The enhanced guidelines propose an absolute minimum pavement width of 2400mm, as this will allow sufficient room for two visually impaired pedestrians each accompanied by a sighted guide to pass in the opposite direction, as outlined in Section 6.6.4. Furthermore the current advisory guidelines still permit a reduction in pavement width in response to an obstacle. It is argued here that obstacles should remain outwith the boundary of the pavement.

Table 9.3: Existing Regulations & Guidance for pavement width alongside Enhanced recommendations

Pavement Width		
Mandatory Regulations	Best Practice Guidelines	**Enhanced Guidelines**
✘	✓ Min. width of 2000mm or 1500mm where this is not possible (Dept. for Transport, 2005a, p. 11) ✓ Min. 1000mm where an obstacle is present, max. length 6000mm (Dept. for Transport, 2005a, p. 11) ✓ Bus stops: min. pavement width 3000mm. Outside shops: min pavement width 3500mm – 4500mm (Dept. for Transport, 2005a, p. 11)	✓ Absolute min, unobstructed pavement width of 2400mm ✘ Obstacles should remain outwith the boundary of a pavement

9.4.4. Kerb Design

There is currently a lack of mandatory regulations and advisory guidelines regarding the optimum dimensional properties and appearance of kerbs. As a consequence there is often a high degree of variability with regards to the appearance and height of kerbs (see Section 6.6.5). British Standards EN 1340 (2003) contains dimensions and specifications for the design of kerbs. A large variety exist all differing in shape, width and height ranging from 150mm to 305mm. However this information is only intended to be informative and not provide recommended best practice guidelines. The findings from this research support the recommendations for a strong colour contrast at the kerb edge (Dept. for Transport, 2005a), with the additional recommendation for the coloured band to be in yellow or white as outlined in Section 5.5.14.

Throughout various stages of the research, specifically Section 5.5.11 and Section 7.9.6, the problematic nature of varying kerb heights was highlighted. Therefore it is essential that a mandatory standard kerb height is enforced in order to remove the uncertainty regarding the changeable distance between the pavement and road at any two given points (see Table 9.4).

Table 9.4: Existing Regulations & Guidance for kerb design alongside Enhanced recommendations

Kerb design		
Mandatory Regulations	Best Practice Guidelines	**Enhanced Guidelines**
✘	✓ Strong colour contrast at kerb edge (Dept. for Transport, 2002, p.13) ✓ Minimum height of 25mm (Dept. for Transport, 2002, p.7)	✓ Contrasting yellow / white kerb to differentiate the pavement edge from road ✓ Adoption of a standard kerb height

9.5. Level Changes

This section has been subdivided into five main categories, namely (i) stair design, (ii) stair material, (iii) stair edge strips (iv) colour & contrast and (v) handrail design. Each category includes a complete listing of the current mandatory regulations and advisory guidelines where applicable. The mandatory regulations regarding the placement and treatment of steps within the built environment primarily focus on the design and layout of level changes on an access route to and from a building (SBSA, 2009, BSI, 2009). Although the regulations and guidelines do not specifically refer to the treatment of a level change on a pavement, the boundaries between an access route and pavement often overlap. For example the entrance to a shopping centre with direct access via steps to a pedestrianised street, as illustrated in Figure 6.16. For this reason, both the regulations for an access route (SBSA, 2009, BSI, 2009) and pavement (Dept. for Transport, 2005a) will be incorporated in the comparison and critique process in the following sections.

9.5.1. Stair Design

The mandatory regulations state that a flight must have at least three risers as the detection of a single or double step is difficult and potentially hazardous. However, the regulations do not stipulate the use of assistive features such as a handrail, contrasting stair edge strips or corduroy tactile paving (SBSA, 2009). The best practice guidelines recommend that level changes of two steps or more should be equipped with a handrail, tactile paving and contrasting edge strips (BSI, 2009). The findings from this research strongly support the recommendation to avoid the use of single isolated steps (BSI, 2009). However in circumstances where the removal of a single step is not achievable, the mandatory regulations should be extended to enforce the use of corduroy hazard warning paving at the top and bottom, a contrasting handrail and contrasting stair edge strip (Table 9.5). This research supports the view that a flight of steps should consist of risers and treads of equal height and length, but expands the regulations and best practice guidelines to specifically ban the use of landscaped and tapered steps due to the associated dangers they pose to the visually impaired pedestrian (refer to Sections 7.7.1 and 7.9.6 for more details).

Table 9.5: Existing Regulations & Guidance for stair design alongside Enhanced recommendations

Stair design					
Mandatory Regulations		Best Practice Guidelines		**Enhanced Guidelines**	
✓	At least 3 rises in a flight (SBSA, 2009, p.27)	✓	Level changes of 2 steps or more should include - handrail, tactile paving and contrasting edge strips (BSI, 2009, p.26)	✓	Any level change including 1 step should be equipped with handrail, corduroy paving & contrasting stair edge strip
✓	All rises should be of uniform height (SBSA, 2009, p.26)	✓	Uniform rise and going (BSI, 2009, p26)	✘	Avoid landscaped / tapered steps
		✘	Avoid single steps (BSI, 2009, p.26)	✘	Avoid ramped steps
		✘	Avoid open treads (BSI, 2009, p.26)		

9.5.2. Stair Material

There are currently no regulations or guidelines as to the preferred material for the surface of steps (see Table 9.6). Highly patterned materials can lead to discomfort and confusion as outlined in Section 6.6.3 and 7.9.3. Therefore it is recommended that stairs should be formed from a continuous, smooth non patterned material such as precast concrete. The use of fragmented materials such as bricks and tiles should be avoided as the spacing between the paving may be mistaken as an additional level change, making it very difficult to identify the beginning and end of each step.

Table 9.6: Existing Regulations & Guidance for Stair material alongside Enhanced recommendations

Stair material		
Mandatory Regulations	Best Practice Guidelines	Enhanced Guidelines
✘	✘	✓ Use a continuous smooth, non patterned and non reflective material such as pre-cast concrete ✘ Avoid highly patterned and reflective surfaces such as bricks or tiles

9.5.3. Stair Edge Strip

Both the mandatory regulations and advisory guidelines recommend the use of contrasting stair edge strips (nosings) on both the riser and tread in order to clearly mark the beginning and end of each step. The mandatory regulations do not contain any dimensional specifications for the depth of a stair tread. Although dimensions are provided in advisory guidance documents, the recommended sizes vary, as illustrated in Table 9.7. The enhanced guidelines propose that stair edge strips should have a standard dimension in order to create a sense of structure and familiarity with regards to the appearance and treatment of level changes. It is also recommended that stair edge strips should be made from a durable material in order to withstand environmental factors such as the weather and the impact from pedestrian traffic. It is not acceptable to simply paint a strip on top of the stair surface as this will become patchy and eventually disappear over time. Stair edge strips should be integrated into the design of the step at the manufacturing stage instead of being placed on top as an afterthought or optional extra.

Table 9.7: Existing Regulations & Guidance for Stair edge strip alongside Enhanced recommendations

Stair Edge strip		
Mandatory Regulations	Best Practice Guidelines	Enhanced Guidelines
✓ Contrasting stair nosings (SBSA, 2009, p.27)	✓ Contrasting stair edge strips across full width of each tread (BSI, 2009, p26; Dept. for Transport, 2005, p.41)	✓ Standard depth of 50mm on both the tread and riser
	✓ 50 mm to 65 mm wide on tread & 30 mm to 55 mm on the riser (BSI, 2009, p.26)	✓ made from durable material to withstand environmental factors
	✓ 55mm deep on tread and riser (Dept. for Transport, 2005a, p.41)	✓ Integrated into the design at manufacturing stage

9.5.4. Colour & Contrast

There are no mandatory regulations for the choice of colour and contrast between the stair and edge strip. Details regarding the preferred colour contrast combinations for stair and edge strip were obtained during the survey presented in Chapter 5 of this thesis. In particular Figures 5.16 and 5.17 and Table 5.31 present the preferred colour contrast combinations with reference to the different visual field loss groups. Two combinations were favoured by all four groups. Individuals with central vision loss and mixed vision loss preferred a black stair with yellow edge strip whereas individuals with peripheral vision loss and other conditions not affecting visual field loss preferred a black stair with white edge strip. The enhanced guidelines therefore recommend that stairs should be black with either a yellow or white contrasting stair edge strip as this combination will be of benefit to all visually impaired users (see Table 9.8). It is interesting to note that a black stair and white edge strip are currently widely used in internal environments where the lighting levels are low. In the case of a theatre or cinema, fully sighted users of the building are effectively visually impaired for the duration of the performance and require a high level of contrast in order to detect the start and end of each step within areas of restricted light. Colour combinations to avoid include a white stair and silver edge strip and white stair with yellow edge strip as these colours in combination provide a very poor contrast when viewed in greyscale (see Table 9.8).

Table 9.8: Existing Regulations & Guidance for Colour & Contrast alongside Enhanced recommendations

Stair Colour & contrast		
Mandatory Regulations	Best Practice Guidelines	**Enhanced Guidelines**
✗	✗	✓ Use - Black stair – Yellow or white edge strip ✗ Avoid white stairs with silver edge strips

9.5.5. Handrail Design

The mandatory regulations and best practice guidelines provide conflicting information with regards to the definition and treatment of a level change (see Table 9.9). In particular, there is a disagreement with regards to the relationship between the number of steps and the need for assistive features. The mandatory regulations state that a handrail must be provided on both sides when there is a level change of 600mm or greater (SBSA, 2009). Assuming that a flight of steps is constructed with a minimum rise of 100mm, the current regulations permit a flight of up to and including six steps before the installation of a handrail is required. The best practice guidelines recommend that a handrail should be provided on both sides to level changes of two steps or more (BSI, 2009). It is recommended in this research that a handrail should be provided at every level change regardless of the number of steps (see Table 9.9).

Differences also exist between the recommended handrail height. The mandatory regulations specify that a handrail should be between 840mm and 1000mm, whereas best practice guidelines recommend a minimum height of 900mm and maximum height of 1000mm. Furthermore, the recommended handrail height at landings differs from between 900mm and 1100mm (Dept. for Transport, 2005a) to a single recommendation of 1100mm (BSI, 2009). The enhanced guidelines within this research recommend that there should be a standard height for all handrails. This would ensure consistency and familiarity when negotiating level changes, as the visually impaired pedestrian is equipped with accurate knowledge regarding the exact location and height of the handrail at every level change. Although reference is made to colour contrast in both the mandatory regulations and advisory guidelines, the definitions differ (Table 9.9). In particular, the mandatory regulations state that a handrail should contrast visually with the adjacent wall surface. This statement may be applicable to internal environments; however for level changes in the external environment, an adjacent wall surface may not always be present. It is therefore necessary to consider the context in which the handrail will be seen (BSI, 2009). It is recommended that stainless steel handrails should be used in areas where vandalism and low maintenance are key issues (BSI, 2009). The enhanced guidelines strongly disagree with this recommendation due to the glare, low visibility and reflective properties associated with this material (refer to section 5.5.13 for colour classifications according to visibility in the built environment).

Table 9.9: Existing Regulations & Guidance for Handrail design alongside Enhanced recommendations

Handrail design		
Mandatory Regulations	Best Practice Guidelines	**Enhanced Guidelines**
✓ Handrail provided on either side of a flight where there is a change in level > 600mm (SBSA, 2009, p.31)	✓ Handrail provided on either side of a flight of 2 or more steps (BSI, 2009, p.26)	✓ Continuous handrail at every external level change, including isolated steps
✓ Min. height 840 mm Max. height 1000mm (SBSA, 2009, p.32)	✓ Top of handrail: min. height 900 mm, max. height 1000mm (BSI, 2009, p.28; Dept. for Transport, 2005, p.44)	✓ Use a standard handrail height of 1000mm
✓ Extend min. 300mm at top and bottom (SBSA, 2009, p.32)	✓ Handrail height at landings 1100mm (BSI, 2009, p.28), 900mm – 1100mm (Dept. for Transport, 2005a, p.44)	✓ Provide a strong colour contrast with the surrounding environment
✓ Contrast visually with adjacent wall surface (SBSA, 2009, p.32)	✓ To extend horizontally beyond the last nosing of the first and last stair (BSI, 2009, p.29; Dept. for Transport, 2005, p.45)	✘ Avoid silver stainless steel handrails due to glare, low visibility and reflective properties
	✓ Contrast visually with surroundings (BSI, 2009, p.29; Dept. for Transport, 2005, p.45)	
	✓ Stainless steel handrails are more suitable in locations where vandalism and low maintenance are key factors (BSI, 2009 p.30)	

9.6. Street Furniture

This section has been subdivided into three main categories, namely (i) colour and contrast, (ii) zoning and (iii) design and material. Each category includes a complete listing of the current mandatory regulations and advisory guidelines where applicable. The enhanced guidelines will provide additional design information aimed to improve the visibility and accessibility standards for the overall design and positioning of street furniture.

The regulations regarding the placement and treatment of street furniture within the built environment primarily focus on the design and zoning of items on an access route to and from a building (SBSA, 2009, BSI, 2009). As a general rule, the regulations and guidelines do not convey detailed design recommendations, but rather provide a general and often vague overview regarding the placement and appearance of certain items. Perhaps the most comprehensive recommendations are published in Inclusive Mobility (Dept. for Transport, 2005a). The guidelines expand beyond the curtilage of a building to consider the design and placement of street furniture on pavements. However it should be noted that these best practice guidelines are still limited in nature and have therefore been expanded within the enhanced guidelines section.

9.6.1. Colour & Contrast

There are currently no mandatory regulations for the choice of colour and contrast for items of street furniture. Best practice guidelines do however encourage the use of colour contrast to assist visually impaired people to avoid obstacles that may present a trip hazard (Dept. for Transport, 2005a). Certain items of street furniture have recommendations regarding colour contrast solutions, details of which will be discussed where applicable on a case by case basis in the following tables. The enhanced guidelines propose three main general considerations for the colour and contrast of street furniture (see Table 9.10). The first recommendation, states that it is essential for items of street furniture to have a strong visual contrast with the surrounding environment regardless of the shape and size. The second recommendation emphasises the importance of using patterned contrasting colours within the design of street furniture. The third recommendation advises against the use of silver stainless steel due to the glare, low visibility and reflective properties associated with this colour and material.

Table 9.10: Existing Regulations & Guidance for the Colour & contrast of street furniture alongside Enhanced recommendations

Colour & contrast		
Mandatory Regulations	Best Practice Guidelines	**Enhanced Guidelines**
✘	✓ Colour contrast should be used to help partially sighted people avoid obstacles that they might trip over (Dept. for Transport, 2005a, p.16)	✓ Use a colour that contrasts with the surrounding when viewed in both greyscale and colour ✓ Use patterned contrasting colours within the design of street furniture ✘ Avoid the use of silver / stainless steel

9.6.2. Zoning of Street Furniture

There are currently no mandatory regulations for the zoning of street furniture outwith the curtilage of a building. Best practice guidelines stipulate that obstacles should be grouped in a regular and logical pattern in a consistent strip away from general lines of movement (Dept. for Transport, 2005a). The use of street furniture should be limited to only essential items such as seating, litter bins and street lighting and should be positioned in a way that does not adversely affect the movement patterns of surrounding pedestrians.

Common sense should be applied in all cases. Where possible, items such as street lighting and signage should be mounted on the exterior wall of buildings to reduce clutter on the pavement. Consideration should also be given as to ways in which items of street furniture can be integrated, for example a litterbin or post box could be mounted onto a lamp post.

Table 9.11: Existing Regulations & Guidance for zoning of street furniture alongside Enhanced recommendations

Zoning		
Mandatory Regulations	Best Practice Guidelines	**Enhanced Guidelines**
✘	✓ Obstacles should be grouped in a logical & regular pattern (Dept. for Transport, 2005a, p.11) ✓ Street furniture should be zoned in a consistent strip and away from general lines of movement (Dept. for Transport, 2005a, p.14)	✓ Where an alternative is available, street furniture should be mounted off the pavement ✓ Only essential items of street furniture should be placed on the pavement. Decorative items which are not essential and do not have a practical function should not be used

9.6.3. Design and Material

There are no mandatory regulations for the general design and appearance of street furniture outwith the curtilage of a building. Guidance is available for certain items such as bollards and lamp posts, however there is not a design concept that outlines general best practice solutions for the design of all items of street furniture. The enhanced guidelines aim to provide a general set of recommendations to address basic best practice design solutions. In particular every item of street furniture must have a solid base and / or tapping rail to provide long cane users with adequate information to detect an object and avoid a collision. All items of street furniture must be designed with rounded edges. This will help to reduce the degree of injury in the event of a collision. It is important that street furniture is designed with a matt finish rather than a shiny reflective surface (see Table 9.12).

Table 9.12: Existing Regulations & Guidance for Design & Material of street furniture alongside Enhanced recommendations

Design & material		
Mandatory Regulations	Best Practice Guidelines	**Enhanced Guidelines**
✘	See individual items of street furniture for details	✔ All items of street furniture must have a solid base and or tapping rail ✔ All items of street furniture must have rounded edge ✔ Use materials with a matt finish ✘ Avoid shiny and reflective surfaces

9.6.4. Street Furniture Categories

Design guidelines have been provided for nine of the most commonly placed items of street furniture within the built environment. Namely; bollards, litter bins, outside dining areas, signage, lamp posts, seating, bus shelters, railings (protective barriers) and trees. The current mandatory regulations and advisory guidelines for each item of street furniture will be compared and critiqued where applicable. Thereafter, the enhanced guidelines will provide recommendations which are tailored to meet the accessibility needs of specific items of street furniture.

9.6.4.1. Bollards

The bollard is the most hazardous item of street furniture according to the views of the visually impaired pedestrian (see Section 5.5.12, Table 5.22). For this reason it is essential to consider ways of reducing the risks to this population by creating a product that is sympathetic to the needs of the visually impaired pedestrian. The mandatory regulations for the design and placement of bollards are restricted to the access route within the curtilage of a building. Designers are advised to avoid the use of low level bollards and chain linked posts as they can be hazardous to visually impaired pedestrians (SBSA, 2009, BSI, 2009, Dept. for Transport, 2005). Best practice guidelines provide numerous recommendations for the design and placement of bollards. In particular it is stated that bollards should have a minimum height of 1000mm (BSI, 2009, Dept. for Transport, 2005) and have a design that avoids the use of projections and tapering at ground level (BSI, 2009). Furthermore, bollards should contrast visually with the surrounding background through the placement of a 150mm contrasting band and light at the top of each bollard to enhance both daytime and night time detection (Dept. for Transport, 2005a). The enhanced guidelines are in support of the aforementioned recommendations with the addition / amendment of certain key issues. In particular, bollards are all too often viewed as the first choice option for controlling vehicular movement. It is recommended that the placement of bollards should be restricted to locations where an alternative barrier cannot be placed. Where more than one bollard is present, the minimum unobstructed pavement width between each bollard should be increased from 2000mm to 2400mm. This distance will allow sufficient room for two visually impaired pedestrians each accompanied by a sighted guide to pass in the opposite direction (see Section 6.6.4). It is essential that bollards have a strong visual contrast when viewed both in colour and greyscale with respect to the overall design and the surrounding environment. Dark colours including black, red, blue and green should be used in combination with light bands of colour such as white or yellow. Silver stainless steel must not be used due to the glare, low visibility and reflective properties associated with this colour and material (see Section 5.5.13).

Table 9.13: Existing Regulations & Guidance for bollards alongside Enhanced recommendations

Bollards		
Mandatory Regulations	**Best Practice Guidelines**	**Enhanced Recommendations**
✓ Low-level bollards or chain-linked posts can be hazardous (SBSA, 2009, p.10)	✓ Bollards should be positioned to leave at least 2m clear pavement width (Dept. for Transport, 2005a, p.14)	✓ Bollards should be positioned to leave at least 2400mm clear pavement width
	✓ Min height 1000mm (Dept. for Transport, 2005a, p.14; BSI, 2009, p.20)	✓ Should contrast visually if viewed in greyscale with respect to overall design and the surrounding environment
	✓ Contrast visually with background (Dept. for Transport, 2005a, p.14; BSI, 2009, p.20)	✓ Black bollard White/yellow strip(s)
	✓ Colour contrast at top of bollard (Dept. for Transport, 2005a, p14)	✘ Restricted use – must not be used as decorative items
	✓ Light at top of bollard (Dept. for Transport, 2005a, p.14)	✘ Silver stainless steel must not be used
	✓ May taper towards top but not towards ground (BSI, 2009, p.20)	
	✘ No horizontal projections (BSI, 2009, p.20)	
	✘ Avoid use of chain-linked bollards (Dept. for Transport, 2005a, p.14; BSI, 2009, p.20)	

9.6.4.2. Litter Bins

There are currently no mandatory regulations enforced for the design of litter bins. Best practice guidelines recommend that bins should be approximately 1300mm in height, have rounded edges and continue to ground level (see Table 9.14). The enhanced recommendations support the best practice guidelines with the addition of two statements. Firstly it is essential that litter bins should contrast visually when viewed both in colour and greyscale. This should apply to the overall design taking into account colours and materials from the surrounding environment. Avoid the use of silver stainless steel due to glare, low visibility and reflective properties. Secondly, litter bins must be zoned in a clear and consistent a strip at the kerb edge so as not to disrupt or pose a hazard to pedestrian movement.

Table 9.14: Existing Regulations & Guidance for litter bins alongside Enhanced recommendations

Litter bins		
Mandatory Regulations	Best Practice Guidelines	Enhanced Guidelines
✗	✓ Approx. height 1300mm (Dept. for Transport, 2005a, p.14)	✓ Should contrast visually if viewed in greyscale with respect to overall design and the surrounding environment
	✓ Should continue to ground level (Dept. for Transport, 2005a, p.14)	✓ Zoned in a clear consistent strip at kerb edge
	✓ Should be of a rounded design (Dept. for Transport, 2005a, p.14)	✗ Avoid the use of silver stainless steel.

9.6.4.3. Outside Dining Areas

The design and zoning of outside dining areas is currently not featured in either the mandatory regulations or best practice guidelines. Therefore enhanced recommendations are required in order to provide a minimum standard to ensure consistency regarding the appearance and available pavement widths bordering any outside dining area. Outside dining areas should only be permitted in cases where they do not impact on the movement of pedestrians. A minimum unobstructed pavement width of 2400mm should be maintained as this will allow sufficient room for two visually impaired pedestrians each accompanied by a sighted guide to pass in the opposite direction, as outlined in Section 6.6.4. Furthermore, a high contrasting protective barrier should be a mandatory requirement in order to contain tables and chairs within a specified area and avoid a further reduction in pavement width. Furthermore it is strongly recommended that silver stainless steel tables and chairs are avoided due to the low visibility, glare and reflective properties (see Table 9.15).

Table 9.15: Existing Regulations & Guidance for outside dining areas alongside Enhanced recommendations

Outside dining areas		
Mandatory Regulations	Best Practice Guidelines	**Enhanced Guidelines**
✘	✘	✓ Provide a contrasting protective barrier ✓ Only positioned where a minimum unobstructed pavement width of 2400mm can be achieved ✘ Avoid silver stainless steel furniture

9.6.4.4. Signage

There are no mandatory regulations for the design and placement of signage on pavements. Best practice guidelines do however provide a list of recommendations as illustrated in Table 9.16. In particular it is recommended that signage should be placed away from the pavement on walls, buildings or as close to the building line as possible (Dept. for Transport, 2005a). Where signage is located on the pavement, there should be a minimum unobstructed width of 2000mm between both poles (Dept. for Transport, 2005a). Furthermore it is recommended that the signage poles contrast visually with the surrounding background through the use of a contrasting band of depth 150mm at a height of between 1400mm and 1600mm (Dept. for Transport, 2005a) and 1500mm (BSI, 2009). The advisory guidelines specifically advise against the use of grey poles as they often blend in with the background (Dept. for Transport, 2005a). The enhanced guidelines are in support of the aforementioned recommendations; however in many respects they go further to improve visibility, zoning and overall accessibility (see Table 9.16). In particular it is recommended that the practice of locating signage (intended for the interest of vehicles) on pavements should be eliminated. Signage should be placed above the road, in a similar way to the practice in motorways. Where this is not possible, existing surrounding elements should be used to attach signage onto. In circumstances where it is necessary to place signage on the pavement the enhanced guidelines recommend that the poles be positioned to leave a minimum width of 2400mm, 400mm wider than current recommendations (for further information see Section 6.6.4). Furthermore, the dimensional criteria for the contrasting band (BSI, 2009; Dept. for Transport, 2005) fails to consider the needs of visually impaired pedestrians of varying height and ability, including children, wheelchair users and individuals with restricted growth. For this reason the enhanced guidelines propose that three bands be placed at a height of 800mm, 1200mm and 1600mm. The bands must contrast with the main colour of the pole when viewed both in greyscale and colour. Grey silver and stainless steel must not be used due to the associated glare, low visibility and reflective properties associated with this colour and material.

Table 9.16: Existing Regulations & Guidance for signage alongside Enhanced recommendations

Signage		
Mandatory Regulations	Best Practice Guidelines	**Enhanced Guidelines**
	✓ Poles positioned to leave at least 2m clear pavement width (Dept. for Transport, 2005a, p.14)	✓ Absolute minimum pavement width of 2400mm between poles
	✓ Signage should be mounted on walls or buildings or as close to building line as possible (max. 275mm from building edge and min. 500mm from kerb edge) (Dept. for Transport, 2005a, p.14)	✓ Directional signage for vehicles should be placed above the road, on lamp posts or sides of buildings
✘	✓ Colour contrasted band: depth of 150mm positioned with lower edge between 1400mm and 1600mm from ground level (Dept. for Transport, 2005a, p.16) or at 1500mm above ground level (BSI, 2009, p.20)	✓ Contrast visually with surrounding environment ✓ Placement use of 3 contrasting bands (150mm) when viewed in greyscale & colour at a height of 800mm, 1200mm, 1600mm
	✓ Contrast with surrounding environment (Dept. for Transport, 2005a, p14; BSI, 2009, p.20)	✘ Avoid the use of silver stainless steel
	✘ Avoid use of grey (Dept. for Transport, 2005a, p.14)	

9.6.4.5. Lampposts

There are no mandatory regulations for the design and placement of lamp posts on pavements. The best practice guidelines outlined in Section 9.6.4.4 (Signage) are also applicable to the design and zoning of lamp posts and should therefore be referred to for further details. The enhanced guidelines also follow a similar structure to those listed in Table 9.16. In particular it is recommended that street lighting should be attached to the façade of buildings in order to remove unnecessary obstacles and clutter from the pavement. Where this is not possible, lamp posts should be zoned in a consistent strip at the kerb edge and incorporate three contrasting bands, 150mm deep at a height of 800mm, 1200mm and 1600mm. The bands should provide a strong colour contrast when viewed both in greyscale and colour. Grey, silver and stainless steel must not be used due to the associated glare, low visibility and reflective properties associated with this colour and material (see Table 9.17 for further details).

Table 9.17: Existing Regulations & Guidance for lampposts alongside Enhanced recommendation

Lampposts		
Mandatory Regulations	Best Practice Guidelines	Enhanced Guidelines
✘	For information regarding current best practice guidelines for the design and zoning of lamp posts see Table 9.16 (Signage)	✓ Mounted on walls / buildings. Otherwise zoned in a consistent strip at kerb edge ✓ Placement of 3 contrasting bands at a height of 800mm, 1200mm, 1600mm ✘ Avoid the use of silver stainless steel

9.6.4.6. Seating

There are no mandatory regulations for the design and zoning of seating outwith the boundary of an access route. The provision of seating within the built environment is a necessary feature as it provides a resting point for individuals who require a break in their journey for reasons relating to a disability or health condition. In particular it is recommended that seating should be provided at intervals of 150 metres for visually impaired pedestrians (Dept. for Transport, 2005a). The enhanced guidelines in Table 9.18 recommend that all types and design of seating should have a solid base in order to enhance the detection by long cane users during the sweep of a long cane. All seats should be located outwith the width of a pavement to leave an unobstructed width of at least 2400mm. Furthermore it is essential that seating contrasts visually with the surrounding background to avoid a collision and injury to the lower leg. Silver stainless steel must not be used.

Table 9.18: Existing Regulations & Guidance for seating alongside Enhanced recommendations

Seating		
Mandatory Regulations	Best Practice Guidelines	**Enhanced Guidelines**
✘	✓ Seats provided every 150 metres for visually impaired pedestrians (Dept. for Transport, 2005 p.10)	✓ All seating / benches should have a solid base ✓ Positioned outwith the width of a pavement to leave at least 2400mm ✓ Contrast visually with surrounding background ✘ Avoid the use of silver stainless steel

9.6.4.7. Bus Shelters

The design and zoning of bus shelters is not covered by mandatory regulations. Best practice guidelines advise that bus shelters should only be placed where there is space to do so. Furthermore the shelter should contrast visually with the surrounding environment. A contrasting band 150mm deep should be applied in the case of glass and transparent shelters at a height of between 1400mm and 1500mm. The enhanced guidelines advise against the placement of obstructive structures that significantly reduce the width of the pavement. By this it is understood that bus shelters should have a back and an overhead canopy but should not have sides. Glass and stainless steel shelters should not be used as they can often be very difficult to detect.

Table 9.19: Existing Regulations & Guidance for bus stops alongside Enhanced recommendations

Bus stops		
Mandatory Regulations	Best Practice Guidelines	**Enhanced Guidelines**
✗	✓ Shelters should be provided where there is space to do so (Dept. for Transport, 2005a, p.31)	✓ Bus shelters should have a back & overhead canopy but no sides
	✓ Contrast with surrounding environment (Dept. for Transport, 2005a, p.31)	✓ Change the paving material and kerb colour at bus stops
	✓ Tonally contrasting band on glass / transparent shelters: min 150mm deep, placed at height of 1400mm to 1600mm (2nd optional band 900mm to 1000mm from ground level) (Dept. for Transport, 2005a, p.31)	✗ Avoid glass & stainless steel structures

9.6.4.8. Railings (protective barriers)

The provision of railings (protective barriers) provides an additional threshold between the pedestrian and vehicle and can be particularly effective at locations where a narrow pavement runs parallel to a busy road with vehicles moving at high speed. The provision of protective barriers can also assist the visually impaired pedestrian by guiding them to the location of a pedestrian crossing. There are no mandatory regulations for the design and appearance of railings however limited information can be sourced from best practice guidelines (see Table 9.20). In particular it is recommended that railings should contrast with the surrounding environment, in order to achieve this they must not have a surface finish of simple galvanised steel (Dept. for Transport, 2005a). The enhanced guidelines are in support of the aforementioned recommendations with the addition of two statements. Firstly it is recommended that railings should continue to ground level or have a tapping rail at ground level in order to be easily detectable during the sweep of a long cane. As with all previous enhanced guidelines, it is strongly advised that silver stainless steel is not used as this colour and material can be very difficult to detect.

Table 9.20: Existing Regulations & Guidance for railings alongside Enhanced recommendations

Railings (protective barrier)		
Mandatory Regulations	Best Practice Guidelines	Enhanced Guidelines
✘	✓ Contrast with surrounding environment (Dept. for Transport, 2005a, p.12) ✘ Avoid simple galvanized railings (Dept. for Transport, 2005a, p.12)	✓ Railings should extend to ground and / or provide a tapping rail. ✘ Avoid silver stainless steel

9.6.4.9. Trees

There are no mandatory regulations or best practice guidelines for the placement and zoning of trees. The enhanced guidelines presented in Table 9.21 provide seven recommendations relating to zoning, unobstructed pavement widths, colour contrast and use of material. In particular it is recommended that trees are zoned at the kerb edge and only in circumstances where this maintains a minimum unobstructed pavement width of 2400mm. Trees should not be placed in the centre of pavements as this can create a potential unforeseen collision hazard.

It is essential that pedestrians are given prior warning as to the presence of any obstacles on the pavement. In the case of a tree, this can be achieved through the installation of a base around the perimeter of the trunk. The base should contrast visually with the main paving surface when viewed both in greyscale and colour. In order to further aid detection for pedestrians with limited residual vision the base should also be of a different texture and material to the surrounding paving surface, as this will convey both auditory and tactile information. Furthermore it is important to maintain a level surface between the main paving surface and the tree base as this will reduce the risk of a trip hazard. The tree base should not have any large openings as this may have an adverse effect when using a mobility aid. Under certain circumstances a symbol cane / long cane may become trapped in between the gaps. Finally, it is essential that tree branches do not interfere with or cause injury to surrounding pedestrians. Poorly maintained and overgrown tree branches can cause significant problems to visually impaired pedestrians due the inability of this population to foresee the object and alter their course accordingly.

Table 9.21: Existing Regulations & Guidance for trees alongside Enhanced recommendations

Trees		
Mandatory Regulations	Best Practice Guidelines	Enhanced Guidelines
✘	✘	✓ Trees should be zoned at kerb edge and only placed where an unobstructed pavement width of 2400mm can be achieved ✓ High contrasting base at least 1500mm around perimeter of tree trunk ✓ Contrasting base must be level with main paving material ✓ Contrasting base should be of different material & texture than main paving surface ✓ Regular maintenance programme to remove low hanging branches ✘ Contrasting base must not contain large openings ✘ Trees must not be placed in the centre of pavements

9.7. Road Crossings

This section has been subdivided into four main categories, namely (i) tactile paving (ii) assistive cues, (iii) control box and crossing pole, and (iv) additional features. Each category includes a complete listing of the current mandatory regulations and advisory guidelines where applicable. The enhanced recommendations are intended to supplement the existing regulations and guidelines as well as introduce new recommendations in cases where no previous guidance has been published.

9.7.1. Tactile Paving

Tactile blister paving is specifically designed to signify the presence and location of a crossing point across a road. This type of paving can be used at both controlled and uncontrolled crossings. There are currently no mandatory regulations for the design and installation of tactile paving surfaces in and around road crossings (Dept. for Transport, 2002). Best practice documents provide recommendations for the design and layout of tactile paving as illustrated in Table 9.22. In particular it is recommended that red tactile blister paving is installed at controlled crossings with buff or a contrasting colour at uncontrolled crossings (Dept. for Transport, 2002). In cases where the surrounding paving is also red then a contrasting strip 150mm deep should be applied to highlight the presence of the paving (Dept. for Transport, 2002). The paving should be applied to extend the full length of the dropped kerb, to a depth of 1200mm when in the direct line of travel and 800mm otherwise. A further strip is required extending from the kerb edge and crossing pole at right angles to the road at a depth of 1200mm (see Section 6.8.1, Figure 6.29 & Figure 6.30 for details). The enhanced guidelines are in support of the aforementioned recommendations with the addition of the following points. It is recommended that tactile paving should be made of a slip-resistant material. Under no circumstances should brass studs be used due to their slippery nature under wet conditions (see Section 7.9.8, Figure 7.16). Furthermore it is imperative that tactile paving contrasts visually with the adjacent paving material when viewed in both grey scale and colour during dry and wet conditions. The recommended use of red at controlled crossings may not provide an adequate visual contrast with the adjacent paving material for certain visual impairments. Therefore a contrasting border of minimum 150mm should be applied to all tactile paving surfaces at controlled crossings.

Table 9.22: Existing Regulations & Guidance for tactile paving alongside Enhanced recommendations

Tactile paving		
Mandatory Regulations	Best Practice Guidelines	**Enhanced Guidelines**
✗	✓ Installed at both controlled & uncontrolled crossings (Dept. for Transport, 2002, p.7)	✓ Tactile paving must have slip resistant surface
	✓ Controlled crossings – red, where surrounding paving is red contrasting border 150mm Uncontrolled crossings - buff/ contrasting colour (Dept. for Transport, 2002, pp. 7, 10)	✓ Contrast visually in greyscale and colour with surrounding paving under both wet & dry conditions
	✓ When crossing is in direct line of travel – depth 1200mm. Otherwise 800mm extending full length of dropped kerb (Dept. for Transport, 2002, p.14). Second row of blister paving extending from kerb edge & crossing pole at a right angle to a depth 1200mm (Dept. for Transport, 2002, p.16).	✓ All controlled crossings should incorporate a contrasting border min 150mm around tactile paving ✗ Brass tactile blister paving must not be used

9.7.2. Assistive Cues

The presence of an audio signal or a tactile spinning cone alerts a visually impaired pedestrian when it is safe to cross without the need for relying on visual cues or sighted assistance. Both audible and tactile cues will be activated during the invitation to cross period. The design of road crossings are outwith the remit of the Scottish Building Regulations, however mandatory standards are available in Statutory Instrument 1997 No. 2400, “The Zebra, Pelican and Pedestrian Crossings Regulations and General Directions 1997” (with minor amendments in 1998) (Office of Public Sector Information, 1997). Reference is made to the use of audible and tactile cues within this document however the implementation of these features are not enforced (see Table 9.23). Best practice documents recommend the use of both an audible signal and tactile spinning cone at every controlled crossing unless specific circumstances prevent their installation. It is recommended that tactile cones should be installed at the right hand side underneath the control box extending to a length of 20mm, measuring 15mm in diameter at the base and tapering to 8mm at the top of the cone (see Figure 6.31). A tactile cone should not be used as a substitute for auditory cues (Dept. for Transport, 2005a). There are two main audible systems, the standard "bleeper" and the "Bleep and Sweep" (Dept. for Transport, 2005a, 2005c). The use of the standard bleeper at staggered crossings has been criticised for misleading pedestrians with regards to the location of the sound and hence the point at which it is safe to cross. However as a means of combating this problem a new style of system was developed, the “Bleep and Sweep” which adjusts in volume to be marginally higher than the surrounding ambient traffic noise (Dept. for Transport, 2005a, 2005c). In light of this, the enhanced guidelines recommend that audible signals should be installed at every pedestrian crossing due to their popularity among visually impaired pedestrians (see Section 7.9.8). Furthermore each controlled pedestrian crossing should also incorporate a tactile facility to be located in a standard position on each control box (see Table 9.23).

Table 9.23: Existing Regulations & Guidance for assistive cues alongside Enhanced recommendations

Assistive cues		
Mandatory Regulations	Best Practice Guidelines	**Enhanced Guidelines**
✓ Pedestrian light signals **may** incorporate a device for emitting audible signals (Office of Public Sector Information, 1997)	✓ Two standard audible signals (a) standard "bleeper"& (b) "Bleep and Sweep" are available (Dept. for Transport, 2005a, 2005c, p.5)	✓ Mandatory use of auditory cues at every crossing
✓ Indicators for pedestrians **may** be so constructed to provide a device giving audible or tactile signals (Office of Public Sector Information, 1997)	✓ Audible and tactile signals should be installed unless specific considerations warrant their exclusion (Dept. for Transport, 2005a, 2005c, p.6)	✓ Mandatory use of tactile spinning cone at every crossing
	✓ Tactile cone should be positioned at right hand side of bottom of control box (Dept. for Transport, 2005a, p.17)	
	✓ Tactile cone length 20mm and diameter 15mm tapering to 8mm (Dept. for Transport, 2005b)	
	✓ Tactile indicators should not be considered as a substitute for audible signals as they are required by different people (Dept. for Transport, 2005a, p17)	

9.7.3. Control Box & Crossing Pole

Information regarding the design and positioning of the crossing pole and control box can be sourced from mandatory regulations and best practice guidelines, details of which are presented in Table 9.24. The mandatory regulations allow the option for the crossing pole to be coloured grey, black, brown, dark green or dark blue. The crossing pole may include the provision of a white or yellow band, between 140mm and 160mm deep at a height of between 1500mm and 1700mm above ground level. However this option is entirely discretionary and is not therefore a standard practice among local authorities. The control box should be positioned to the right hand side of the crossing. This allows pedestrians to face in the direction of the oncoming traffic and also benefits guide dog users as the guide dog is trained to navigate to the left hand side of its owner. The best practice guidelines expand upon the mandatory regulations to include the standard use of a contrasting band on every crossing pole. Furthermore, details are provided regarding the design and positioning of the push button on the control box. In particular it is recommended that a larger push button with illuminated LED surround be positioned at a height of between 1000mm and 1100mm above ground level. The enhanced guidelines recommend that all crossing poles should contrast visually with the surrounding background in which they will be seen. The provision of three 150mm deep contrasting bands at a height of 800mm, 1200mm and 1600mm will ensure that the crossing pole is visible to pedestrians of varying height and ability. It is stressed that the bands provide a strong visual contrast when viewed both in greyscale and colour. This enables visually impaired pedestrians who are also colour blind to detect the location of the crossing pole. It is strongly recommended that silver stainless steel is not used due to the glare, low visibility and reflective properties associated with this colour and material. The enhanced guidelines are in support of a redesigned control box with larger button and LED surround (Dept. for Transport, 2005a). However this feature should also be accompanied by a red and green man symbol backlit with LED's, as the research conducted in this thesis suggests that the majority of visually impaired pedestrians are unable to see the red / green man symbols in their current location on the opposite side of the road (see Section 7.9.8, Figure 7.16). The provision of this facility should replace the illuminated "WAIT" sign as it can be extremely difficult to detect, especially during daylight hours (see Section 6.8.3).

Table 9.24: Existing Regulations & Guidance for control box & crossing pole Enhanced recommendations

Control Box & Crossing Pole		
Mandatory Regulations	Best Practice Guidelines	**Enhanced Guidelines**
✓ Crossing pole shall be of a single colour, which may be grey, black, brown, dark green or dark blue (Office of Public Sector Information, 1998)	✓ Crossing pole - contrasting band 140mm to 160mm deep with the lower edge positioned between 1500mm & 1600mm above ground level (Dept. for Transport, 2005a, p.17)	✓ Crossing pole should contrast visually with surrounding environment
✓ Crossing pole **may** incorporate one yellow / white band 140mm to 160mm deep, with the lower edge positioned between 1500mm & 1700mm above ground level (Office of Public Sector Information, 1997)	✓ Control box should be positioned to right hand side (Dept. for Transport, 2005a, 2005c, p. 2)	✓ Placement of 3 contrasting bands when viewed in greyscale & colour at a height of 800mm, 1200mm, 1600mm
✓ Control box should be positioned to right hand side of the crossing (Office of Public Sector Information, 1997)	✓ Bigger push button with illuminated LED surround & centre position1000mm - 1100mm above ground level (Dept. for Transport, 2005a, p. 17)	✓ Avoid the use of silver stainless steel for both crossing pole and control box ✓ Control box must contain red & green man symbols backlit with LEDs

9.7.4. Additional Features

Mandatory regulations and best practice guidelines are available for the provision of additional features to provide further assistance to the visually impaired pedestrian (see Table 9.25). In particular, the mandatory regulations recommend the use of grey, silver or light grey studs to indicate the boundary of the crossing area on the road surface. A minimum crossing width of 2400mm should be adhered to extending to a maximum width of 10000mm. The studs should have a non reflective lens and be of a circular or square design with a minimum diameter / length of 95mm and maximum diameter / length of 110mm with a vertical projection no greater than 20mm. Best practice guidelines recommend the provision of a coloured carriageway surface between the studs in order to further highlight the boundary of the crossing for both pedestrians and vehicles. However the colour and texture of such a surface must be different to that of the main paving material in order to avoid confusion regarding the threshold between the pavement and designated crossing area.

The enhanced guidelines are in support of the recommendations featured in best practice guidelines with the addition of the following points. In particular it is recommended that a contrasting paving surface should be installed at every controlled crossing point in order to replace the current system of reflector studs. It is essential that the paving surface is different in colour and texture to the main paving surface and contrasts with the road surface when viewed in greyscale and colour. The material should not change in colour or appearance when subject to environmental conditions. It is also suggested that the reflector studs should be illuminated with diffused lighting at night time. This feature may assist the visually impaired pedestrian to remain within the boundary of the crossing area in circumstances where the ambient light levels are otherwise too low to provide adequate guidance. The lights may be permanently lit or activated only when it is safe to cross the road. The introduction of a diffused lighting system would provide an additional cue to vehicular traffic and elevate the status of the pedestrian during evening hours potentially leading to a reduction in both traffic speed and accidents.

Table 9.25: Existing Regulations & Guidance for additional features alongside Enhanced recommendations

Additional features		
Mandatory Regulations	Best Practice Guidelines	**Enhanced Guidelines**
✓ Limits of crossing should be indicated by studs on carriageway (Office of Public Sector Information, 1997)	✓ Coloured carriageway surface between studs creates pedestrian discipline & reduction in vehicle speed (Dept. for Transport, 2005a, 2005c, p. 2)	✓ Change in texture from main paving material, contrasting with surrounding road surface when viewed in both grey scale & colour during wet & dry conditions
✓ Studs should be white, silver, or light grey and shall not be fitted with reflective lenses(Office of Public Sector Information, 1997)	✘ Avoid use of same texture and colour as main paving material (Dept. for Transport, 2005a, 2005c, p. 2)	✓ Extend full width & length of crossing
✓ Studs should be circular / square with diameter / length of side min 95 mm & max 110 mm (Office of Public Sector Information, 1997)		✓ Studs illuminated at night time with defused lighting
✓ Studs should not project more than 20 mm above the carriageway at its highest point nor more than 6 mm at its edges (Office of Public Sector Information, 1997)		
✓ Minimum width between studs should be 2400mm & max 10000mm (Office of Public Sector Information, 1997)		

9.7.5. Maintenance of Pedestrian Crossings

This section reports on issues relating to the overall maintenance of pedestrian crossings and associated features including; tactile paving, assistive cues, the control box and reflector studs. A pedestrian crossing may incorporate all the necessary assistive features to facilitate the safe and unrestricted movement of the visually impaired pedestrian, however if these features are not subject to a rigorous maintenance programme the crossing may become inaccessible and restrict movement similar to the way in which a physical barrier would impede the movement of a wheelchair user. Therefore it is desirable that a comprehensive maintenance programme is in place in order to resolve any issues as quickly and efficiently as possible.

9.7.5.1. Tactile Paving

The layout and appearance of tactile blister paving can often be affected by the intervention of utility companies while carrying out maintenance work. During the resurfacing phase, the tactile paving is often not reinstated but instead resurfaced using tarmac or a similar material. Apart from being unsightly, this situation can be particularly misleading to the visually impaired pedestrian and potentially dangerous. Therefore it is advisable that a mandatory regulation is enforced that requires utility companies to resurface the pavement with the pre existing paving material immediately after the completion of any works.

9.7.5.2. Assistive Cues

The audit of pedestrian crossings presented in Section 6.8.5 highlighted the unreliability of the tactile spinning cone, with 18% of all cones non operational at the time of the survey. A structured maintenance programme would ensure that problems of this nature would be resolved quickly and efficiently without placing the visually impaired pedestrian at a disadvantage over other street users.

9.7.5.3. Control Box / Crossing Pole

The control box containing the push button and illuminated "WAIT" sign can be subject to both vandalism and maintenance issues, as described in Section 6.8.3, Figure 6.32. In particular the light bulb behind the "WAIT" sign can often stop working. An event of this nature can restrict further movement particularly in circumstances where the crossing is not equipped with a tactile spinning cone or audible signal and the pedestrian is unable to see the red / green man symbol on the opposite side of the road. The presence of advertisement stickers on the control box can often obscure the illuminated "WAIT" symbol (Figure 6.32b). The solution to this problem may be to provide a dedicated space above the control box on the crossing pole for the placement of advertisements. The introduction of tougher penalties may also act as a deterrent. However ultimately there needs to be a structured maintenance programme to replace broken bulbs and remove stickers at the earliest possible opportunity.

9.7.5.4. Additional Features

The reflector studs marking the perimeter of the crossing area over the carriageway can also be subject to discolouration, displacement, removal or coverage by the adjacent road material. Any of the events described above are permissible under the current mandatory regulations for the design of pelican pedestrian crossings and are not required to be fixed or reinstated (Office of Public Sector Information, 1997; Schedule 4, Section 1.8). It is recommended that this clause is revoked and amended to provide a minimum standard of practice requiring the inclusion of reflector studs at every crossing point and the prompt reinstatement of any studs in the event of maintenance issues.

9.8. Summary

This chapter documents the incorporation of the research findings from the literature reviews, questionnaire, access audit and navigational experiments into a set of enhanced guidelines to accommodate the needs of the visually impaired pedestrian. In order to achieve this, a process is followed beginning with a demarcation of the remit and content of existing Scottish Building Regulations and best practice guidelines for the design of accessible external environments. Extending the reviews in Section 2.3 and the deliberations in Chapters 6 and 8, a critique is conducted which reveals the coverage and limitations of these regulations and guidelines. In more detail, the compulsory specifications within the Scottish Building Regulations (SBSA, 2009) are confined within the curtilage of a building, thus excluding navigational requirements in the wider context of urban streetscapes. On the other hand, the optional nature of the recommendations provided by the British Standards BS:8300 (BSI, 2009) and Inclusive Mobility (Dept. for Transport, 2005a) limits their application to the discretion of designers, planners and local authorities. Furthermore, their adoption is hindered by two main factors. Firstly, at certain points the two documents provide dissimilar guidance for the same feature e.g. specifications for the treatment of handrails and level changes, thus obscuring the selection of an optimal design solution. Secondly, the ambiguity regarding the exact areas around and beyond buildings which are covered by the guidance documents do not clearly define the extent of their applicability under different circumstances.

To further investigate the limitations and inconsistencies between the accessibility requirements of mandatory regulations and advisory guidance, a comparative review is carried out. The comparison demonstrates the insufficient provision of mandatory standards for the design of the external environment outwith the curtilage of a building. In particular the Scottish Building Regulations fail to provide mandatory standards for features associated with pavement design. Such features include suitable paving materials, the design and appearance of paving surfaces, adequate pavement widths under certain scenarios and the optimum dimensions and appearance of kerbs. Regulations are available for the treatment of level changes, specifically dimensional and quantitative specifications for stair riser and tread, stair edge strips, handrails and areas of applicability. No regulations are provided for the surface material of a stair riser and tread, or the colour and contrast of handrails and stair edge strips. With regards to street furniture, there are currently no mandatory regulations available for preferred colour and contrast combinations, the overall design and use of material and the zoning methods outwith the curtilage of a building. Certain regulations apply to the design and layout of pedestrian crossings, which are not directly included in the Scottish Building Regulations but rather mentioned by reference to the "The Zebra, Pelican and Pedestrian Crossings Regulations and General Directions 1997" (Office of Public Sector Information, 1997). In particular these relate to the design and positioning of the crossing pole and control box, and the size and colour specifications for demarcating the perimeter of the crossing area on the carriageway. No regulations exist for the implementation of tactile paving surfaces at either controlled or uncontrolled crossing points, as specified in the "Guidance for the Use of Tactile Paving Surfaces" document (Dept. for Transport, 2002). Furthermore the legislation fails to specifically enforce the incorporation of audible and tactile cues within the design of the crossing, leaving the installation of such features as an optional extra (Office of Public Sector Information, 1997). From the best practice guidance documents, only Inclusive Mobility (Dept. for Transport, 2005a) comprehensively addresses accessibility aspects relating to pavement design, road crossings and street furniture beyond the curtilage of a building. Although British Standards BS: 8300 cover some of these areas, it is not sufficiently defined whether the recommendations apply to the areas surrounding the curtilage of a building and the nearest public transport stop.

The enhanced guidelines augment current Scottish Building Regulations and best practice design guidelines to provide a set of recommendations based on the views of the visually impaired population. This user-orientated design approach introduced recommendations relating to pavement design, level changes, street furniture and pedestrian crossings. It is envisaged that the enhanced guidelines should not be treated as an optional extra but rather incorporated to form part of the mandatory Building Regulations to provide equal access opportunities to pedestrians regardless of ability or location, either internal or external.

The enhanced guidelines for the design of pavements focused on paving material, design and appearance of the paving surface, minimum pavement widths and the design and appearance of kerbs. In particular the guidelines recommend that the paving material should have a matt finish with non reflective properties under both wet and dry conditions in order to minimise the effects of glare. The use of highly patterned surfaces consisting of many individual elements should be avoided as this can often introduce visual confusion and discomfort during navigation. A greyscale toned paving surface formed from a smooth single uniform material was regarded as the preferable choice for principle areas of pedestrian traffic. Furthermore the recommendations favour an extension of 400mm to the minimum pavement width recommended in best practice guidelines in order to allow for the interaction of two visually impaired pedestrians using either a long cane, guide dog or accompanied by a sighted guide when passing in the opposite direction. The adoption of a standard kerb height will eliminate the uncertainty regarding the vertical distance between the pavement and road at any two given points. This regulation in conjunction with a contrasting kerb edge when viewed in both greyscale and colour will provide clarification between the boundaries of pavement, kerb and road.

The enhanced guidelines for the design and treatment of level changes highlight the importance of using a consistent riser and tread within the design of each separate flight. The use of tapered, landscaped or ramped steps should not be used due to the dangers they impose on the visually impaired pedestrian. Furthermore, new guidelines were established for the use and layout of materials for stair treads. In particular, the use of highly patterned and reflective surfaces should be avoided in favour of a smooth uniform and continuous material. The recommendations favour the mandatory use stair edge strips of a standard width of 50mm at every level change. Stair edge strips should be incorporated into the design at manufacturing stage and not regarded as an afterthought. The correct use of colour contrast was also viewed as an essential factor for increasing the accessibility of level changes; with recommendations favouring the use of a black tread with either a yellow or white edge strip. Furthermore the provision of a visually contrasting handrail of a standard height at every level change will provide support, guidance and relevant information to facilitate the safe passage of a change in level regardless of the number of risers.

The guidelines for the design of street furniture focused on the three main areas of colour contrast, zoning and design and material. In particular it was recommended that all items of street furniture should contrast visually both within the design and with the surrounding environment. The use of colours which contrast visually when viewed in both greyscale and colour will cater for the needs of the visually impaired pedestrian who is also affected by a loss of colour vision. The guidelines recommend a common sense approach when positioning items of street furniture on pavements. By only retaining the essential items necessary for daily living and sourcing alternative locations for the placement of furniture, the pavement can be reserved for the sole use of the pedestrian. Where street furniture has a practical function which justifies its placement on the pavement, items should be easily detectable with and without the use of a mobility aid and have a design that minimises the effects of injury in the event of a collision. As a general rule the guidelines recommend that silver stainless steel should not be used due to the glare, low visibility and reflective properties associated with such a colour and material.

A number of recommendations were introduced for the design and layout of pedestrian crossings taking into account tactile paving, auditory and tactile cues, the design and layout of the crossing pole and control box and the implementation of additional features to facilitate the safe passage across the carriageway. In particular, the recommendations call for more detailed specifications to be implemented for the design and layout of tactile paving. It is advised that all tactile paving surfaces should be made from a slip resistant material and contain a contrasting border at controlled crossings in order to increase visibility. The guidelines recommend that both auditory and tactile facilities should be considered as mandatory requirements rather than an optional extra and good will gesture from local authorities. Furthermore both the crossing pole and control box should provide a clear visual contrast with regards to the overall design and surrounding environment. The incorporation of additional contrasting bands on the crossing pole and use of LED displays on the control box are possible suggestions to improve the visibility and accessibility. Finally at controlled crossings the provision of a surface which is different in colour and material to that of the surrounding carriageway or connecting pavements would introduce additional visual and tactile cues for the visually impaired pedestrian.

Finally, the enhanced guidelines highlight the importance of a structured maintenance programme to actively resolve any issues relating to breakages, vandalism or malfunctioning equipment. By addressing any issues in an efficient manner, hazardous features and barriers to access can be effectively resolved without placing the visually impaired pedestrian at a disadvantage over other street users. Although not a design guideline as such, the continual upkeep and refurbishment of features and facilities requires commitment, investment and above all, an understanding of the accessibility requirements of the visually impaired pedestrian, for which the enhanced guidelines play a pivotal role.

Chapter 10: Conclusions

10.1. Research Aims

This work commenced with the recognition that the built environment in modern urban architecture does not cater for the specific access requirements of the visually impaired population. Current design practices reflect a dysfunction between the understanding of accessibility needs at a theoretical level and the consideration of these issues at a practical level. This thesis has investigated the hazardous nature of the built environment and has analysed the degree to which this affects the quality of life of visually impaired individuals. The research hypothesis postulates that commonalities exist between colour combinations, contrasts, materials and physical hazards experienced in the urban environment by individuals with different types and degree of visual field loss. This work suggests that interpreting these commonalities into a hazard rating calculation and respective augmentations in current building regulations can generate inclusive design solutions, which accommodate the needs of all visually impaired pedestrians.

To date, the access requirements of visually impaired individuals when navigating in urban environments has remained a relatively unexplored area in relation to the hypothesis defined in this thesis. In this work, the views of visually impaired users are considered paramount in informing the street hazard rating system and subsequent design guidelines. The methodological approach aims to enhance the findings with narrative and real-life examples from the every-day encounters of visually impaired individuals with the built environment. Hence, data was collected through an extensive survey that consisted of questionnaires, interviews and navigational experiments. This data was further enriched by the results of an access audit of Glasgow city centre. Glasgow represents a strong case for analysis. The city has the largest visually impaired population in Scotland and is a major hub for various activities in the region. In taking a holistic approach that incorporates structural evidence in the form of an access audit, user needs through a nationwide questionnaire and interviews, and observation in situ through a series of navigational experiments, a broad understanding was gained as to the problems surrounding access to the built environment, as well as accessibility requirements when designing urban spaces. Through this approach a street hazard rating calculation was established that encapsulates the social culture of the visually impaired population in order to analyse and critique the effectiveness of design regulations, policies and the current state of urban architecture. The main research findings of this work are presented in the following section.

10.2. Main Conclusions

10.2.1. Accessibility in Current Urban Environments

The analysis of commonly used spaces within the study area revealed that urban street design is generally lacking the accessibility features necessary to accommodate unobstructed usage by visually impaired individuals. The audit identified a number of problematic areas that can be attributed to bad planning, inappropriate design and deficient design specifications in existing documentation. In particular, the lack of consistency with regards to pavement characteristics, the design and zoning of street furniture and the presence of assistive cues to aid navigation, leads to the creation of a confusing environment with an absence of applied logic. This affects a person’s ability to reference and associate specific features and situations with relation to a particular standardised material. The current state of the built environment can largely be attributed to the insufficient provision of a legislative framework specifically catering for the needs of the visually impaired pedestrian. Despite the availability of best practice guidelines, their content is often dissimilar in nature and ambiguous in the areas of applicability. Therefore the vision of creating an inclusive, user-friendly environment is largely dependent on the attitude of local authorities to the provision of inclusive access in all areas.

10.2.2. Travel Behaviour

An investigation into the travel behaviour of the visually impaired population revealed that almost one third made no independent journeys to their nearest town or city centre and that over half expressed a desire to increase their independent travel behaviour. The restrictions to independent mobility do not originate from a deficiency in an individual's cognitive ability or the limitations of their visual impairment, but rather the design and physical influence of features within the built environment. The extent to which these features restrict the movement of the visually impaired pedestrian are clearly demonstrated when comparing the time and distance of routes traversed by individuals with visual impairments against those not affected by vision loss. In particular, the visually impaired participants had a completion time over twice that of their sighted counterparts and an average additional 310 metres extension to their journey. Visually impaired participants adhered to known, planned routes, even when these routes took longer to complete, led to an increase in distance and involved walking in the opposite direction from the end destination for part of the journey. This further highlights the detrimental effect of the currently insufficient provision of enforceable design regulations on the travel behaviour of the visually impaired pedestrian and the need for safer, more accessible environments.

10.2.3. Spatial Awareness & Cognitive Mapping Abilities

The many problems encountered by the visually impaired pedestrian when navigating within the built environment do not result from a lack of spatial awareness or failure to use cognitive mapping abilities. During the navigational experiment, the pointing task revealed that the level of spatial awareness among the visually impaired participants is similar if not the same to that of their sighted counterparts. Furthermore, all of the participants who took part in the navigational experiments made reference to their cognitive map and the way in which it enables them to plan a route within a familiar location. In particular, cognitive mapping abilities were used in order to memorise the location of hazardous features such as street furniture and inaccessible pedestrian crossings. This process gradually builds up the accuracy and detail of the cognitive map in a pictorial form for frequently used routes. There was a general preference to stay within the boundary of the cognitive map and in particular well known and rehearsed routes, where the exact location of potential hazards have been mapped out. The extent of spatial awareness and cognitive mapping abilities enables the visually impaired pedestrian to take shortcuts and plan alternative routes in the event of encountering obstacles along the original route. However, deviation from a known route can introduce unforeseen complications, due to the uncertainty regarding the presence of accessible pedestrian crossings and the location of unexpected obstacles. This finding is significant as it shows that the visually impaired population in this study are capable of employing both route knowledge and configurational knowledge, but are limited in doing so due to the non-standard approach in urban design and the inaccessible nature of the built environment.

10.2.4. Problematic Features in the Built Environment

The main problematic features associated with the design of the external built environment were not related to the lack or misuse of features implemented to assist navigation such as tactile paving, but rather with core elements inherent within the design of the built environment. In particular, uneven paving, the location and presence of street furniture and unexpected level changes were highlighted to be the most problematic features associated with pavement design. The lack of guidance regarding suitable paving materials contributes to a pedestrian environment infused with reflection, glare and ambiguity. Furthermore the high degree of variability and non-standard approach to kerb design contributes to the unpredictable nature of the environment, leading to an uncertainty regarding the definition of the threshold between pavement and road. These elements should therefore be viewed as high priority by designers and local authorities when considering which adjustments should be made in order to alleviate the hazards associated with navigation in the external environment.

The accumulation of different types of street furniture and the layering of new items on top of old, suffocates the streetscape resulting in a situation whereby street furniture takes precedence over the access needs of the pedestrian through the intrusive occupation of circulation zones. Furthermore, the non-standardised design, positioning and choice of colour and material culminate in a hostile landscape infused with unexpected and often invisible dangers. In particular, bollards were highlighted as the most hazardous item of street furniture by all visual field loss categories due to the design, zoning and over-saturation within the public realm. However, other items were not exempt from criticism, namely litter bins, outside dining areas, signage and lamp posts.

When planning their journey, participants were primarily influenced by the location of accessible pedestrian crossings. The access audit highlighted the sporadic nature of the provision of assistive features, with over 30% of crossings found not to incorporate either an audible signal or tactile spinning cone. The failure of current mandatory legislation to specifically enforce the incorporation of such features within the design of pedestrian crossings is largely responsible for this situation. The installation of assistive features is therefore reliant upon the resources available to each local authority in response to perceived need. This can ultimately lead to the creation of an urban landscape consisting of unreachable islands, placing the lives of the visually impaired population at risk and severely limiting their movement. It is acknowledged in this thesis that the removal of barriers or problematic features from the built environment can be both a costly and time consuming process. Therefore, it is necessary to prioritise the order in which such adjustments should be made. As the presence of inaccessible pedestrian crossings has severe implications to the movement patterns of the blind or visually impaired pedestrian this should be considered as one of the main priorities due to the widespread benefits that such a change would bring to the independence and lifestyle choices of blind and visually impaired people. A change of this nature would also constitute a reasonable adjustment under the terms outlined in the DDA. In particular, the DDA calls for reasonableness in implementing accessibility features in the built environment. This thesis encapsulates a comprehensive solution specifically for visually impaired and blind people. It is argued that by offering designers, architects and public authorities with a complete set of recommendations for this specific user group, adjustments following the specifications of the DDA can be more straightforwardly accommodated. The proposed solution offers the possibility to select recommendations that are tailored to the specific needs of individual circumstances, further promoting its use in conjunction with other guidelines focusing on a variety of physical impairments.

10.2.5. The Onset and Impact of Visual Impairment

Throughout the survey there was a clear distinction between the responses of individuals diagnosed before the age of 13 (early blind) and individuals diagnosed from the age of 13 onwards (late blind). In particular, individuals diagnosed with a visual impairment at an early stage in life proved to be more confident and independent travellers, consistently rating factors and features as less influential, problematic and hazardous than those in the late blind group. This finding was reinforced by the faster completion time and shorter distance travelled by the early blind group during the navigational experiment. The ability to navigate more efficiently within the built environment may result from having more experience living in a world with low vision, enabling the development of a set of coping strategies.

Many similarities were found among the different visual field loss groups with regards to the survey responses and problems encountered during the navigational experiment. In general, individuals with other conditions not affecting visual field loss tend to perceive their environment to be less disabling than those affected by visual field loss and blindness. The type of vision loss did not have a significant influence on the number of independent journeys made or whether individuals travelled with the assistance of a sighted companion. Individuals affected by a total loss of vision expressed the greatest wish to make more independent journeys. However, among the other visual field loss categories there was little difference in demand for more independent journeys. The type of visual field loss also does not have a significant influence on the psychological and physical factors preventing independent travel. However with respect to physical pavement features and items of street furniture, the peripheral, blind and mixed vision loss categories rated these features and items as more problematic and hazardous than the other visual field loss groups. This was further demonstrated in the navigational experiment with a significantly higher number of incidents recorded involving individuals with peripheral vision loss and those who are fully blind. Furthermore individuals with peripheral vision loss and blindness took the longest time and travelled a greater distance than all other visual field loss groups. Interestingly both groups used either a guide dog or a long cane indicating that the use of a mobility aid alone does not eliminate the hazardous nature of the built environment as perceived by the visually impaired pedestrian.

10.2.6. Colour and Contrast

Perhaps one of the most significant findings relates to colour and contrast combinations within the built environment. In particular, the survey responses show a general trend favouring the visibility of warm, bright, vibrant colours and also establish silver as the most difficult colour to identify. The low visible properties of silver were highlighted as a major hazard throughout the navigational experiment, due to the high prominence of silver stainless steel in the built environment. The three least visible colours – silver, green and blue – were identical for each visual field loss category. Furthermore, there was a general agreement among all visual field loss categories as to the most suitable colour contrast combinations for use in the three scenarios of stair and edge strip, pavement and bollard, and pavement, kerb and road. The four main colours to be used were black or grey in combination with yellow or white in any one of the above scenarios. The results from this section facilitate the creation of a hazard rating calculation and an enhanced set of design guidelines providing recommendations that can improve the visibility of features within the built environment for all types of visual field loss.

10.3. Contributions

This thesis builds upon past theory to provide a practical solution to overcome many of the barriers inherent within current architectural practice. Building on the main findings documented in the previous section, the research extends current perceptions about the navigational behaviour and needs of visually impaired pedestrians, providing at the same time a comprehensive solution to measure the accessibility of current urban environments and ultimately aid the design of visually impaired-friendly streetscapes. In order to achieve this, the adopted approach integrates the work of existing theory and previous research with new evidence on navigational requirements. Specifically, current knowledge on the research area is dispersed in many disciplines, including geography (Golledge, 1993; Golledge & Timmermanns, 1990), psychology (Kitchin, 1997; Passini *et al.*, 1990; Ungar, 2000), technology (Bradley & Dunlop, 2005; Bradley & Dunlop, 2003) and sociology (Vujakovic & Matthews, 1994). In addition, charitable organisations (Royal National Institute for the Blind, Guide Dogs for the Blind Association) and governmental bodies (Dept. for Transport, British Standards Institute) have also addressed accessibility issues. According to the findings of this work, architecture remains one of the least represented disciplines in the research area. Even when reference is made to accessibility, this primarily focuses on internal environments (e.g. Bright *et al.*, 1997, 1999, 2004; Barker *et al.*, 1995). As opposed to previous studies that focus on sociological or psychological factors that impede accessibility, this work advances the current know-how in the architectural community. By combining the knowledge from these domains in an architecture-oriented study, this thesis offers a thorough understanding of the barriers to access for visually impaired individuals imposed by architecture.

In terms of spatial awareness and cognitive mapping abilities of the visually impaired population, previous research has focused on internal artificial environments (Levine *et al.*, 1982; Loomis *et al.*, 1993; Passini *et al.*, 1990), internal real spaces (Butler *et al.*, 1993; Marston & Golledge, 2003; Passini & Proulx, 1988) and to a lesser extent external suburban environments (Blades *et al.*, 2002; Bradley & Dunlop, 2005). In all the above cases, the effects of architectural design to real-life navigational needs are confined by either the introduction of controlled variables or the limited scale of the setting. Through the navigational experiments, this thesis has identified the need for studies in large-scale urban environments and its practical importance (Golledge, 1993; Golledge *et al.*, 1999; Shearer, 1981) and presents original research within an inner-urban environment by utilising the city centre of Glasgow as an exemplar case. A comparable study has been carried out by Espinosa *et al.*, (1998) in central Madrid and Sheffield. The difference is that Espinosa *et al.*'s study was conducted in a setting unfamiliar to the participants and – similarly to work by Jacobson *et al.* (1998) and Ochaíta & Huertas (1993) – the study focused on the learning and mapping abilities of visually impaired people. The navigational experiments in this work have instead taken place in an area familiar to the subjects – which was a prerequisite for taking part. Having established from previous research that visually impaired individuals are capable of learning routes (Golledge *et al.*, 1999; Millar, 1995), this approach has made it possible to scrutinise and identify the influence of specific architectural features to access when navigating in commonly used, real and complex spaces. By choosing an inner-urban environment, this research provides a realistic test bed, which specifically focuses on architectural barriers rather than perceived influences of visual impairment.

Regarding subject groups, this research builds on recommendations by other scholars (e.g. Ungar 2000) by using a mixed sample of visually impaired individuals. In doing so, previous work on exclusively blind participants (Byrne & Salter, 1983; Hollins & Kelley, 1988; Rieser *et al.*, 1986) has been extended and has enabled this work to investigate possible differences between visual impairments (Bradley and Dunlop, 2005). The study of these differences has been further complemented by including a wide range of ages, use of mobility aids and age of diagnosis. The study of features has previously been restricted to specific categories (for instance, Ochaíta & Huertas (1993) focused on teenagers, Passini & Proulx, (1988) studied congenitally blind subjects using a white cane). By selecting a sample with even numbers of participants for each type of visual field loss, this work has examined similarities and differences in order to provide evidence on navigational needs of each category and identify the areas of convergence. In doing so, a holistic approach is endorsed to inform the design of spaces that incorporate the needs of the visually impaired population as a whole and to ultimately test the verity of the research hypothesis.

The navigational needs of the visually impaired population have been comprehensively explored through a nationwide survey. The survey consists primarily of a questionnaire, which has collected demographic data (such as age of the participants, type of vision loss, age of diagnosis and mobility aid) as well as information on psychological factors, hazardous features of the built environment and the influence of weather conditions that collectively prevent independent travel specifically for visually impaired pedestrians. Previous surveys (e.g. Pey *et al.*, 2007; Douglas, *et al.*, 2006) have covered a broad spectrum of issues including employment, education, social activities, technology, mobility and service provision. Instead, this work has focused exclusively on navigation and the architectural features that impede access to the external built environment. Furthermore, the survey provides evidence on colour and contrast combinations in external spaces, thus extending previous research that has solely investigated their application in internal environments (e.g. Bright *et al.*, 2000). The findings from the questionnaire – complemented by the results of the post-experiment interviews and access audit – have been instantiated as an evaluation tool to measure the hazardous nature of architectural features on a street-by-street basis. The *Street Hazard Rating Calculation* is the first effort to quantify the degree to which street elements can disable pedestrians with a wide spectrum of visual impairments and exposes the insufficiencies in current legislation for creating accessible and inclusive urban environments. The calculation is informed by the findings of previous studies in geography, environmental psychology and sociology, as these have been reviewed in Chapter Four. The thesis further contributes to this previously unstudied area, by mapping this information in a visual format that can be straightforwardly interpreted by designers, planners and local authorities, so as to raise awareness on the impact of their design decisions to the lives of the visually impaired population.

Building on the analysis conducted throughout the research, a major contribution is made in the area of accessibility guidelines. The lack of extensive provisions for designing urban environments to address the needs of the visually impaired population in existing mandatory regulations (SBSA, 2009) and optional guidelines (BSI, 2009; Dept. for Transport, 2002, 2005a) has been repeatedly signalled throughout this thesis. By enhancing these regulations and guidelines with formal evidence, this work offers a new perspective in designing external urban environments that cater for the needs of the visually impaired population and confirms the statements outlined in the research hypothesis.

10.4. Recommendations for Future Directions

The findings of this thesis can be used to both inform further research in the field and provide the groundwork for future practical implementations of the research outputs. Future research should build on the successful employment of the human-centred methodology presented in this work and include it as both general good practice and as a fundamental source of evidence. This “community approach” can be particularly apposite for architectural studies, which have thus far not explored accessibility issues on a wider scale. For instance, the reflective properties of pavement materials under various weather conditions is an issue that influences seamless navigation for visually impaired individuals and definitely requires further investigation. Although this work has presented recommendations with the visually impaired population in mind, their effect should also be tested with other types of disability. For example, comparative studies should be conducted to examine how the accessibility needs of visually impaired individuals align with those of wheelchair users. Additionally, the focus of future studies could move beyond the UK context and compare practices within and among other countries.

Future consultation on the effective design of surveys should allow for consideration to the current format employed in the data collection instruments used in this work. In particular, there are areas in the design of the questionnaire that could be improved. For instance, the introduction of non-committal responses in the rating scale of hazardous items (such as “Not a hazard” or “Not applicable”) could contribute towards eliminating bias from respondents that possibly felt obligated to assert a statement they otherwise did not believe. Reversing the coding of the scale so that rating 1 describes factors as the least hazardous/problematic/influential, and rating 5 describes factors as most hazardous could also improve the respondents’ understanding of the questionnaire item and therefore enhance their motivation to complete the survey.

The Street Hazard Rating Calculation is a preliminary effort to quantify and measure the hazardous nature of streets within an urban area. The calculation should now be used to measure the accessibility levels in urban environments other than Glasgow City centre. Further research will contribute towards corroborating its verity and efficiency under variable conditions. The deriving findings will highlight potential calibrations in the calculation methodology, additions to the elements measured and augmentations in the presentation of results. For instance, instead of providing an overall rating for a street, future iterations of the Hazard Rating Calculation could measure the accessibility of individual zones within a specific street in order to provide a more personalised and site specific representation of the potential hazards on a particular street. Future adaptations should consider the implications of variations in vehicular and pedestrian traffic flow, natural and artificial lighting levels, ongoing or future maintenance work, the differences between primary and secondary routes and the proximity and grouping of hazards in addition to the route taken and direction of travel. Wider adoption is possible, with potential implementations of the calculation in mobile technologies. Such applications will report on the hazardousness of chosen routes prior to travel and inform the decision-making process for visually impaired users. However, it is argued in this work that technology should not be perceived as a panacea to the many design problems of current urban environments. Technological aids are inarguably necessary in certain cases, but they are not a comprehensive solution. Independent travel cannot be promoted if the expectation is that visually impaired pedestrians will become dependent to costly – and often unreliable – gadgets. Rather than seeking substitutes, a ‘back to basics’ approach to simplify the manner that urban environments are designed could provide solutions for unobstructed navigation.

The set of enhanced design guidelines highlights the inadequacies in existing documentation and should therefore be reviewed by relevant government bodies, who will consider its incorporation in future mandatory regulations. In parallel, future work should test the acceptance of the enhanced guidelines by visually impaired individuals in real-life situations. To this end, prototypes should be built to examine whether the guidelines require further enhancements that reflect feedback from actual interaction of user groups with the proposed environment. More urgent is the incorporation of the recommendations from this work to teaching and training materials, so that design professionals share a common understanding of the barriers that visually impaired pedestrians face when navigating within urban environments. It would also be expedient that this type of dissemination moves beyond professionals to the general public. In this manner, a cognitive culture can be created that embraces awareness of these issues on a wider population scale.

Finally, this work is not an end in itself. The dynamic nature of the built environment and the manner that urban spaces evolve only dictate that the hazard rating calculation and design guidelines are equally dynamic. The decisive first step has now been made. Further collaborations with planners, city councils and the visually impaired population will ensure that these guidelines not only solve problems at present, but continue to evolve and ultimately ameliorate the lives of many users.

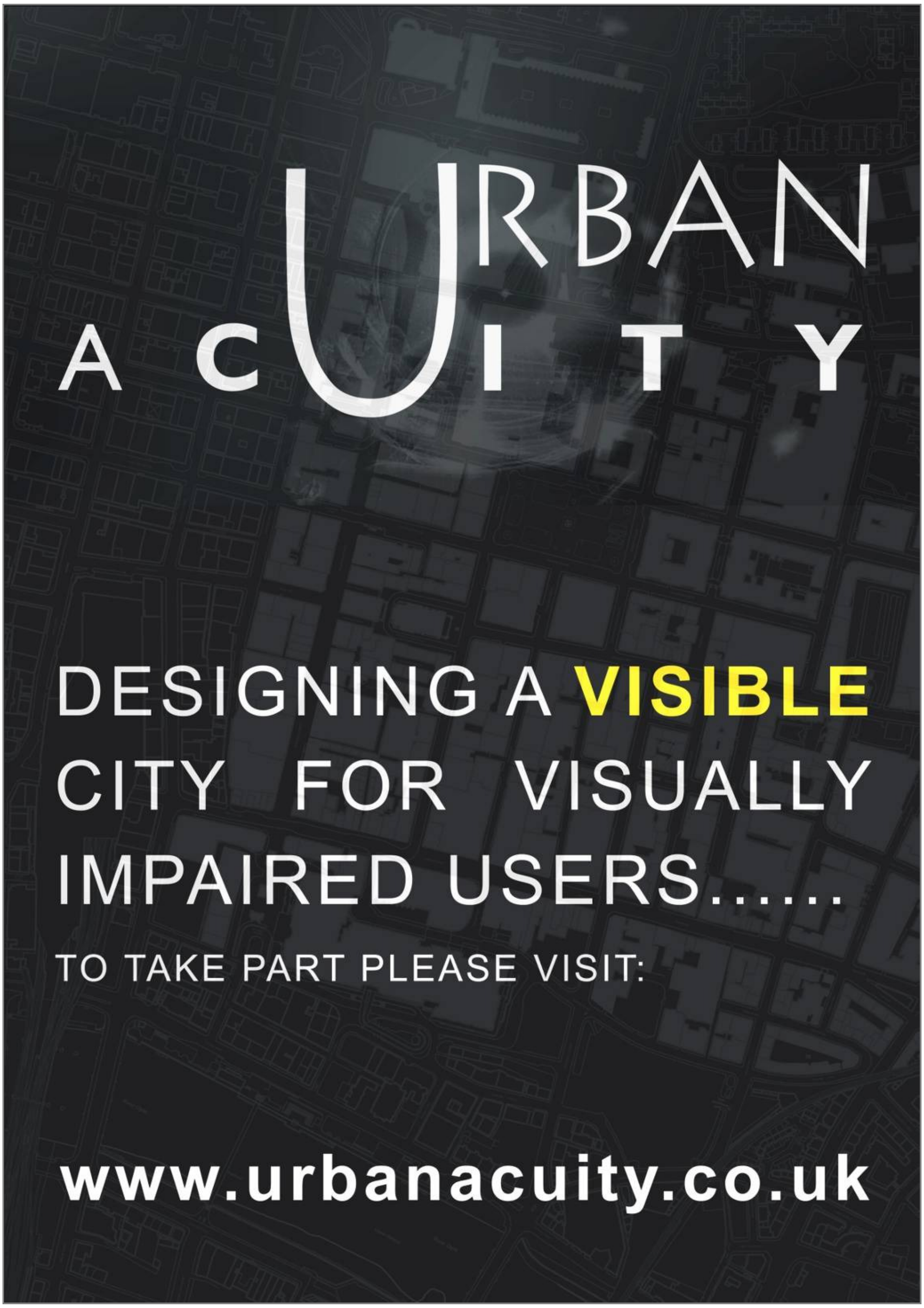
Appendix A: Questionnaire Documentation

A.1. Recruitment poster

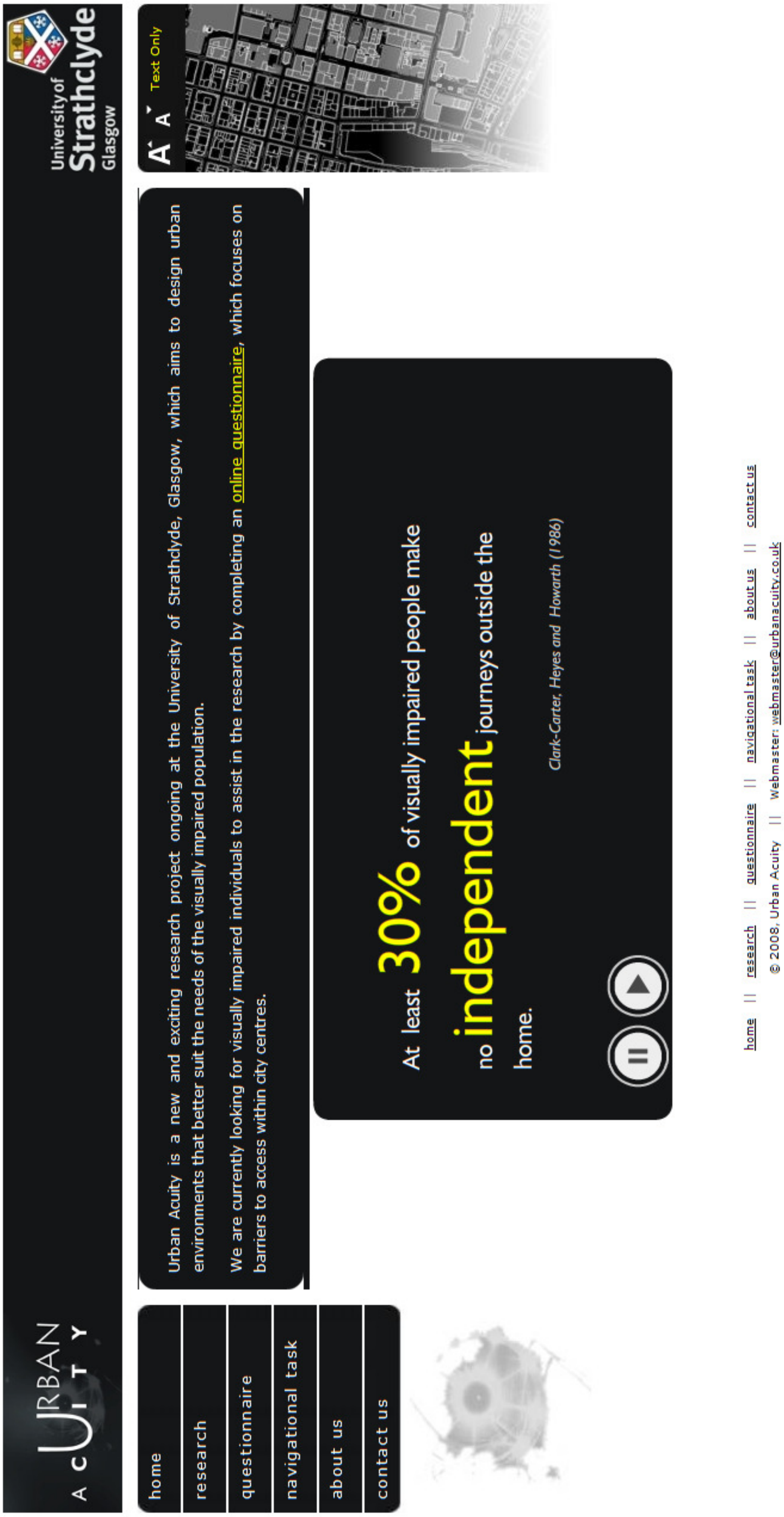
A.2. Project website

A.3. Sample questionnaire

A.1. Recruitment Poster



A.2. Project Website



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Urban Acuity is a new and exciting research project ongoing at the University of Strathclyde, Glasgow, which aims to design urban environments that better suit the needs of the visually impaired population.
We are currently looking for visually impaired individuals to assist in the research by completing an online questionnaire, which focuses on barriers to access within city centres.
At least 30% of visually impaired people make no independent journeys outside the home.
Clark-Carter, Heyes and Howarth (1986)
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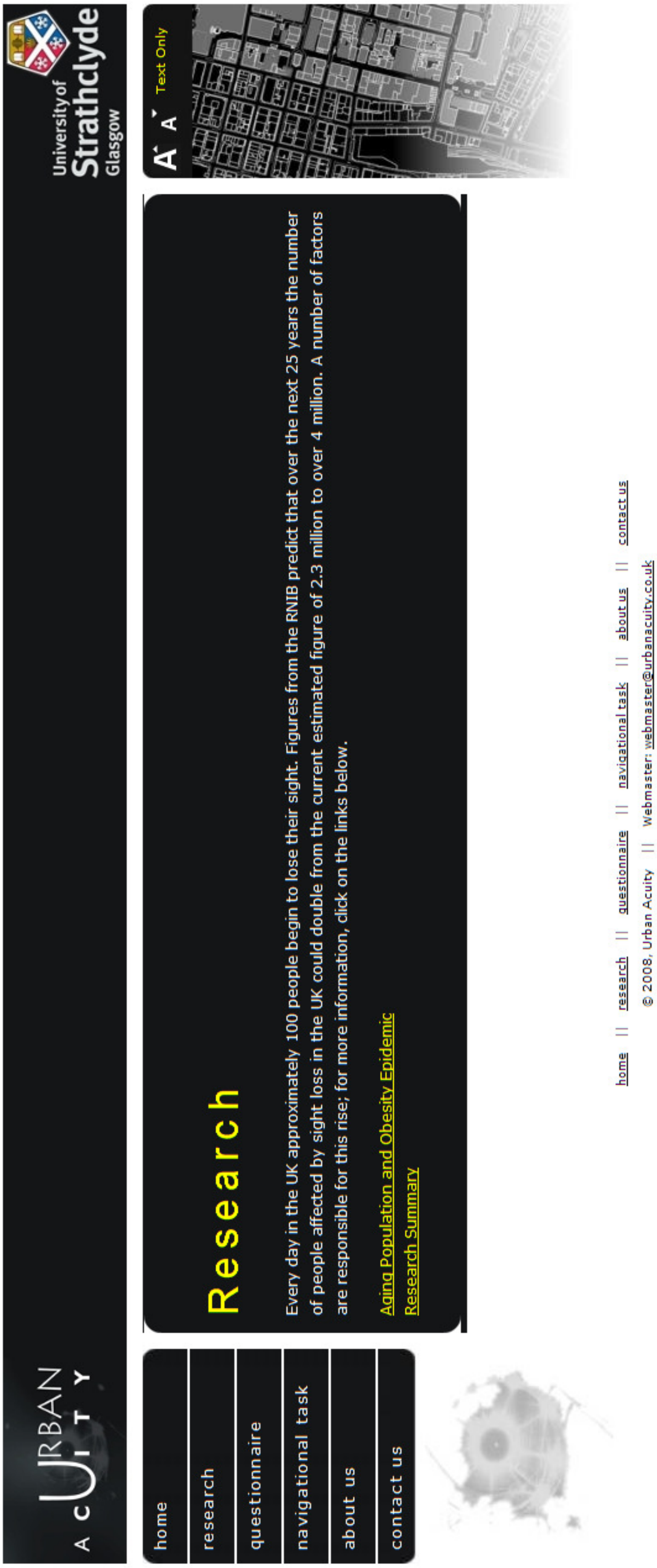
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Research
Every day in the UK approximately 100 people begin to lose their sight. Figures from the RNIB predict that over the next 25 years the number of people affected by sight loss in the UK could double from the current estimated figure of 2.3 million to over 4 million. A number of factors are responsible for this rise; for more information, click on the links below.
Aging Population and Obesity Epidemic
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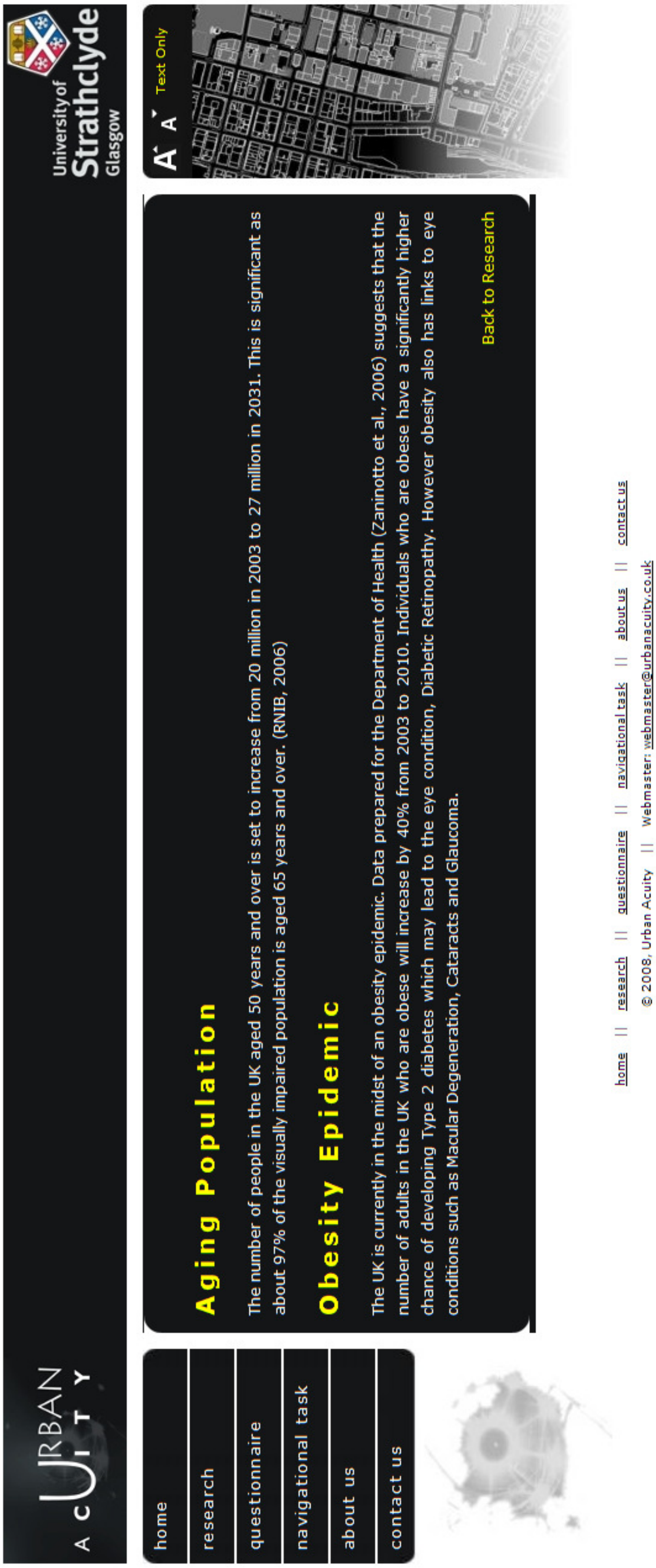
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Aging Population
The number of people in the UK aged 50 years and over is set to increase from 20 million in 2003 to 27 million in 2031. This is significant as about 97% of the visually impaired population is aged 65 years and over. (RNIB, 2006)
Obesity Epidemic
The UK is currently in the midst of an obesity epidemic. Data prepared for the Department of Health (Zaninotto et al., 2006) suggests that the number of adults in the UK who are obese will increase by 40% from 2003 to 2010. Individuals who are obese have a significantly higher chance of developing Type 2 diabetes which may lead to the eye condition, Diabetic Retinopathy. However obesity also has links to eye conditions such as Macular Degeneration, Cataracts and Glaucoma.
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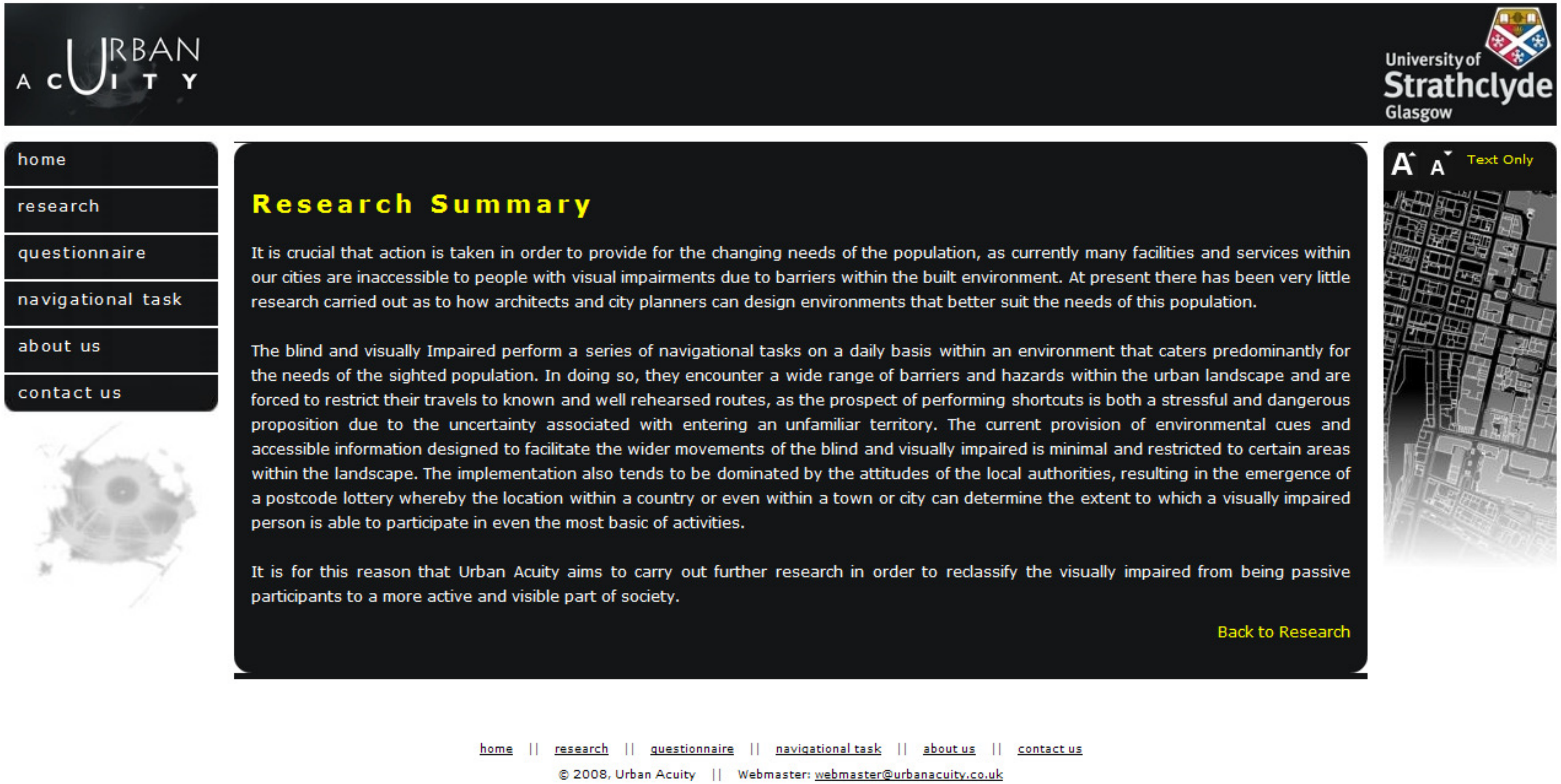

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Research Summary

It is crucial that action is taken in order to provide for the changing needs of the population, as currently many facilities and services within our cities are inaccessible to people with visual impairments due to barriers within the built environment. At present there has been very little research carried out as to how architects and city planners can design environments that better suit the needs of this population.

The blind and visually Impaired perform a series of navigational tasks on a daily basis within an environment that caters predominantly for the needs of the sighted population. In doing so, they encounter a wide range of barriers and hazards within the urban landscape and are forced to restrict their travels to known and well rehearsed routes, as the prospect of performing shortcuts is both a stressful and dangerous proposition due to the uncertainty associated with entering an unfamiliar territory. The current provision of environmental cues and accessible information designed to facilitate the wider movements of the blind and visually impaired is minimal and restricted to certain areas within the landscape. The implementation also tends to be dominated by the attitudes of the local authorities, resulting in the emergence of a postcode lottery whereby the location within a country or even within a town or city can determine the extent to which a visually impaired person is able to participate in even the most basic of activities.

It is for this reason that Urban Acuity aims to carry out further research in order to reclassify the visually impaired from being passive participants to a more active and visible part of society.

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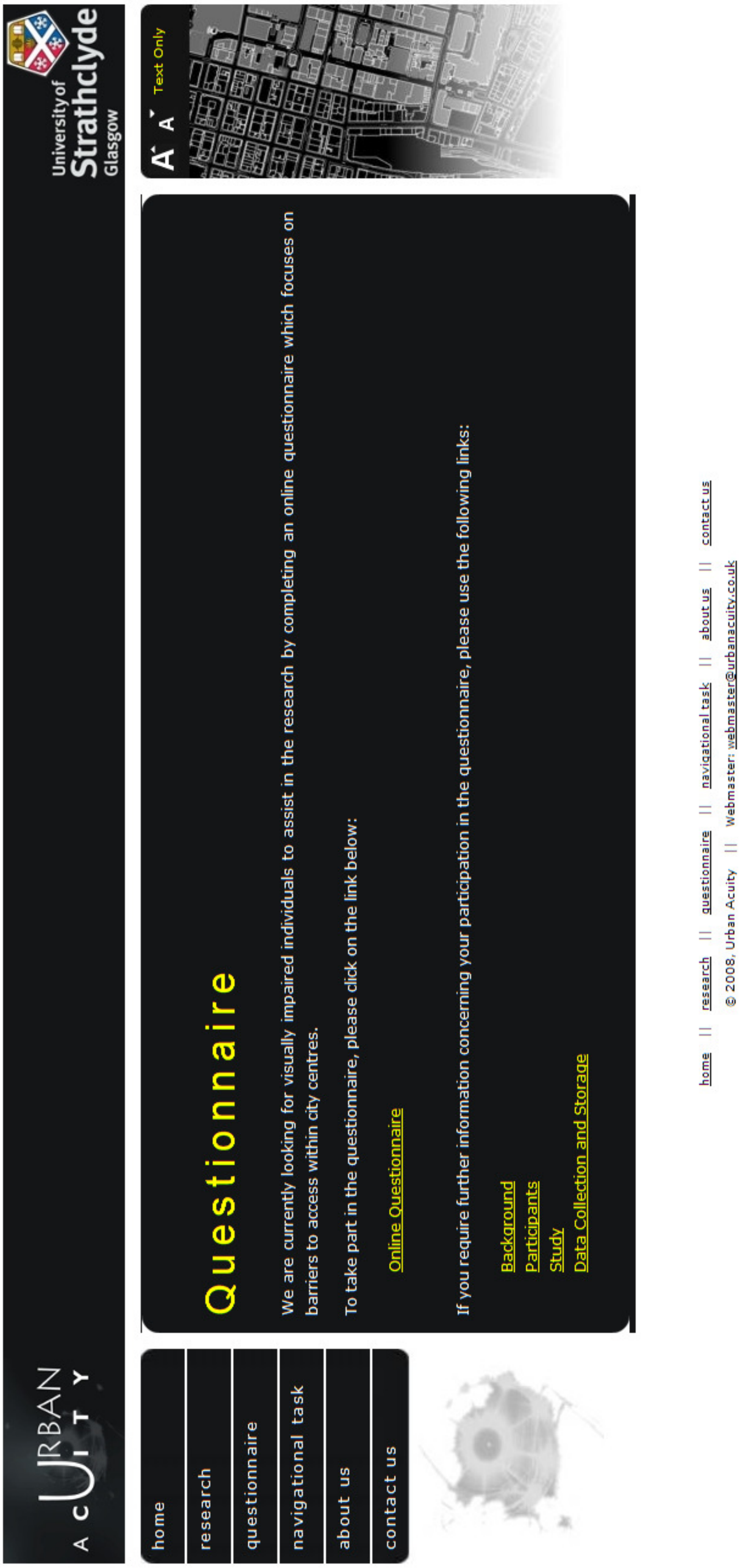
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Questionnaire
We are currently looking for visually impaired individuals to assist in the research by completing an online questionnaire which focuses on barriers to access within city centres.
To take part in the questionnaire, please click on the link below:
Online Questionnaire
If you require further information concerning your participation in the questionnaire, please use the following links:
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Data Collection and Storage
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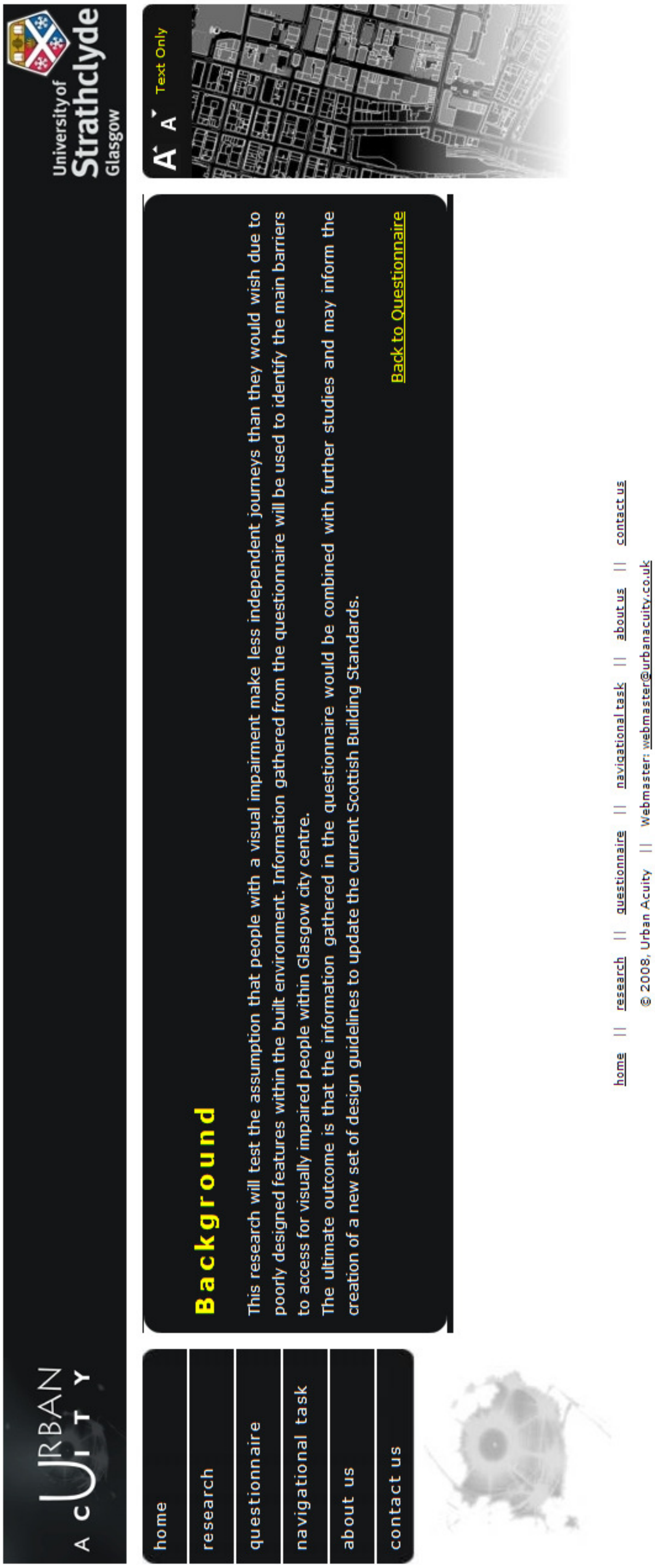

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Background

This research will test the assumption that people with a visual impairment make less independent journeys than they would wish due to poorly designed features within the built environment. Information gathered from the questionnaire will be used to identify the main barriers to access for visually impaired people within Glasgow city centre.

The ultimate outcome is that the information gathered in the questionnaire would be combined with further studies and may inform the creation of a new set of design guidelines to update the current Scottish Building Standards.

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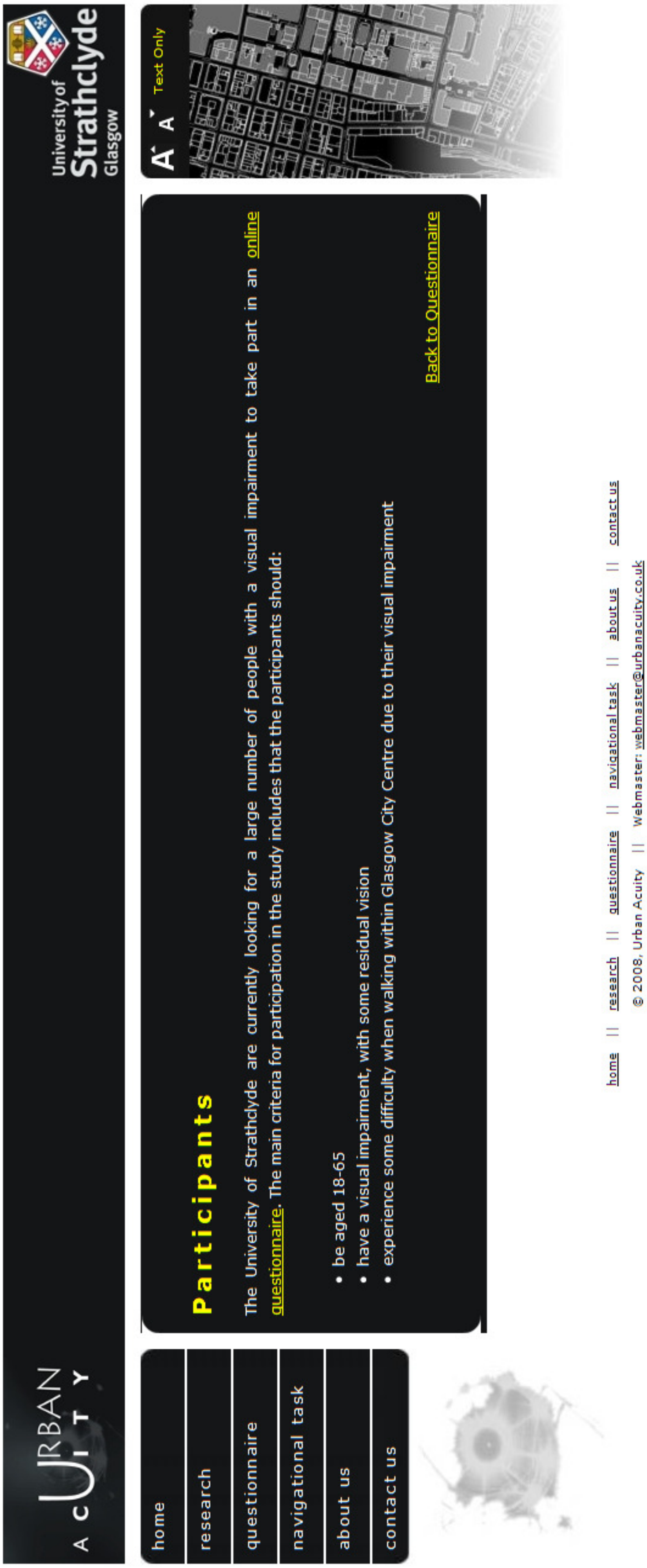
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Participants
The University of Strathclyde are currently looking for a large number of people with a visual impairment to take part in an online questionnaire. The main criteria for participation in the study includes that the participants should:
• be aged 18-65
• have a visual impairment, with some residual vision
• experience some difficulty when walking within Glasgow City Centre due to their visual impairment
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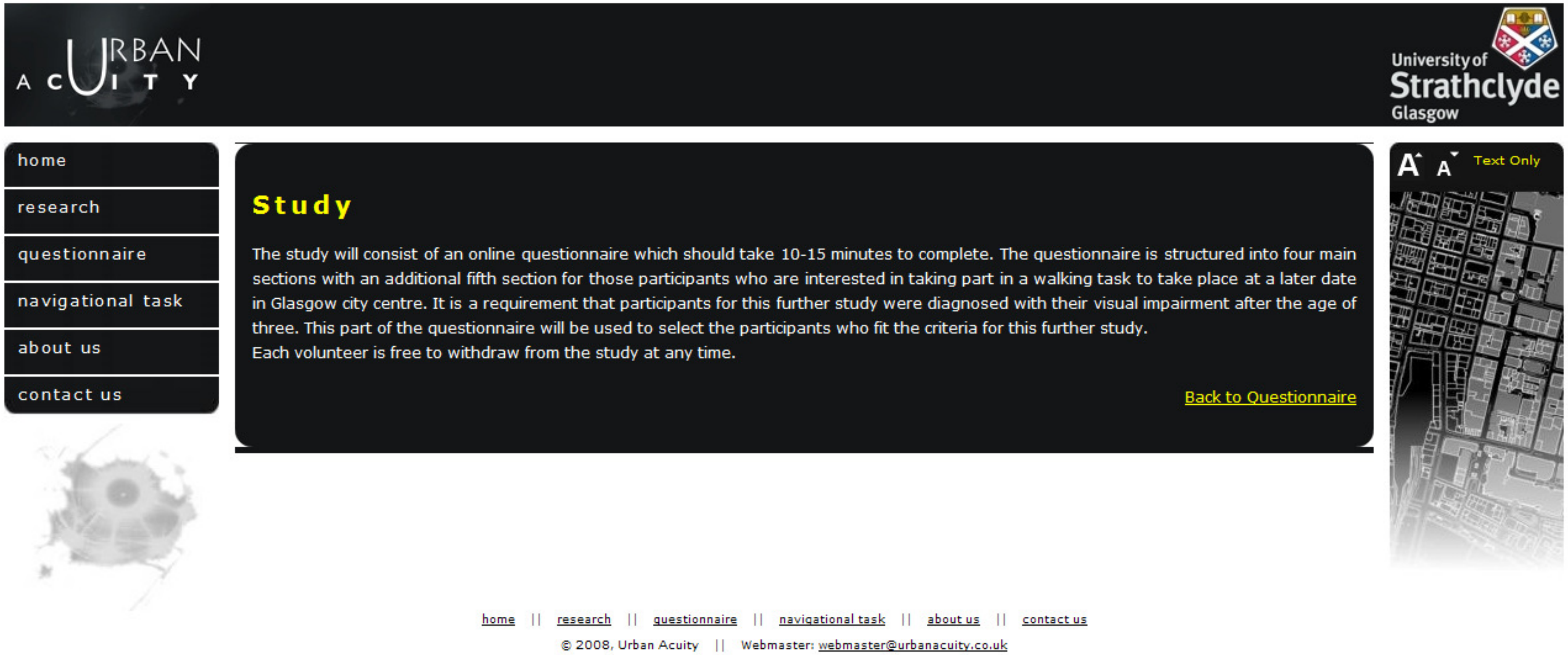
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Study
The study will consist of an online questionnaire which should take 10-15 minutes to complete. The questionnaire is structured into four main sections with an additional fifth section for those participants who are interested in taking part in a walking task to take place at a later date in Glasgow city centre. It is a requirement that participants for this further study were diagnosed with their visual impairment after the age of three. This part of the questionnaire will be used to select the participants who fit the criteria for this further study.
Each volunteer is free to withdraw from the study at any time.
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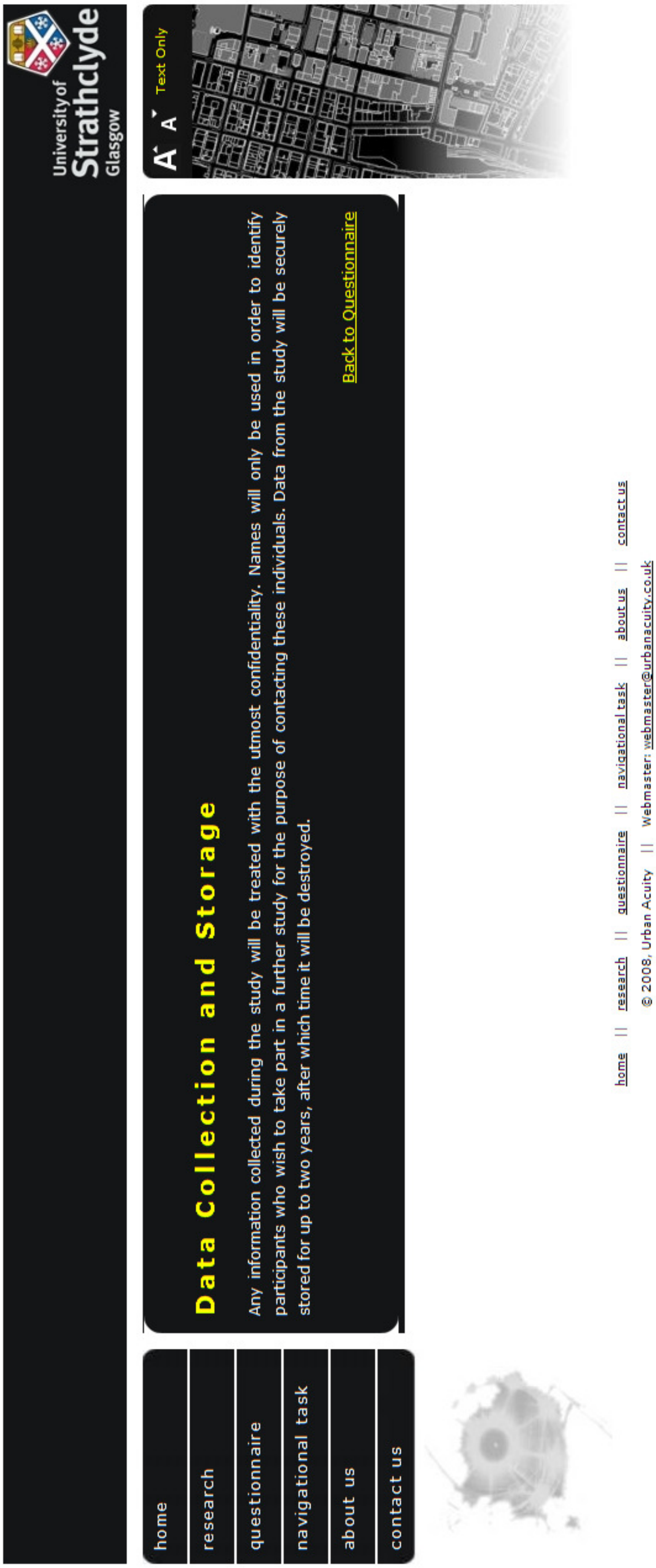
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Data Collection and Storage
Any information collected during the study will be treated with the utmost confidentiality. Names will only be used in order to identify participants who wish to take part in a further study for the purpose of contacting these individuals. Data from the study will be securely stored for up to two years, after which time it will be destroyed.
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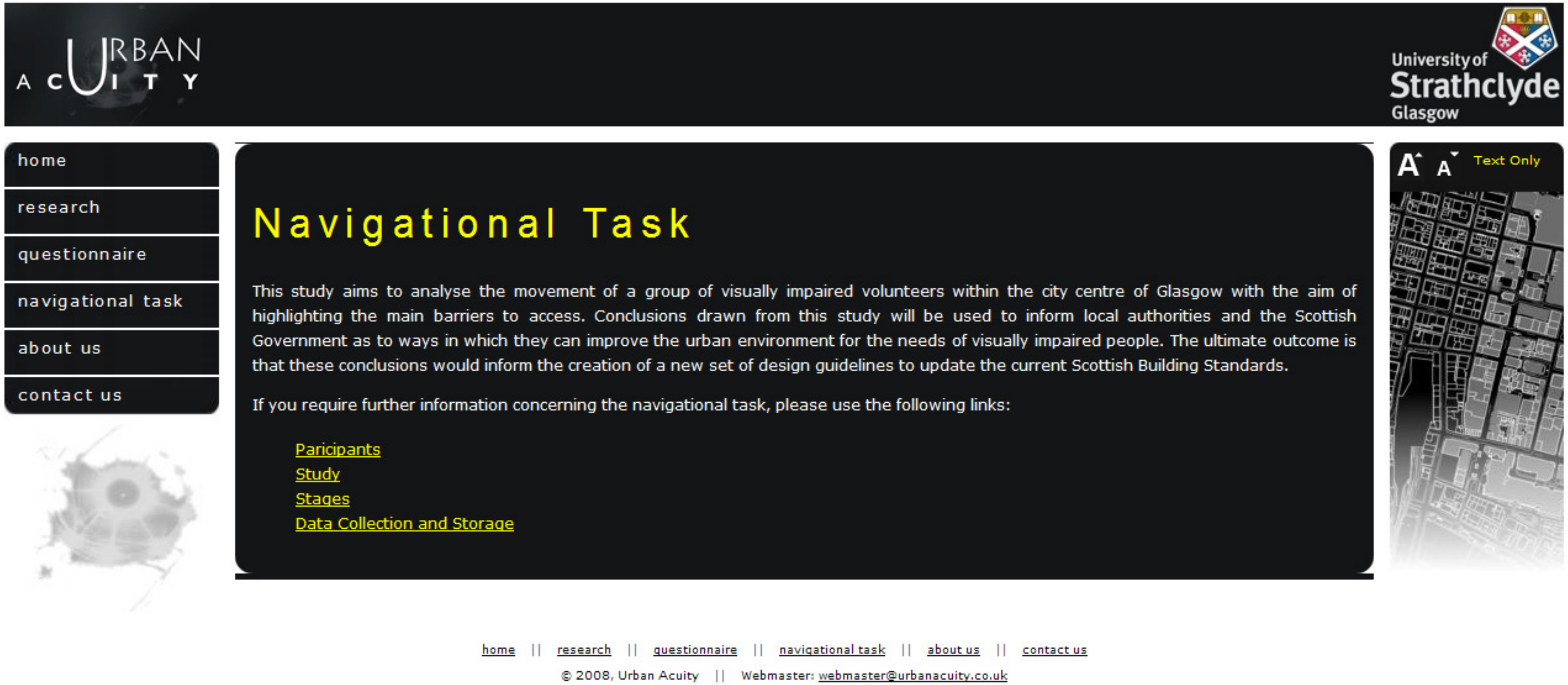
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Navigational Task
This study aims to analyse the movement of a group of visually impaired volunteers within the city centre of Glasgow with the aim of highlighting the main barriers to access. Conclusions drawn from this study will be used to inform local authorities and the Scottish Government as to ways in which they can improve the urban environment for the needs of visually impaired people. The ultimate outcome is that these conclusions would inform the creation of a new set of design guidelines to update the current Scottish Building Standards.
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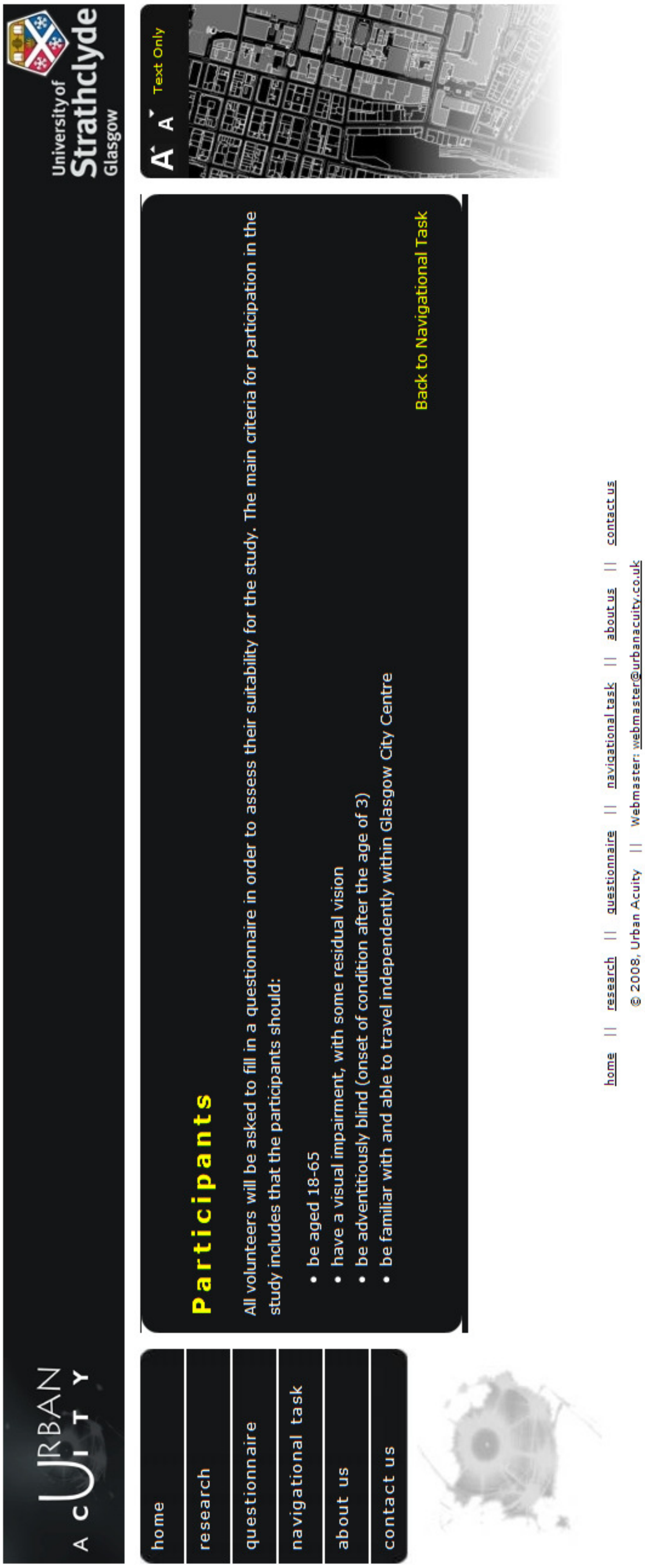
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Participants
All volunteers will be asked to fill in a questionnaire in order to assess their suitability for the study. The main criteria for participation in the study includes that the participants should:
• be aged 18-65
• have a visual impairment, with some residual vision
• be adventitiously blind (onset of condition after the age of 3)
• be familiar with and able to travel independently within Glasgow City Centre
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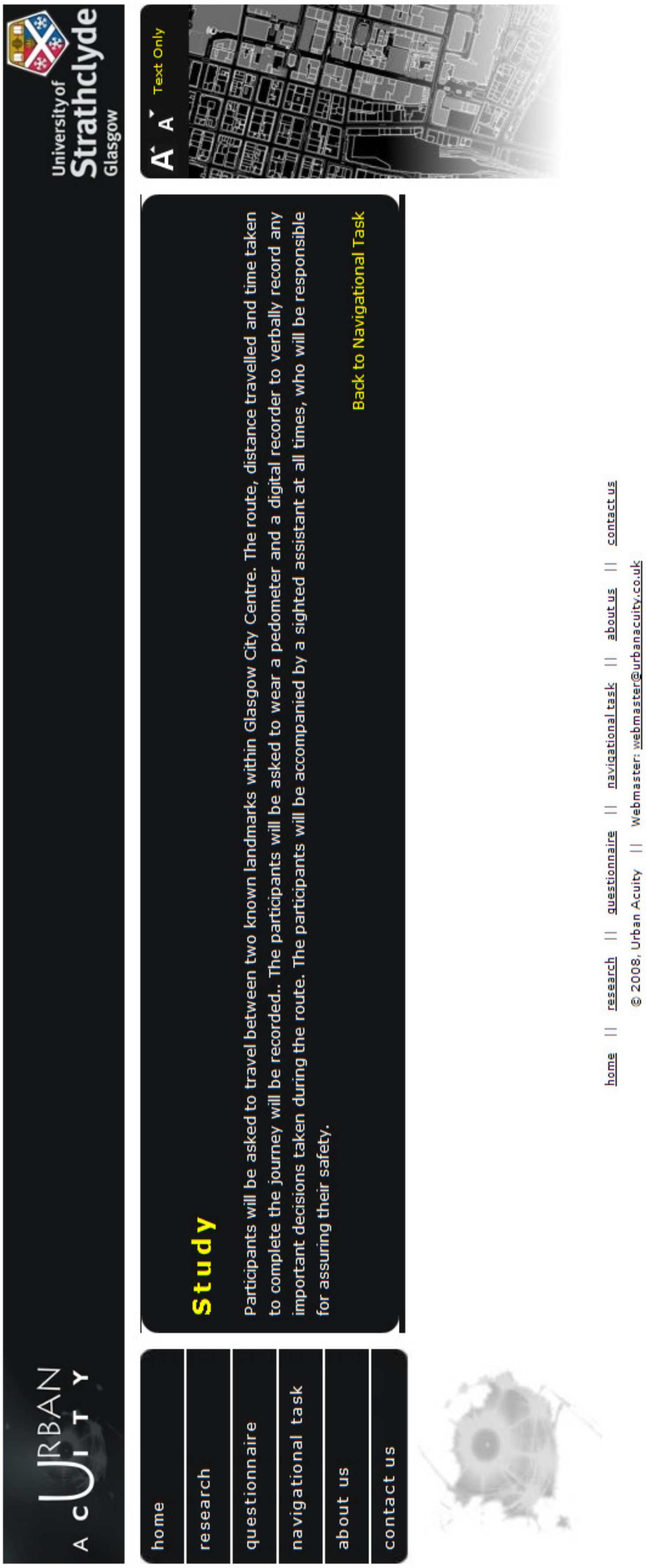
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Study
Participants will be asked to travel between two known landmarks within Glasgow City Centre. The route, distance travelled and time taken to complete the journey will be recorded.. The participants will be asked to wear a pedometer and a digital recorder to verbally record any important decisions taken during the route. The participants will be accompanied by a sighted assistant at all times, who will be responsible for assuring their safety.
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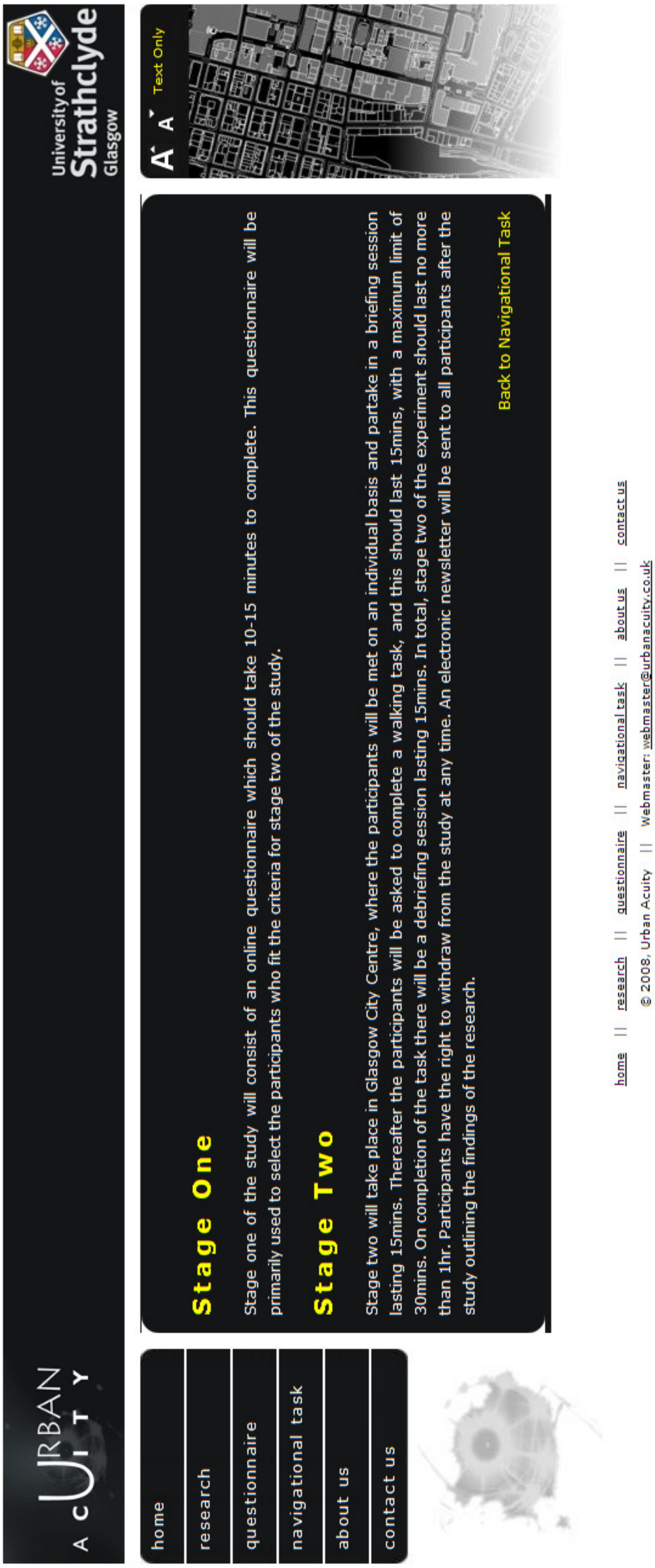

Stage One

Stage one of the study will consist of an online questionnaire which should take 10-15 minutes to complete. This questionnaire will be primarily used to select the participants who fit the criteria for stage two of the study.

Stage Two

Stage two will take place in Glasgow City Centre, where the participants will be met on an individual basis and partake in a briefing session lasting 15mins. Thereafter the participants will be asked to complete a walking task, and this should last 15mins, with a maximum limit of 30mins. On completion of the task there will be a debriefing session lasting 15mins. In total, stage two of the experiment should last no more than 1hr. Participants have the right to withdraw from the study at any time. An electronic newsletter will be sent to all participants after the study outlining the findings of the research.

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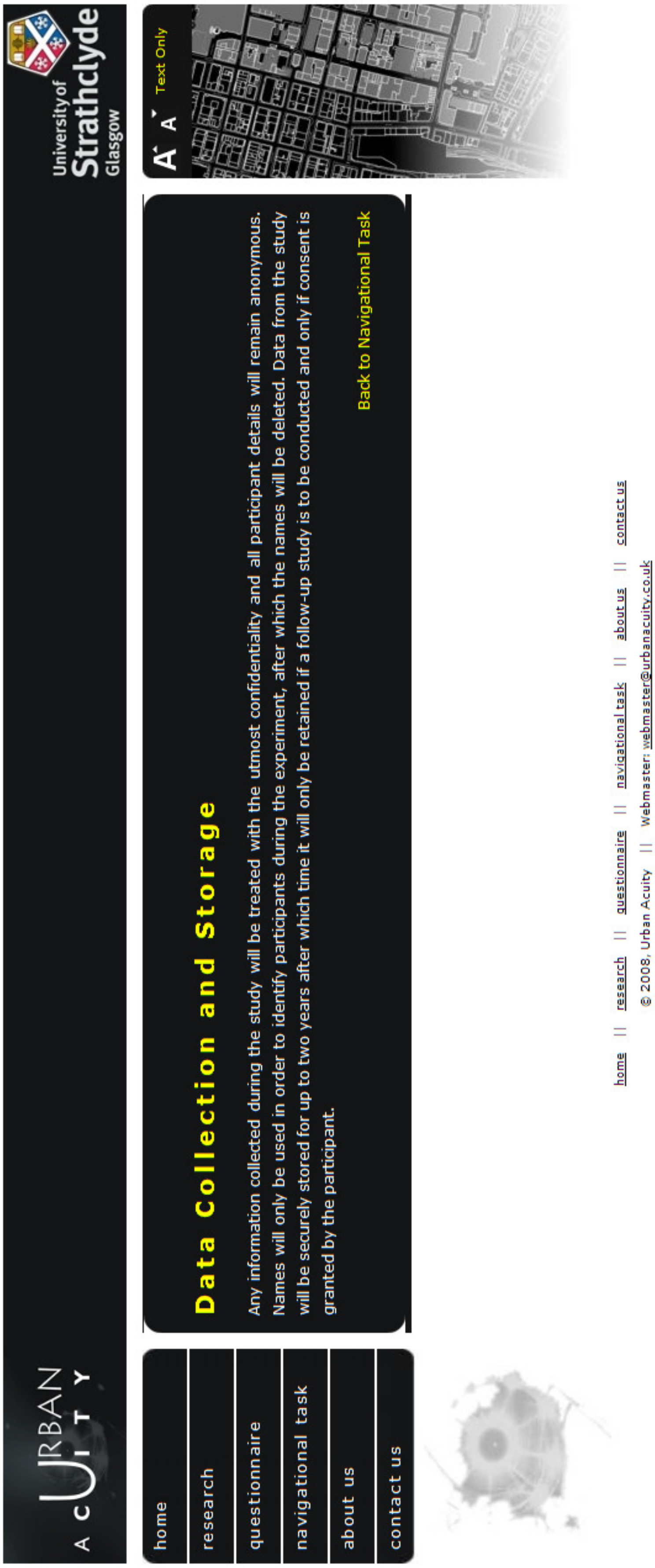

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Data Collection and Storage

Any information collected during the study will be treated with the utmost confidentiality and all participant details will remain anonymous. Names will only be used in order to identify participants during the experiment, after which the names will be deleted. Data from the study will be securely stored for up to two years after which time it will only be retained if a follow-up study is to be conducted and only if consent is granted by the participant.

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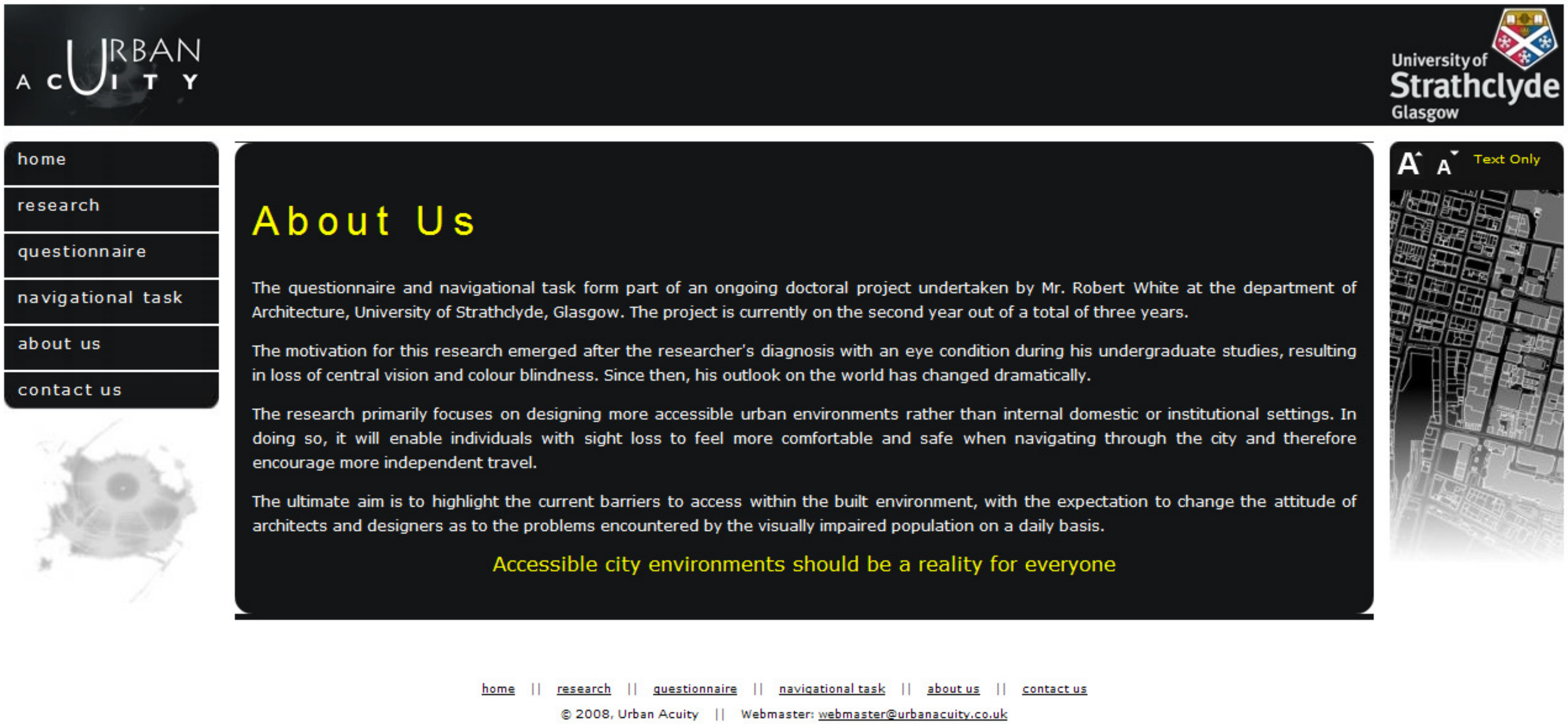
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About Us
The questionnaire and navigational task form part of an ongoing doctoral project undertaken by Mr. Robert White at the department of Architecture, University of Strathclyde, Glasgow. The project is currently on the second year out of a total of three years.
The motivation for this research emerged after the researcher's diagnosis with an eye condition during his undergraduate studies, resulting in loss of central vision and colour blindness. Since then, his outlook on the world has changed dramatically.
The research primarily focuses on designing more accessible urban environments rather than internal domestic or institutional settings. In doing so, it will enable individuals with sight loss to feel more comfortable and safe when navigating through the city and therefore encourage more independent travel.
The ultimate aim is to highlight the current barriers to access within the built environment, with the expectation to change the attitude of architects and designers as to the problems encountered by the visually impaired population on a daily basis.
Accessible city environments should be a reality for everyone
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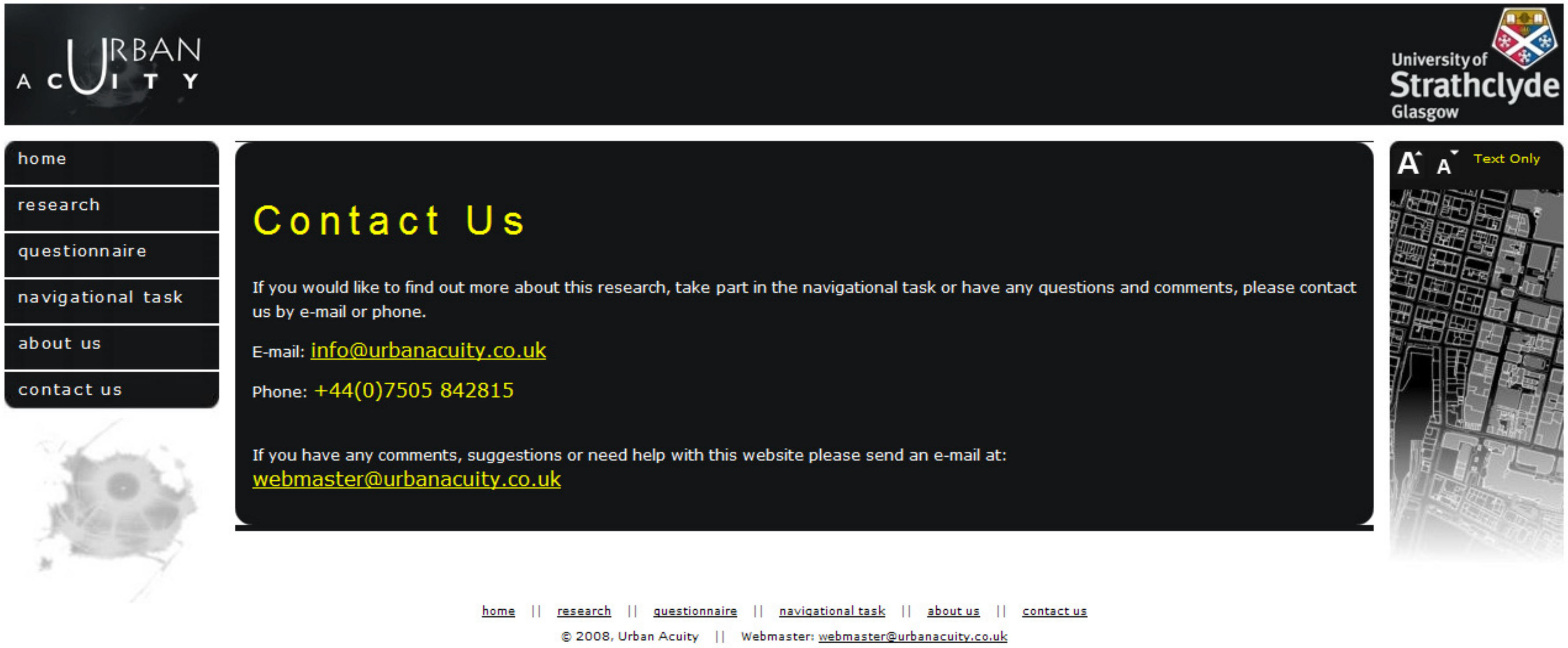
URBAN ACUITY
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A.3. Sample Questionnaire

1. Consent Form

WELCOME TO THE URBAN ACUITY 2008 QUESTIONNAIRE

Before continuing, please take a few moments to read and acknowledge the following terms.

I understand that my participation in this questionnaire is voluntary. I can request for my data to be withdrawn from the study and I am under no obligation to respond to all questions.

I understand that all information I give will be treated with the utmost confidentiality and that my anonymity will be respected at all times.

I give permission to the University of Strathclyde to maintain records of the data for up to two years.

1. I agree to the above terms and would like to take part in this survey.	☐ **Yes** ☐ **No**
2. Personal Details	
1. Age	
2. Sex	☐ **Male** ☐ **Female**

3. Please tick one of the following which best describes your main occupation:	☐ **A student** ☐ **Employed** ☐ **Unemployed** ☐ **Retired** ☐ **Voluntary worker** ☐ **Other (please specify)**
3. Visual Impairment	
1. What is the name of your eye condition(s)? (Optional)	

2. What type of vision loss does your condition involve?	☐ **Loss of central vision** ☐ **Loss of peripheral vision** ☐ **Mixed vision loss** ☐ **Total blindness** ☐ **Other (please specify)**
3. Are you colour blind?	☐ **Yes** ☐ **No**
4. At which age were you diagnosed with this condition?	
5. Please indicate the type of navigational aid you use.	☐ **None** ☐ **Guide dog** ☐ **Symbol cane** ☐ **Long cane** ☐ **Other (please specify)**

4. Travel Behaviour	
1. On average how many times per week do you visit your nearest city centre?	Independently With Sighted Companion
2. Please give the name of this city or town centre	
3. In general what is the purpose of these visits? (Please tick all that apply)	☐ Shopping ☐ Meeting friends or family ☐ Bank /Post office ☐ Work ☐ Education ☐ Entertainment ☐ Sport

4. Would you like to make more independent visits to your nearest city or town centre?	☐ **Yes** ☐ **No**

5. Travel Behaviour

1. From the list below, please rate each of the following 10 factors which may prevent you from visiting the city centre ALONE, from 1 to 5 with 1 being the most influential and 5 the least influential.

Apprehension of using public transport alone

☐ **1** ☐ **2** ☐ **3** ☐ **4** ☐ **5**

Crowded streets

☐ **1** ☐ **2** ☐ **3** ☐ **4** ☐ **5**

Fear of getting lost

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Fear of personal safety

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Heightened stress levels

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Inaccessible pedestrian crossings

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Lack of accessible information (e.g. street signage)

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Lack of knowledge of the area ☐ **1** ☐ **2** ☐ **3** ☐ **4** ☐ **5**
Positioning of unexpected obstacles (e.g. road works) ☐ **1** ☐ **2** ☐ **3** ☐ **4** ☐ **5**
Problems walking along pavements ☐ **1** ☐ **2** ☐ **3** ☐ **4** ☐ **5**
2. From the list below, please rate each of the following features, which you may find problematic when walking along pavements with 1 being the most problematic and 5 the least problematic.
Type of street lighting ☐ **1** ☐ **2** ☐ **3** ☐ **4** ☐ **5**

Lack of tactile paving ☐ **1** ☐ **2** ☐ **3** ☐ **4** ☐ **5**
Misuse of tactile paving ☐ **1** ☐ **2** ☐ **3** ☐ **4** ☐ **5**
Unexpected level changes ☐ **1** ☐ **2** ☐ **3** ☐ **4** ☐ **5**
Lack of dropped kerbs ☐ **1** ☐ **2** ☐ **3** ☐ **4** ☐ **5**
Narrow pavements ☐ **1** ☐ **2** ☐ **3** ☐ **4** ☐ **5**
Varying kerb heights ☐ **1** ☐ **2** ☐ **3** ☐ **4** ☐ **5**

Type of paving

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Street furniture (e.g. bollards, bins, seating)

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Uneven paving

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

3. From the list below, please rate each of the following items of street furniture in terms of how hazardous you find them when walking along pavements, with 1 being the most hazardous and 5 the least hazardous.

Bollards

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Seating ☐ **1** ☐ **2** ☐ **3** ☐ **4** ☐ **5**
Lamp posts ☐ **1** ☐ **2** ☐ **3** ☐ **4** ☐ **5**
Signage ☐ **1** ☐ **2** ☐ **3** ☐ **4** ☐ **5**
Railings ☐ **1** ☐ **2** ☐ **3** ☐ **4** ☐ **5**
Bus stops ☐ **1** ☐ **2** ☐ **3** ☐ **4** ☐ **5**
Bins ☐ **1** ☐ **2** ☐ **3** ☐ **4** ☐ **5**

Telephone boxes

☐ **1** ☐ **2** ☐ **3** ☐ **4** ☐ **5**

Trees

☐ **1** ☐ **2** ☐ **3** ☐ **4** ☐ **5**

Outside dining areas

☐ **1** ☐ **2** ☐ **3** ☐ **4** ☐ **5**

6. Daylight and Weather	
1. Does the nature of your eye condition mean that you find it more difficult to travel at certain times of the day due to levels of natural light?	☐ **Yes** ☐ **No**
2. If yes, which time of day do you find it most difficult to travel due to levels of natural light? (Please tick all that apply)	☐ **I have no preference** ☐ **Dawn** ☐ **Morning** ☐ **Afternoon** ☐ **Evening** ☐ **Dusk** ☐ **Night-time**

3. Does the nature of your eye condition mean that you find it more difficult to travel under certain weather conditions?	☐ **Yes** ☐ **No**
4. If yes, please state under which weather conditions you find it most difficult to travel due to glare and the resulting appearance of the ground and objects (Please tick all that apply)	☐ **I have no preference** ☐ **Bright and Wet** ☐ **Bright and Dry** ☐ **Cloudy and Wet** ☐ **Cloudy and Dry** ☐ **Snow**

7. Colours	
1. Which colours do you find the easiest to identify within the built environment? (Tick all that apply)	☐ None, I am colour blind ☐ None, I have no vision ☐ Red ☐ Orange ☐ Yellow ☐ Green ☐ Blue ☐ White ☐ Black ☐ Silver
Comments	

2. Which colours do you find most difficult to identify within the built environment? **(Tick all that apply)**	☐ **None, I am colour blind** ☐ **None, I have no vision** ☐ **Red** ☐ **Orange** ☐ **Yellow** ☐ **Green** ☐ **Blue** ☐ **White** ☐ **Black** ☐ **Silver**
Comments	
3. If applicable, please indicate the two colours you feel best contrast each other under the following circumstance: Stair and Edge Strip (Nosing)	**Stair:** **Edge Strip:**

4. If applicable, please indicate the two colours you feel best contrast each other under the following circumstance: Pavement and Bollard.	**Pavement:** **Bollard:**
5. If applicable, please indicate the three colours you feel best contrast each other under the following circumstance: Pavement, Kerb and Road.	**Pavement:** **Kerb:** **Road:**

8. Further Study

It is planned that a further study will be carried out within the coming months which will investigate the movements of visually impaired individuals within Glasgow City Centre. In total the experiment should last no longer than 1 hour. The volunteers will be asked to walk between two well-known locations within a specified study area (this should take no longer than 20 minutes with the remainder of the time being used for briefing and debriefing sessions). At all times each volunteer will be accompanied by a sighted assistant.

It is a requirement for this further study that all volunteers were diagnosed with their eye condition after the age of 3. Furthermore all volunteers for this part of the study should be familiar with Glasgow City Centre.	
1. Would you be interested in taking part in this experiment?	☐ **Yes** ☐ **No**
9. Further Study	
The study area is located within Glasgow City Centre and is enclosed by Cathedral St to the North, High St to the East, Argyle St to the South and Buchanan St to the West. This area covers Queen St Station, George Sq, Merchant City and Trongate.	
1. Are you familiar with this area?	☐ **Yes** ☐ **No**

2. How confident would you be travelling independently in this area?	☐ **Very Confident** ☐ **Confident** ☐ **Slightly Confident** ☐ **Not Confident**
3. Contact details	Name: Email Address: Phone Number: (Optional)

4. Do you have any medical conditions (other than visual impairment) which may affect your ability to participate in the walking task? If yes, please specify.	☐ **Yes** ☐ **No** **If Yes (please specify):**

10. Thank You

Thank you for taking the time to fill out this questionnaire.

Your views and opinions are very important to us and can make a real difference.

For more information please visit:

www.urbanacuity.co.uk

Alternatively you can contact Urban Acuity by e-mail or telephone:

info@urbanacuity.co.uk

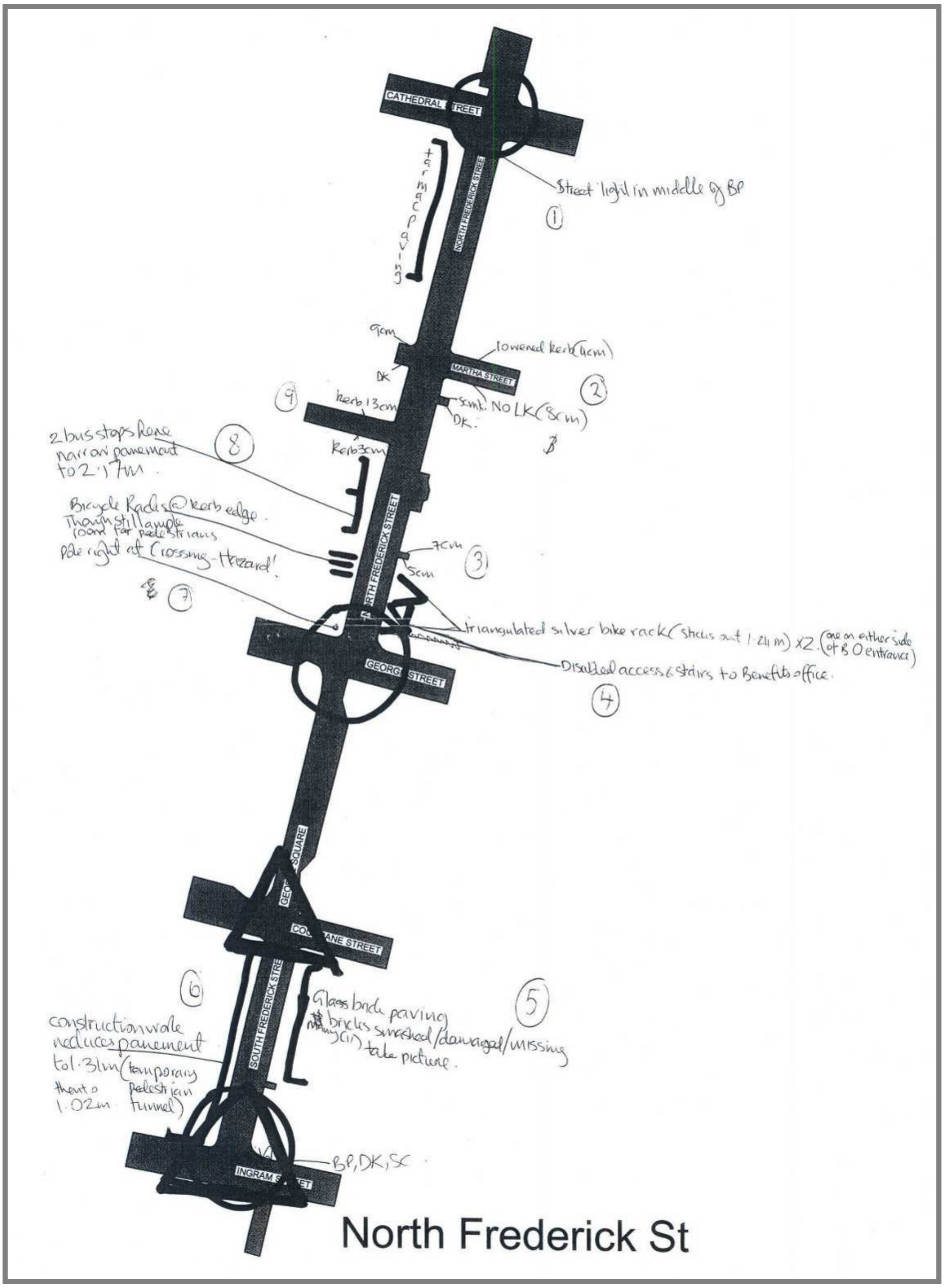
Tel: 07505 842 815

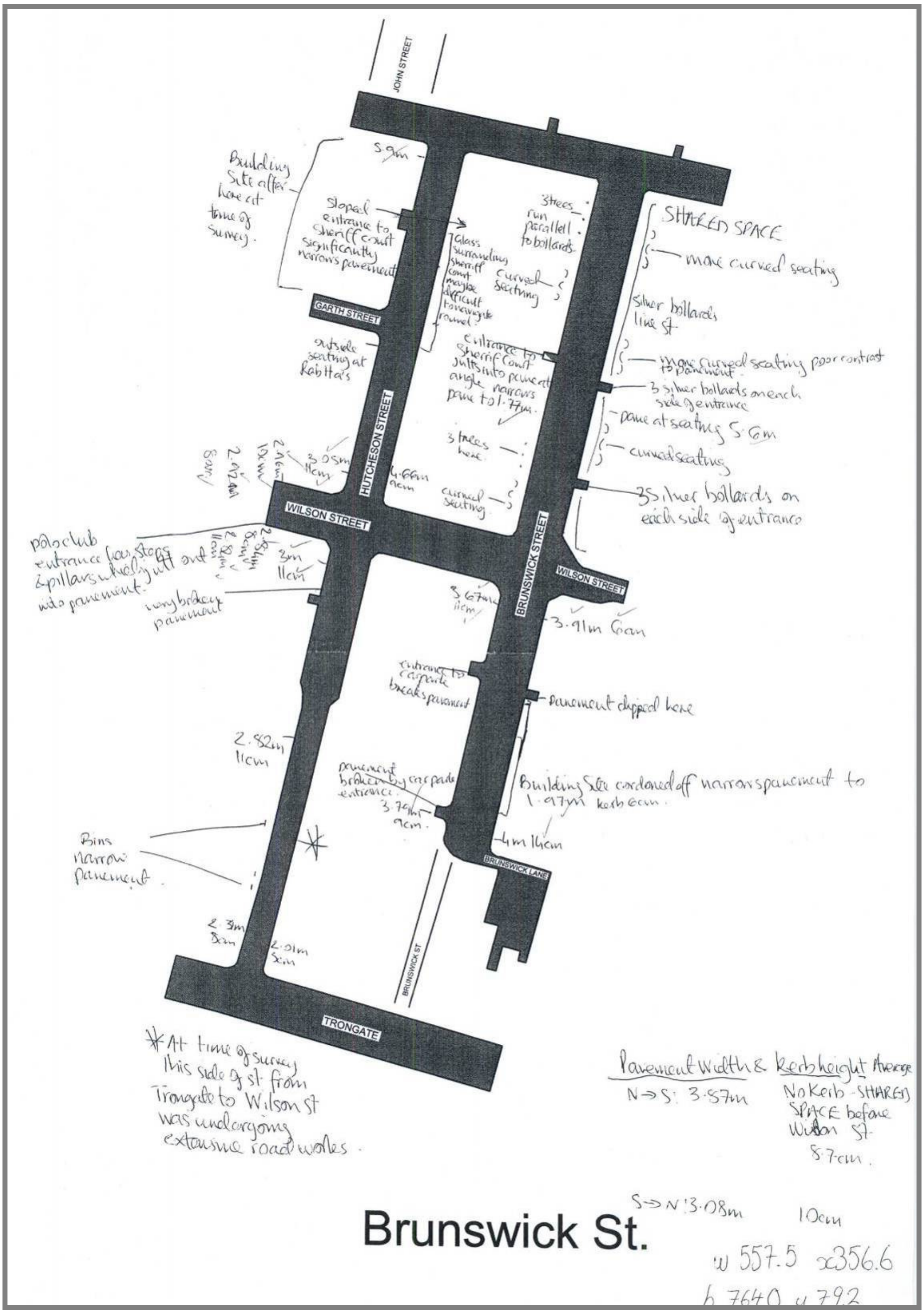
Appendix B: Access Audit Documentation

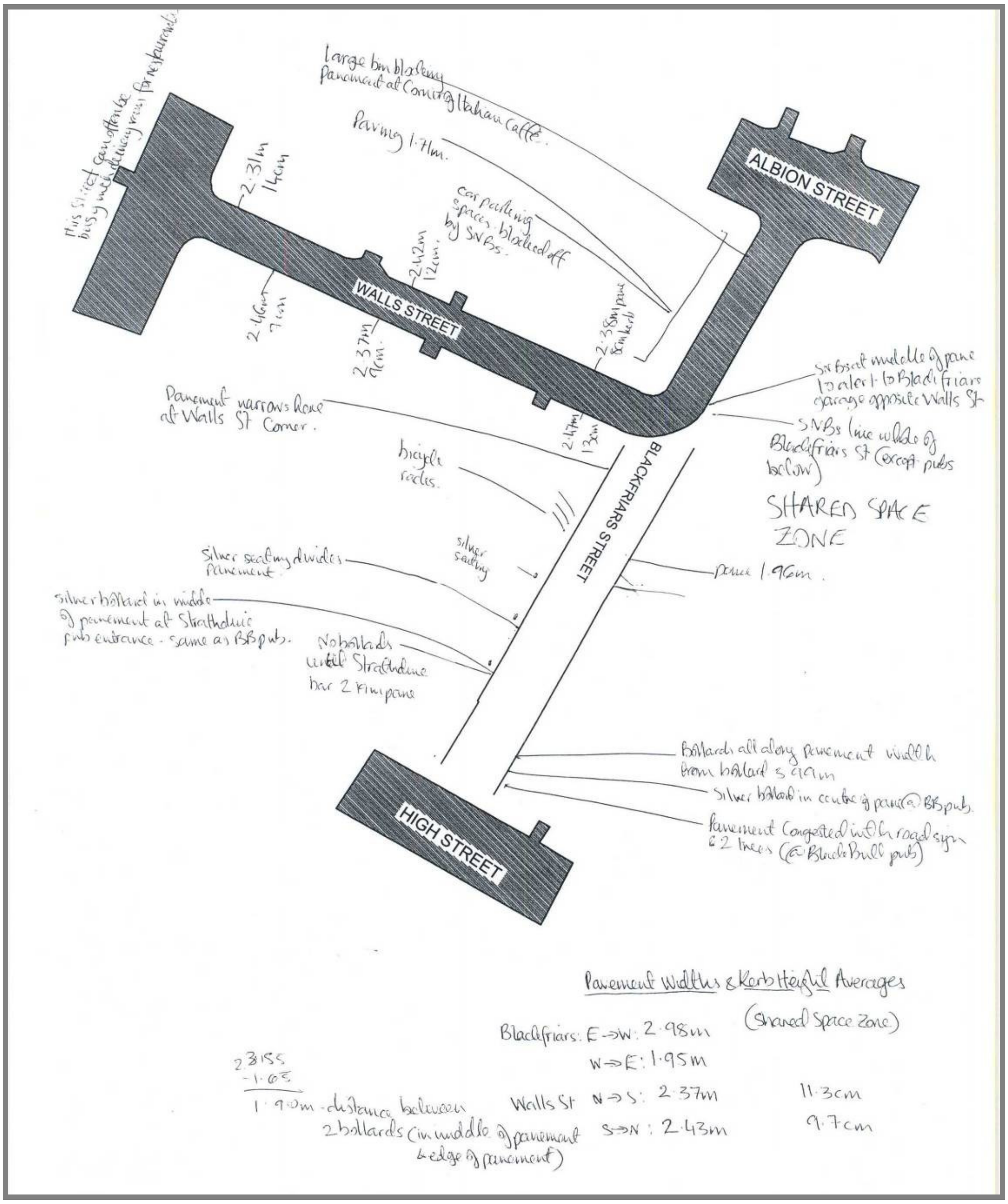
B.1. Audit of Streets (38)

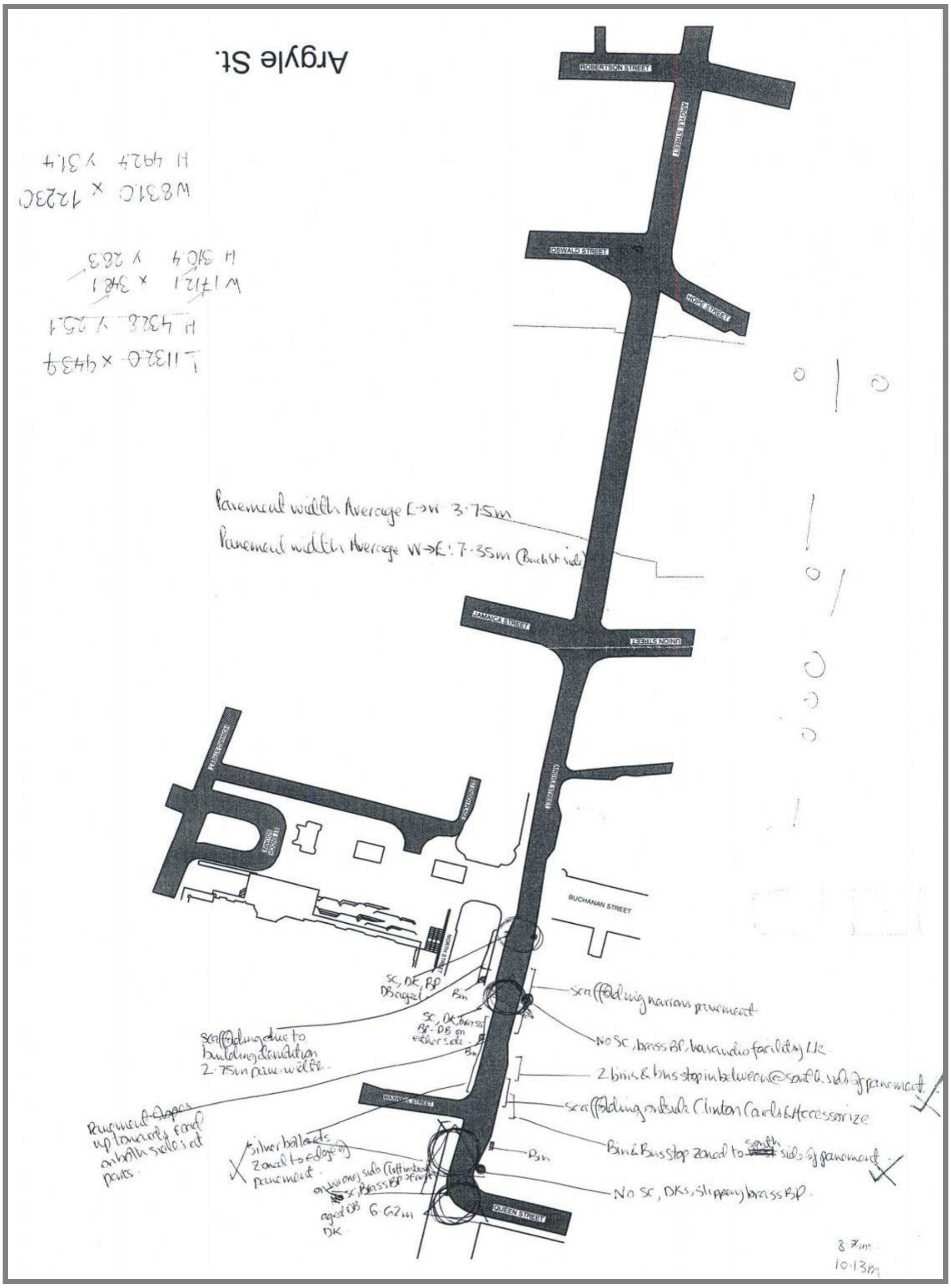
B.2. Average Pavement Width and Kerb Height Data Sheet

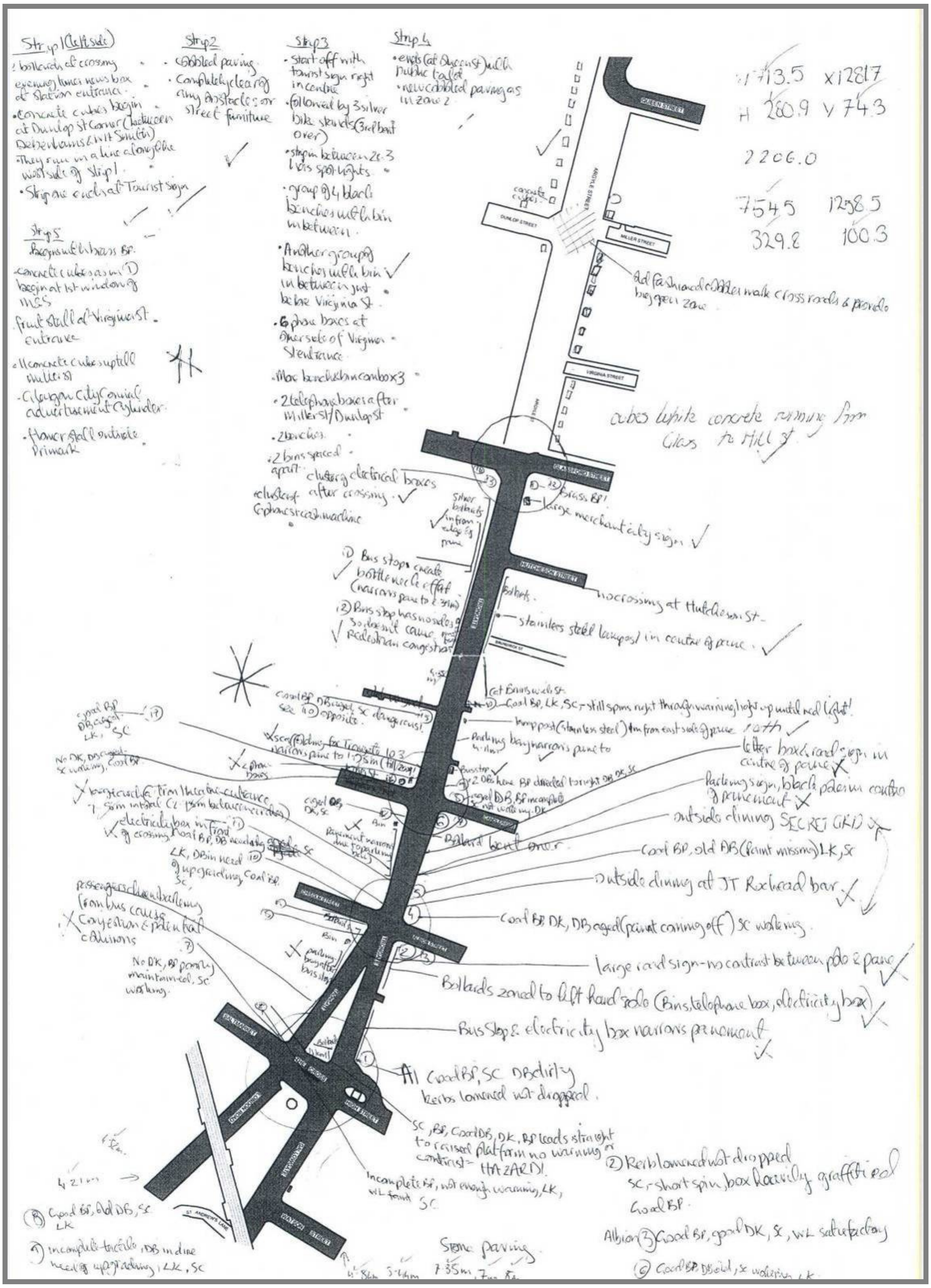
B.2. Audit of Streets

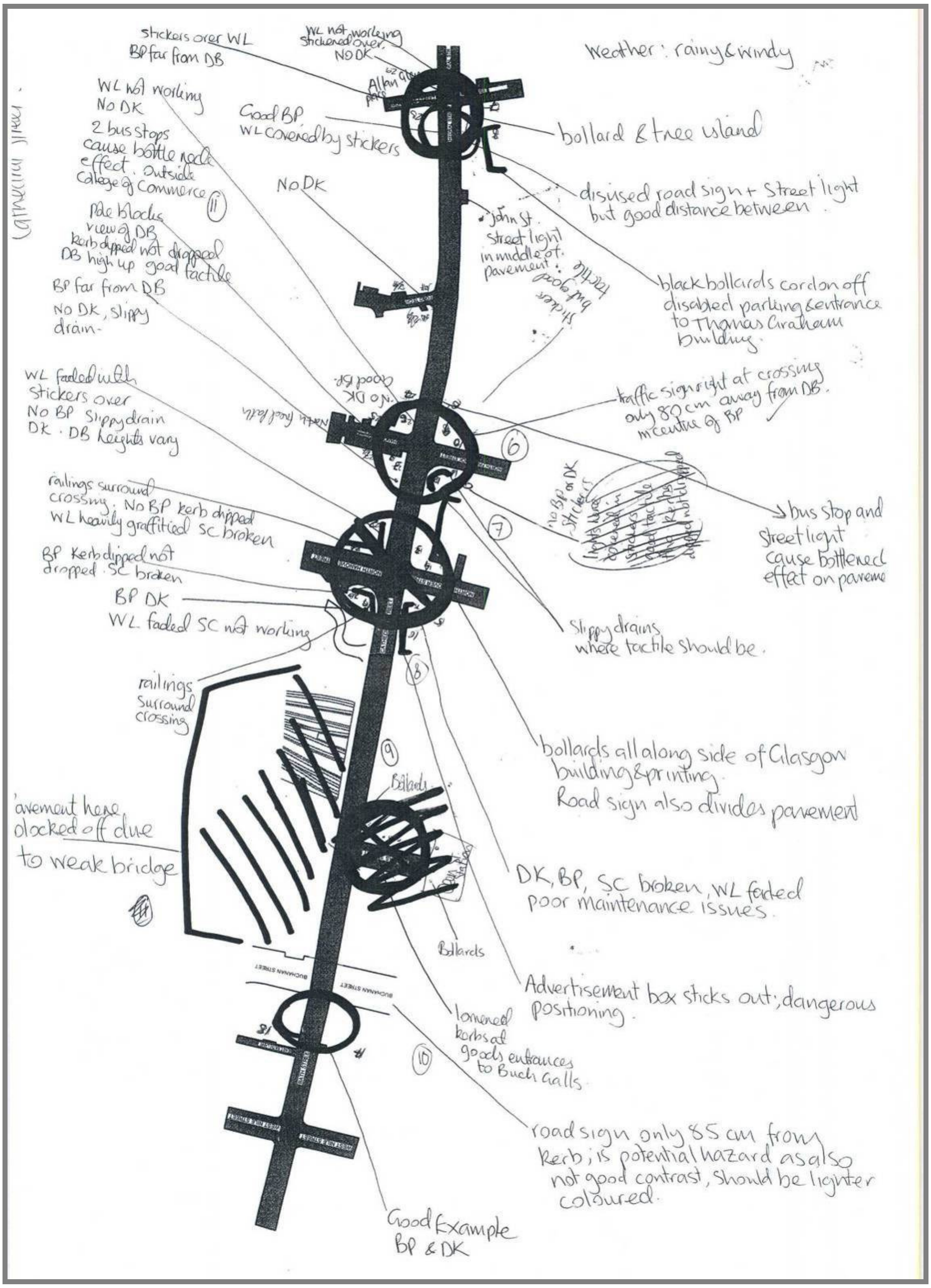


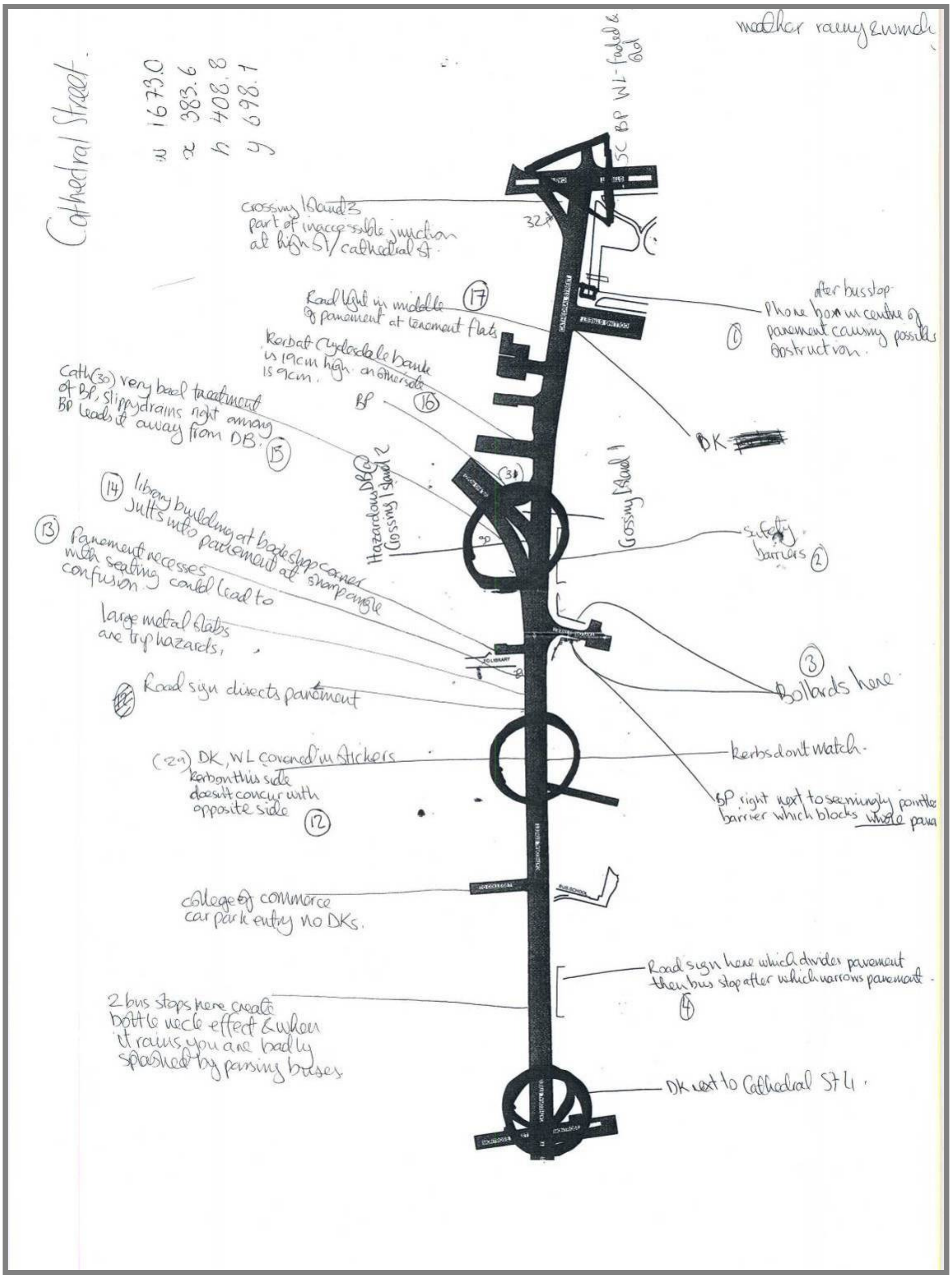

JOHN STREET
GARTH STREET
HUTCHESON STREET
WILSON STREET
BRUNSWICK STREET
WILSON STREET
BRUNSWICK LANE
BRUNSWICK ST
TRONGATE
SHARED SPACE
more curved seating
Silver bollards line st
3 silver bollards on each side of entrance
3 silver bollards on each side of entrance
curved seating
Pavement dipped here
Building site cordoned off narrows pavement to 1.97m kerb 6cm
4m 16cm
3.91m 6cm
Bins narrow pavement
* At time of survey this side of st from Trongate to Wilson St was undergoing extensive road works.
Pavement Width & Kerb height Average
N→S: 3.57m
No Kerb - SHARED SPACE before Wilson St. 8.7cm.
S→N 3.08m
10cm
Brunswick St.

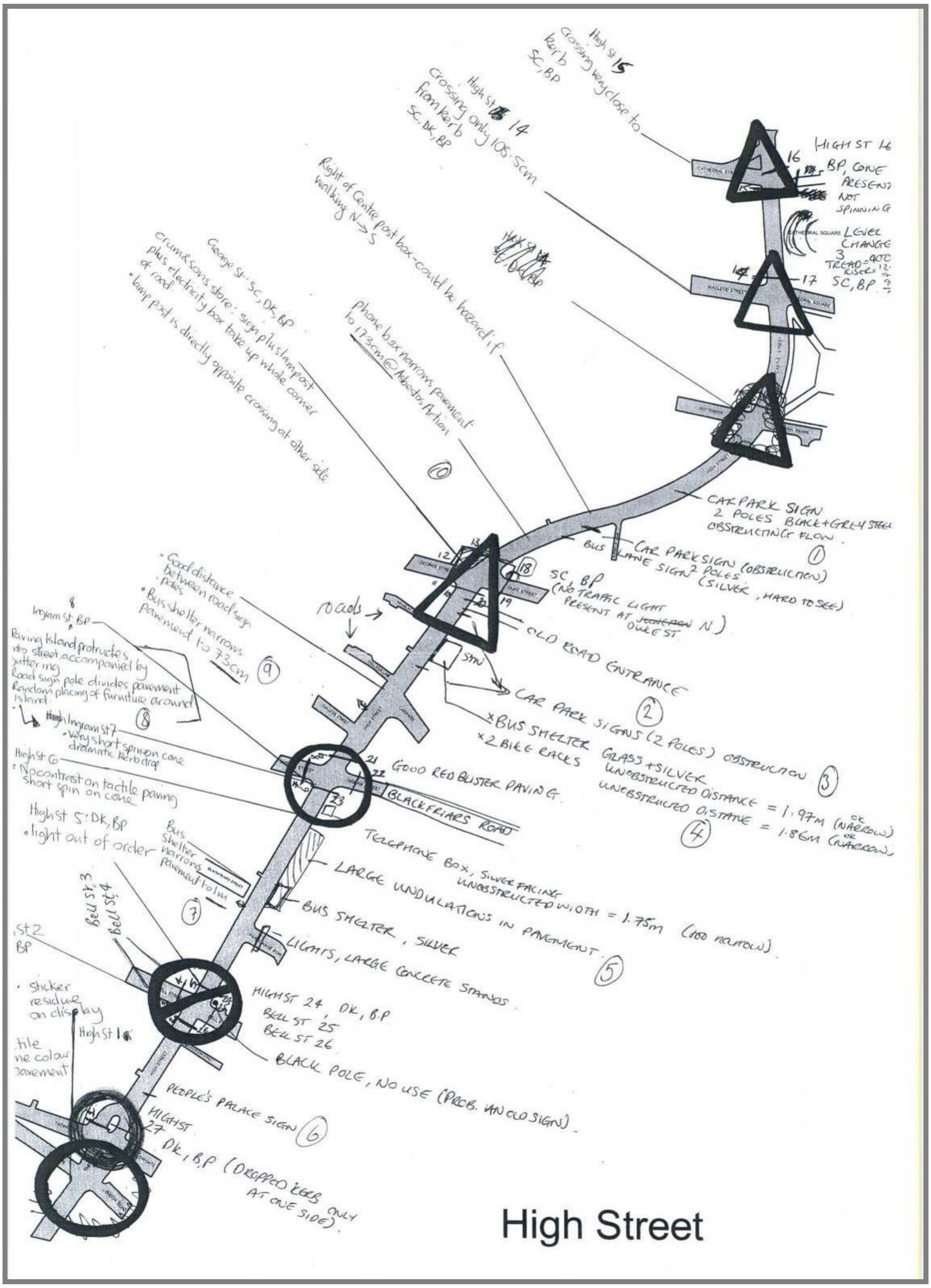

ALBION STREET
WALLS STREET
BLACKFRIARS STREET
HIGH STREET
SHARED SPACE ZONE
Pavement Widths & Kerb Height Averages
(Shared Space Zone)
Blackfriars: E→W: 2.98m
W→E: 1.95m
Walls St N→S: 2.37m 11.3cm
S→N: 2.43m 9.7cm


Argyle St.
ROBERTSON STREET
OSWALD STREET
HOPE STREET
Pavement width Average E→W 3·75m
Pavement width Average W→E: 7·35m (Buch St side)
JAMAICA STREET
UNION STREET
BUCHANAN STREET
Scaffolding narrows pavement
Scaffolding outside Clinton Cards & Accessorize
Bin & Bus Stop zoned to South side of pavement
No SC, DKs, slippery brass BP.
QUEEN STREET

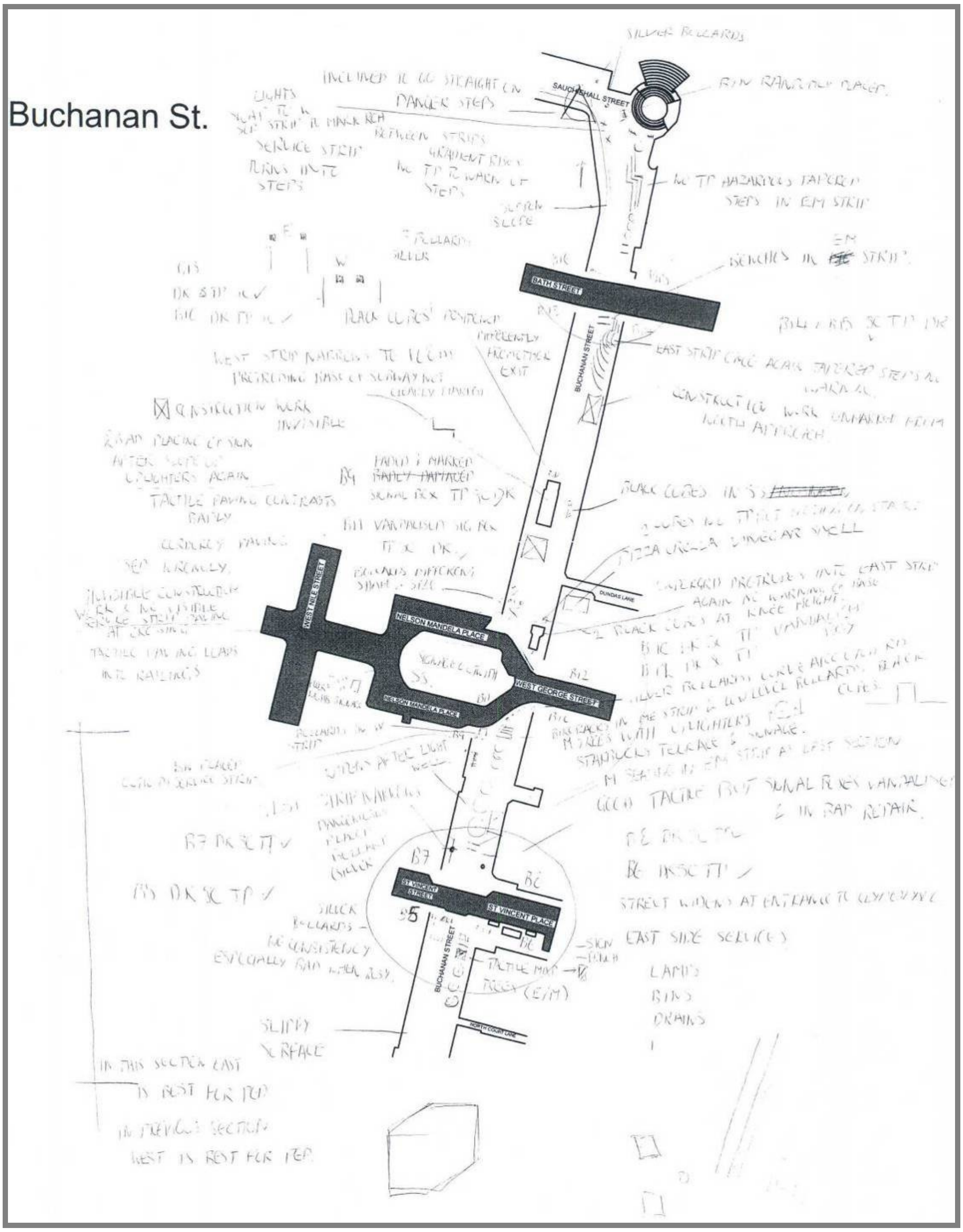

Strip 2
Strip 3
Strip 4
Strip 5
2206.0
7545
329.8
100.3
cubes white concrete running from Glas to Hill St
Bus Stop & electricity box narrows pavement
outside dining at JT Rochead bar
Stone paving

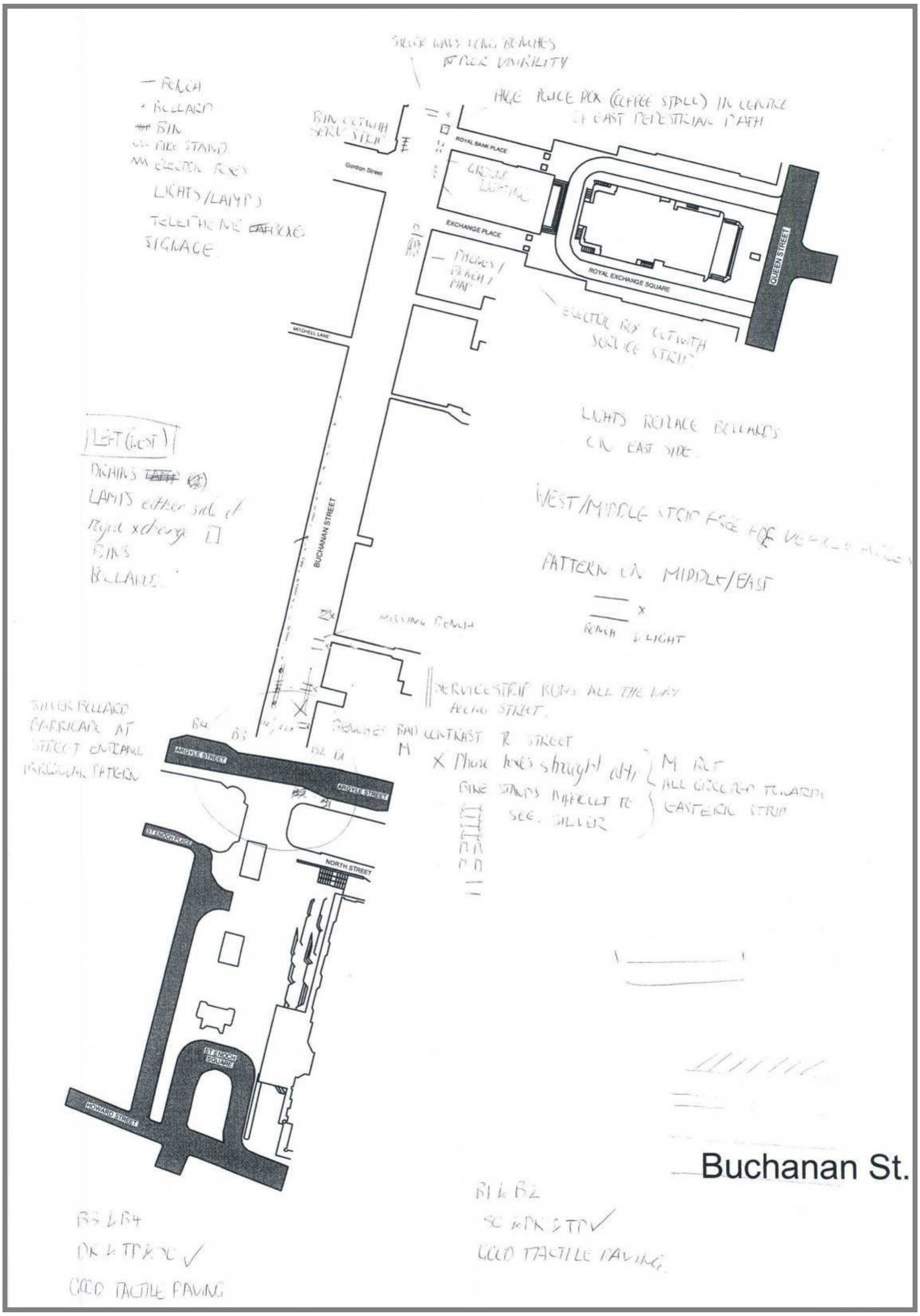

stickers over WL
BP far from DB
WL not working stickered over. NO DK
Weather: rainy & windy
WL not working
No DK
2 bus stops cause bottle neck effect. Outside College of Commerce
Good BP
WL covered by stickers
bollard & tree island
No DK
disused road sign + Street light but good distance between
John St. Street light in middle of pavement
Pole blocks view of DB
Kerb dipped not dropped
DB high up good tactile
BP far from DB
No DK, slippy drain.
black bollards cordon off disabled parking & entrance to Thomas Graham building.
WL faded with stickers over
No BP Slippy drain
DK. DB heights vary
Good BP
No DK
traffic sign right at crossing only 80 cm away from DB. in centre of BP
railings surround crossing. No BP kerb dipped
WL heavily graffitied SC broken
bus stop and Street light cause bottlened effect on paveme
BP Kerb dipped not dropped. SC broken
BP DK
WL faded SC not working
Slippy drains where tactile should be.
railings surround crossing
bollards all along side of Glasgow building & printing.
Road sign also divides pavement
Bollards
avement here blocked off due to weak bridge
DK, BP, SC broken, WL faded
poor maintenance issues.
Bollards
Advertisement box sticks out; dangerous positioning.
lowered kerbs at goods entrances to Buch Galls.
road sign only 85 cm from kerb; is potential hazard as also not good contrast, should be lighter coloured.
Good Example BP & DK

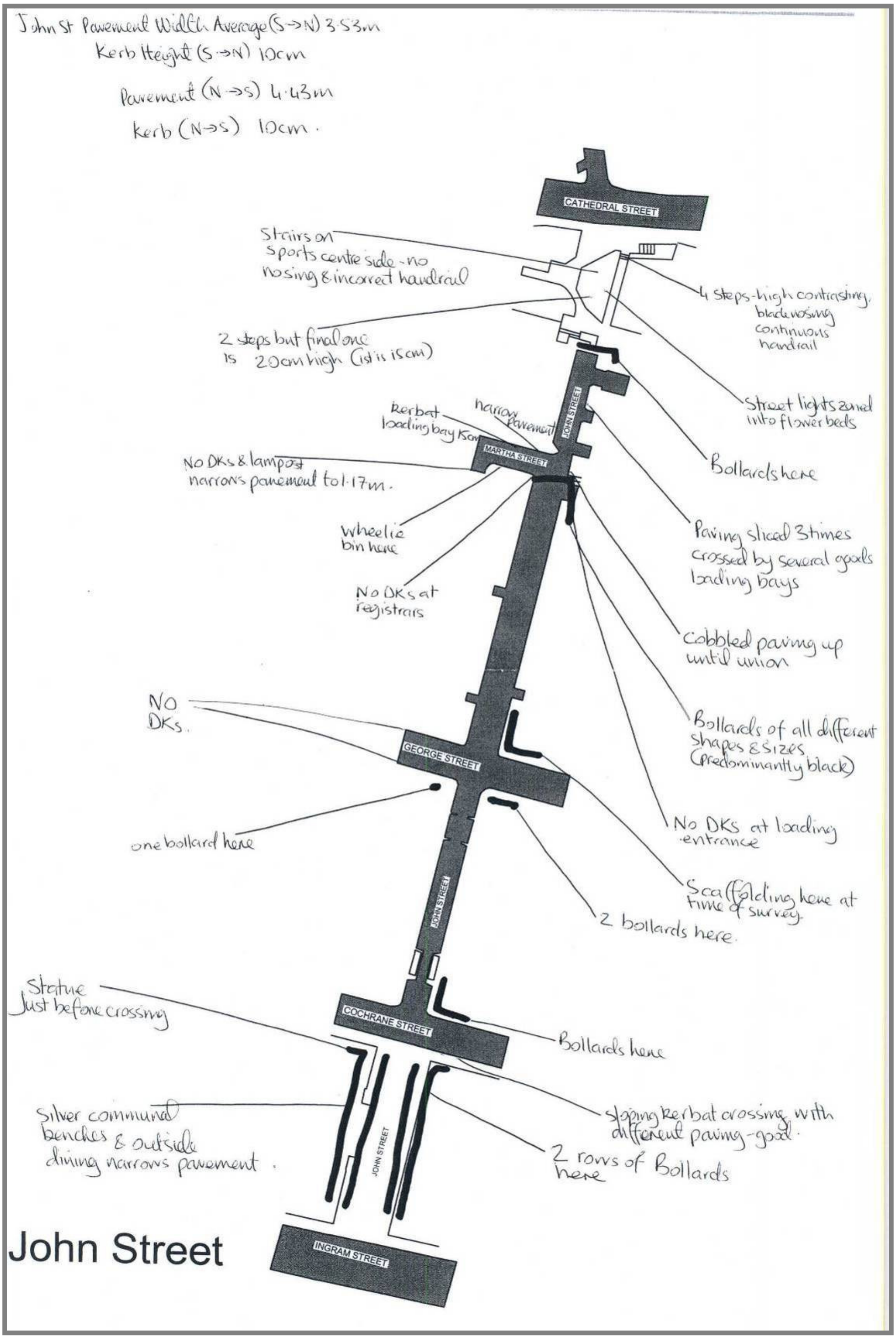


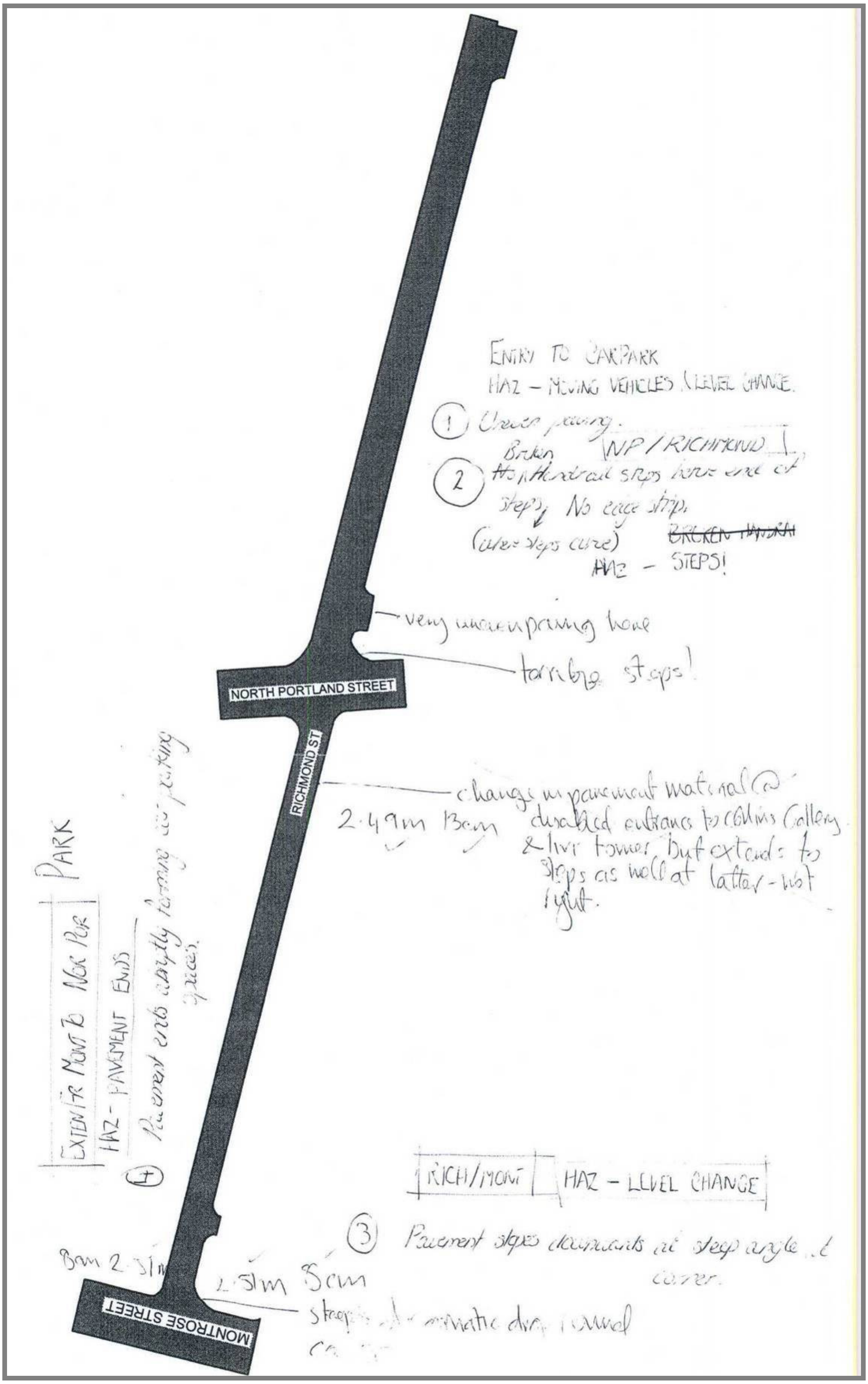


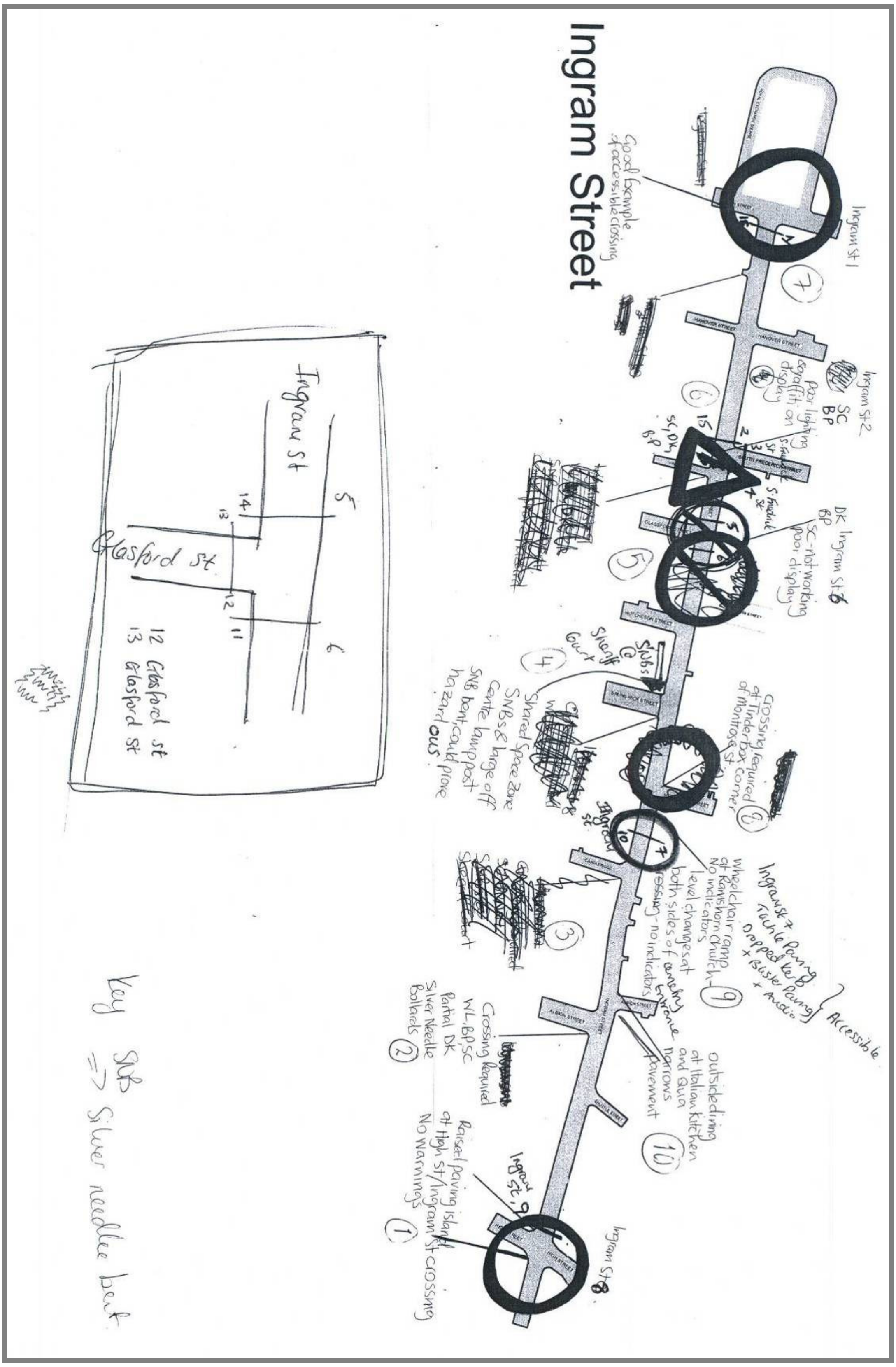
High Street

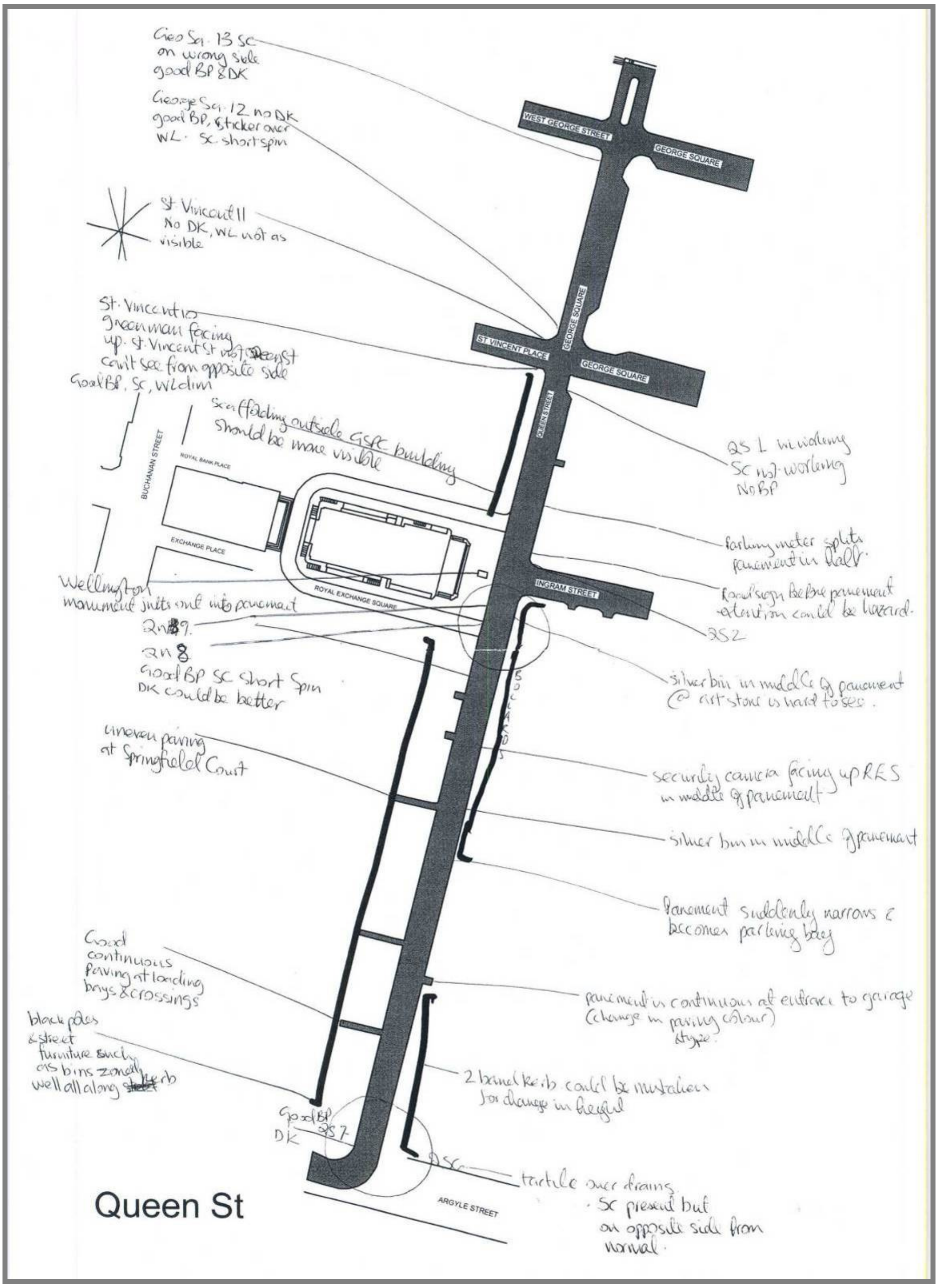

Buchanan St.
SAUCHIEHALL STREET
BATH STREET
BUCHANAN STREET
DUNDAS LANE
WEST NILE STREET
NELSON MANDELA PLACE
WEST GEORGE STREET
NELSON MANDELA PLACE
ST VINCENT STREET
ST VINCENT PLACE
BUCHANAN STREET
NORTH COURT LANE

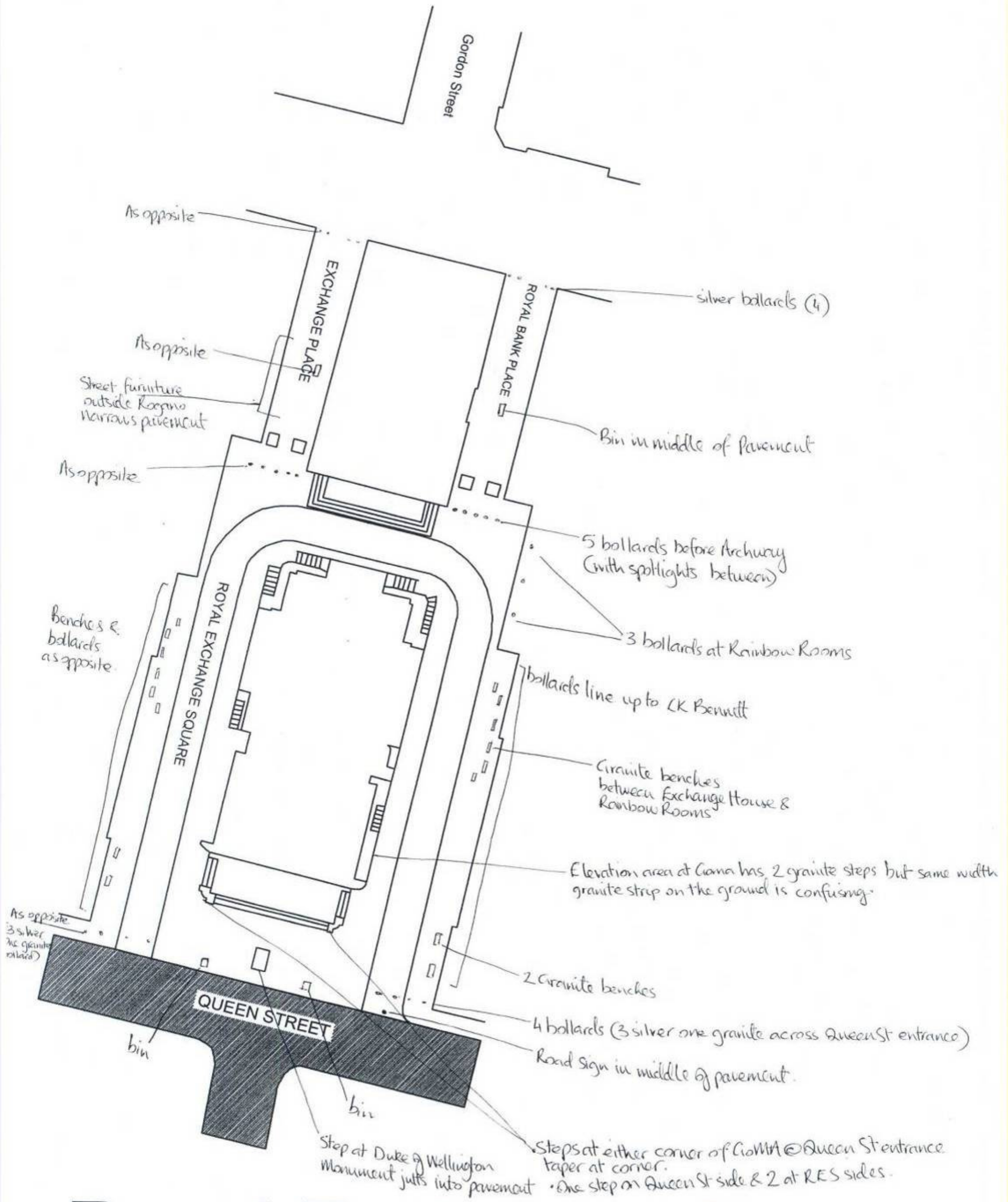

ROYAL BANK PLACE
Gordon Street
EXCHANGE PLACE
ROYAL EXCHANGE SQUARE
QUEEN STREET
MITCHELL LANE
BUCHANAN STREET
ARGYLE STREET
ST ENOCH PLACE
NORTH STREET
ST ENOCH SQUARE
HOWARD STREET
Buchanan St.
LIGHTS REPLACE BOLLARDS ON EAST SIDE
PATTERN ON MIDDLE/EAST
GOOD TACTILE PAVING


John St Pavement Width Average (S→N) 3.53m
Kerb Height (S→N) 10cm
Pavement (N→S) 4.43m
Kerb (N→S) 10cm.
CATHEDRAL STREET
Stairs on sports centre side - no nosing & incorrect handrail
4 steps - high contrasting black nosing continuous handrail
2 steps but final one is 20cm high (1st is 15cm)
Street lights zoned into flower beds
Kerbat loading bay 15cm
narrow pavement
JOHN STREET
MARTHA STREET
No DKs & lampost narrows pavement to 1.17m.
Bollards here
Wheelie bin here
Paving sliced 3 times crossed by several goods loading bays
No DKs at registrars
Cobbled paving up until union
NO DKs.
Bollards of all different shapes & sizes (predominantly black)
GEORGE STREET
one bollard here
No DKs at loading entrance
Scaffolding here at time of survey.
2 bollards here.
JOHN STREET
Statue just before crossing
COCHRANE STREET
Bollards here
Silver communal benches & outside dining narrows pavement.
Sloping kerbat crossing with different paving - good.
2 rows of Bollards here
JOHN STREET
John Street
INGRAM STREET

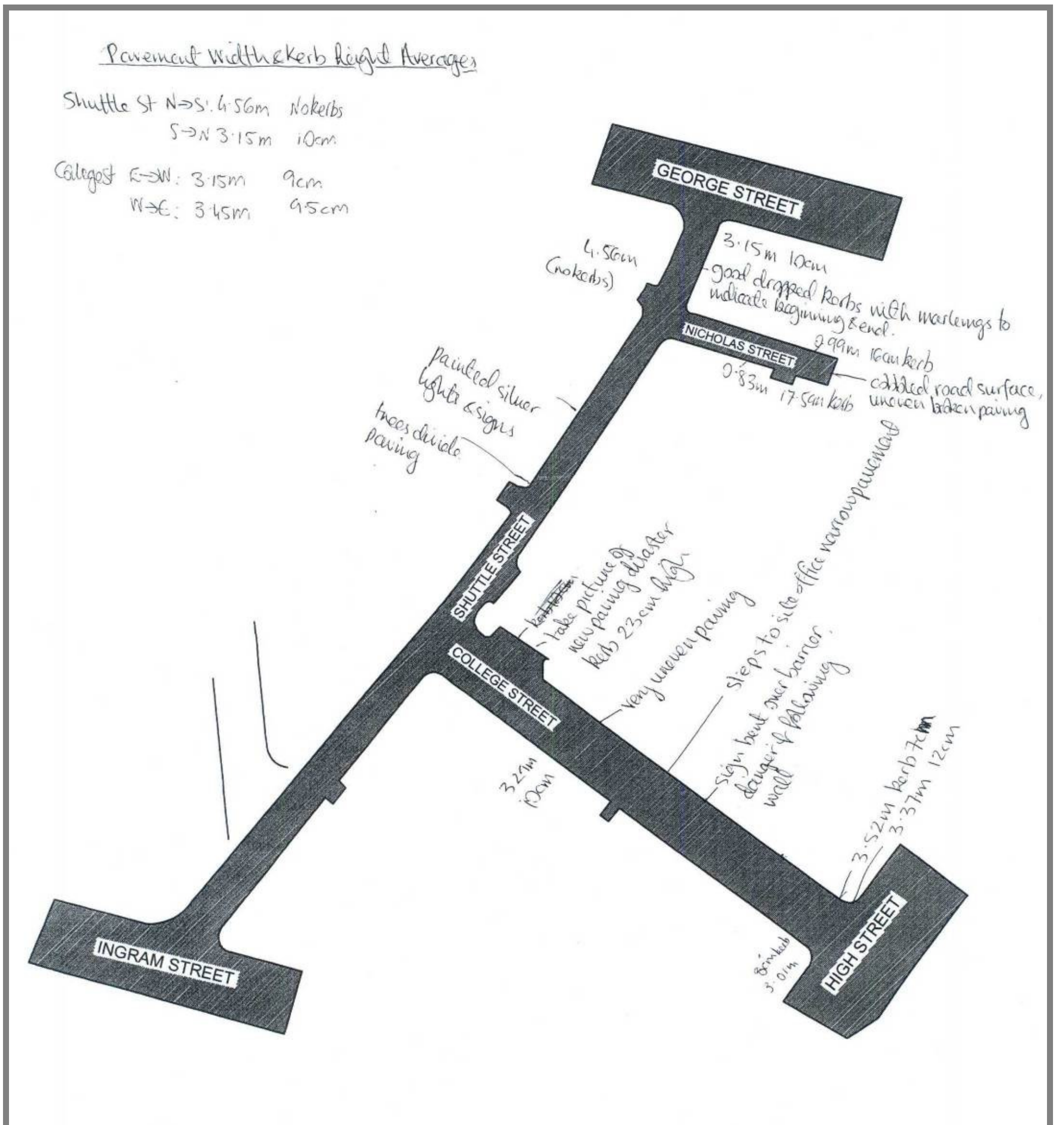

ENTRY TO CARPARK
NORTH PORTLAND STREET
RICHMOND ST
MONTROSE STREET
HAZ – STEPS!
terrible steps!
2.49m
PARK
HAZ - PAVEMENT ENDS
RICH/MONT
HAZ – LEVEL CHANGE
2.51m


Ingram Street
Ingram St
Glasford St
12 Glasford st
13 Glasford st
Key SNB => Silver needle bent

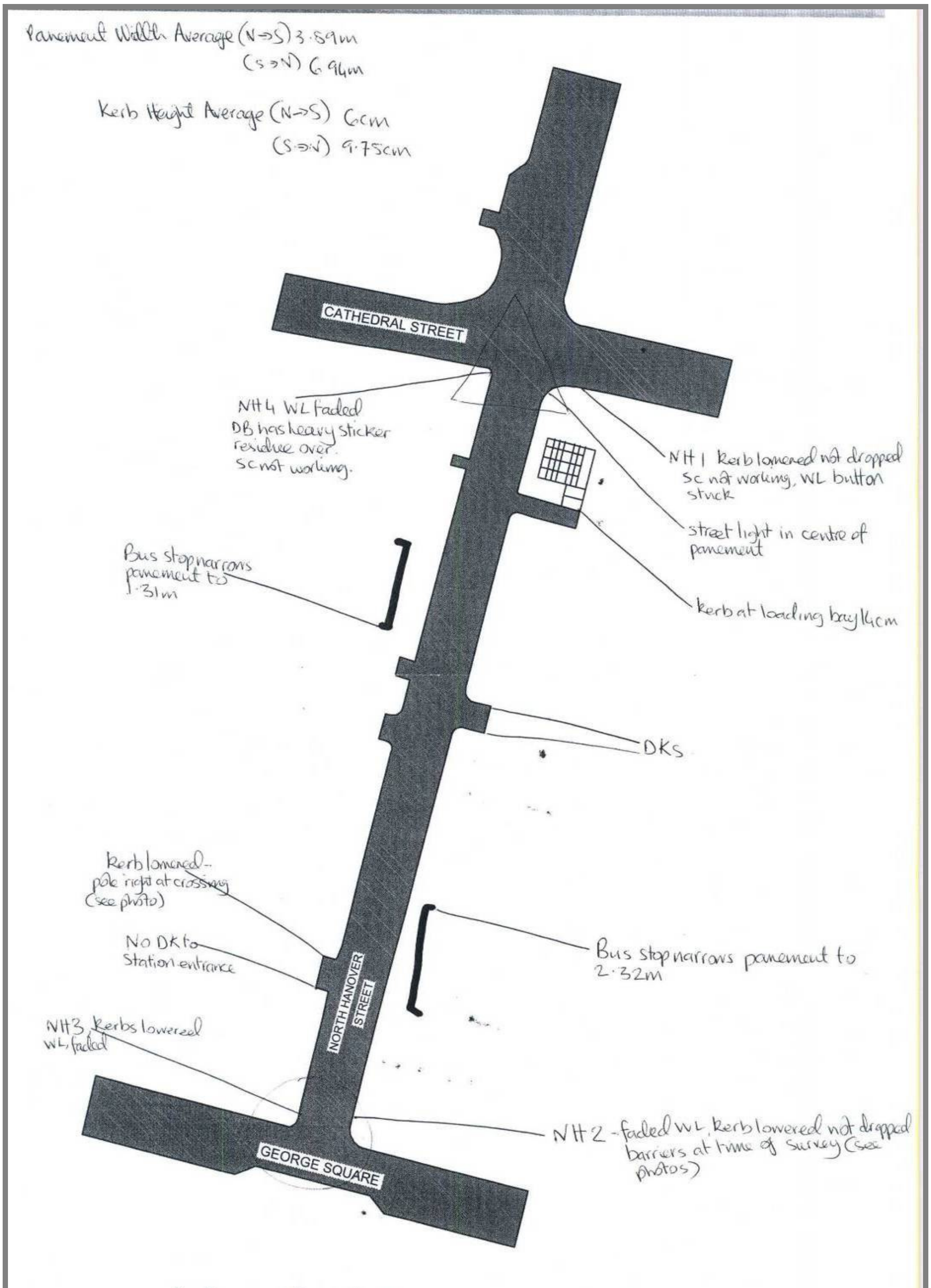

Geo Sq. 13 SC
on wrong side
good BP & DK
George Sq. 12 no DK
good BP, sticker over
WL. SC short spin
St Vincent 11
No DK, WL not as
visible
St. Vincent 10
green man facing
up. St. Vincent St not Queen St
can't see from opposite side
Good BP, SC, WL dim
Scaffolding outside GSPC building
should be more visible
WEST GEORGE STREET
GEORGE SQUARE
ST VINCENT PLACE
QUEEN STREET
BUCHANAN STREET
ROYAL BANK PLACE
EXCHANGE PLACE
ROYAL EXCHANGE SQUARE
INGRAM STREET
ARGYLE STREET
Wellington
monument juts out into pavement
QN 9.
QN 8
Good BP SC Short Spin
DK could be better
uneven paving
at Springfield Court
Good
continuous
paving at loading
bays & crossings
black poles
& street
furniture such
as bins zoned
well all along kerb
Good BP
DK
QS 7
QS 1 WL working
SC not working
No BP
parking meter splits
pavement in half.
QS 2
silver bin in middle of pavement
@ art store is hard to see.
security camera facing up RES
in middle of pavement
silver bin in middle of pavement
Pavement suddenly narrows &
becomes parking bay
pavement is continuous at entrance to garage
(change in paving colour
& type)
tactile over drains
. SC present but
on opposite side from
normal.
Queen St



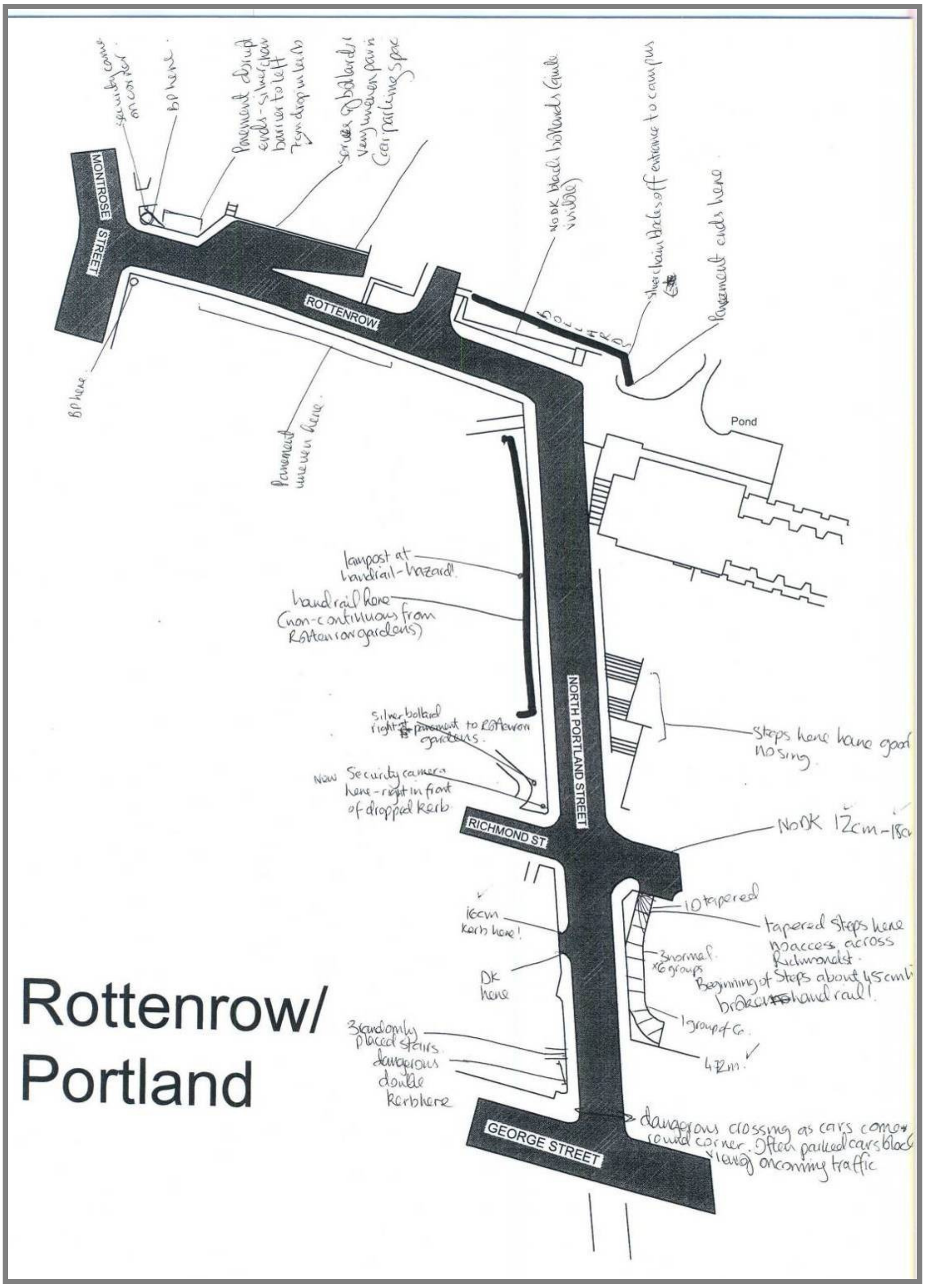
Royal Exchange Square

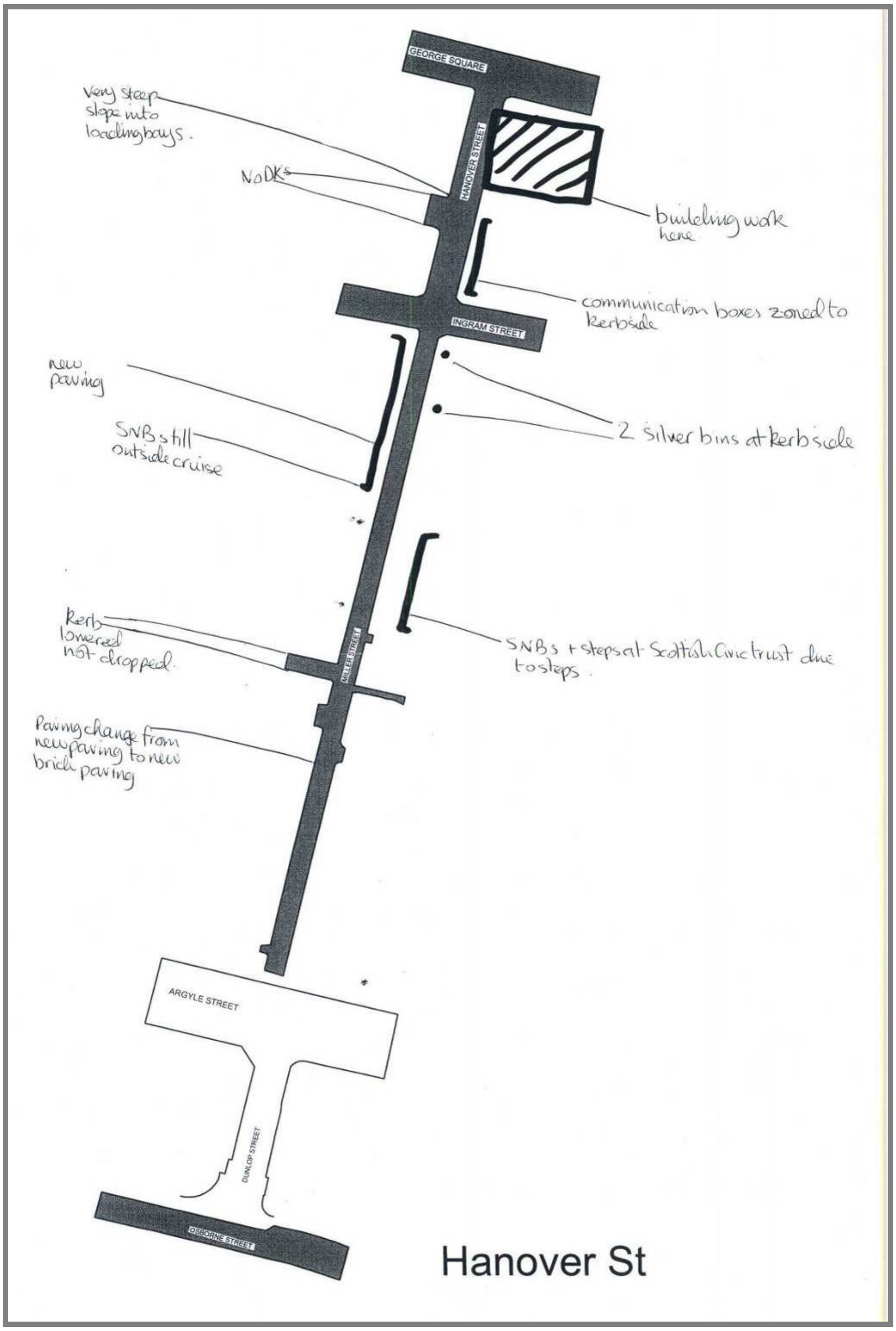


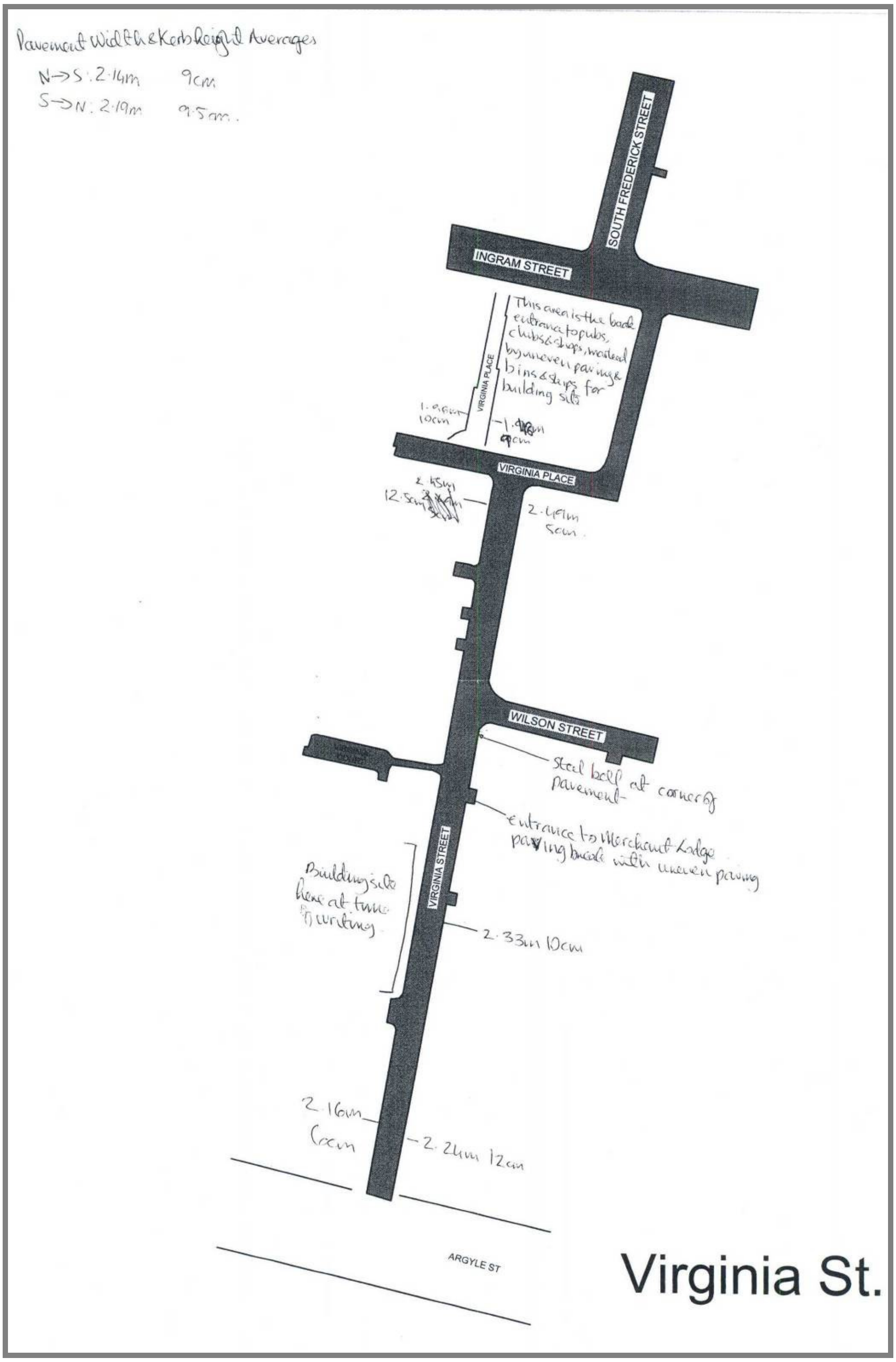
Shuttle/College St.

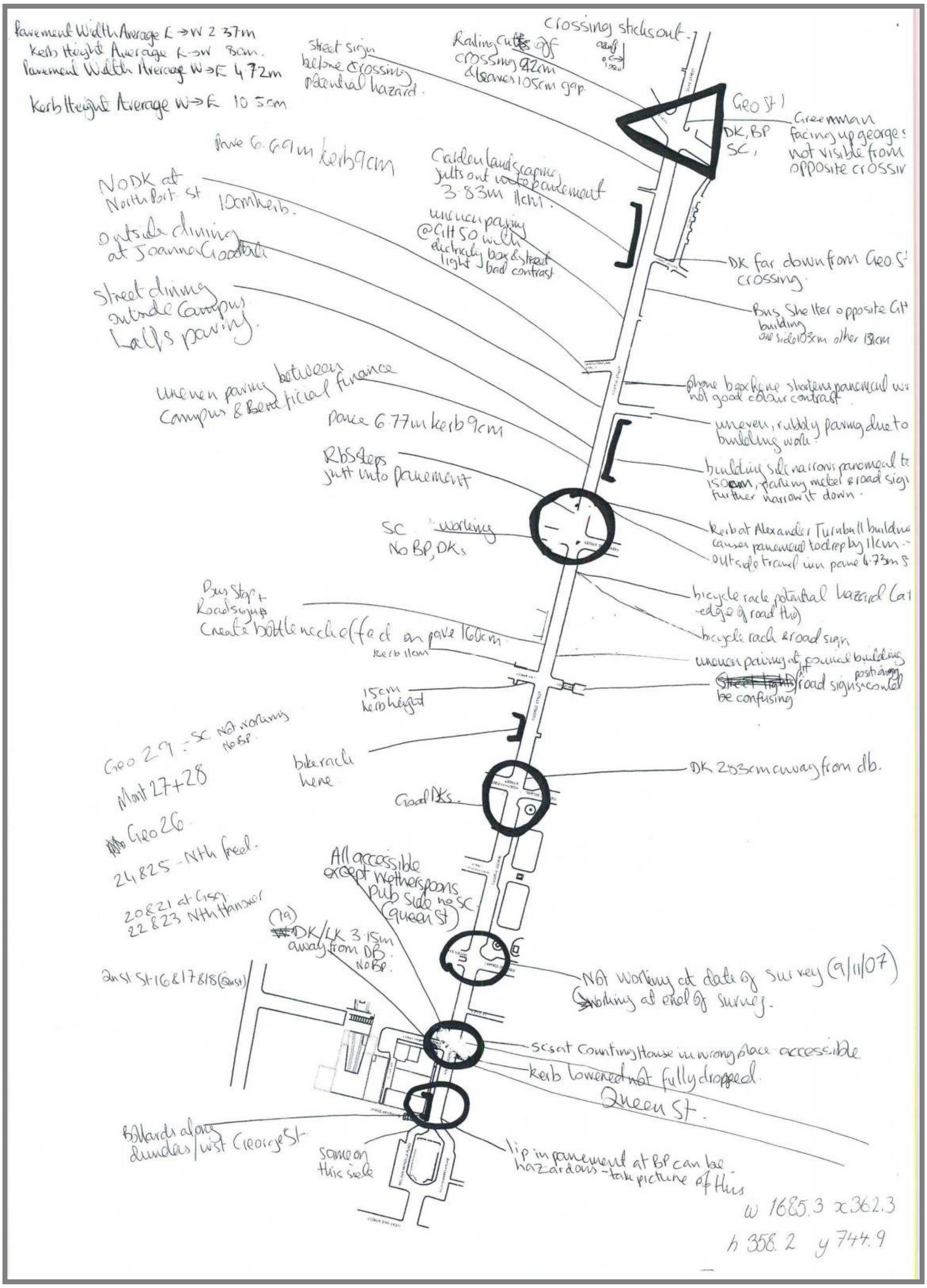


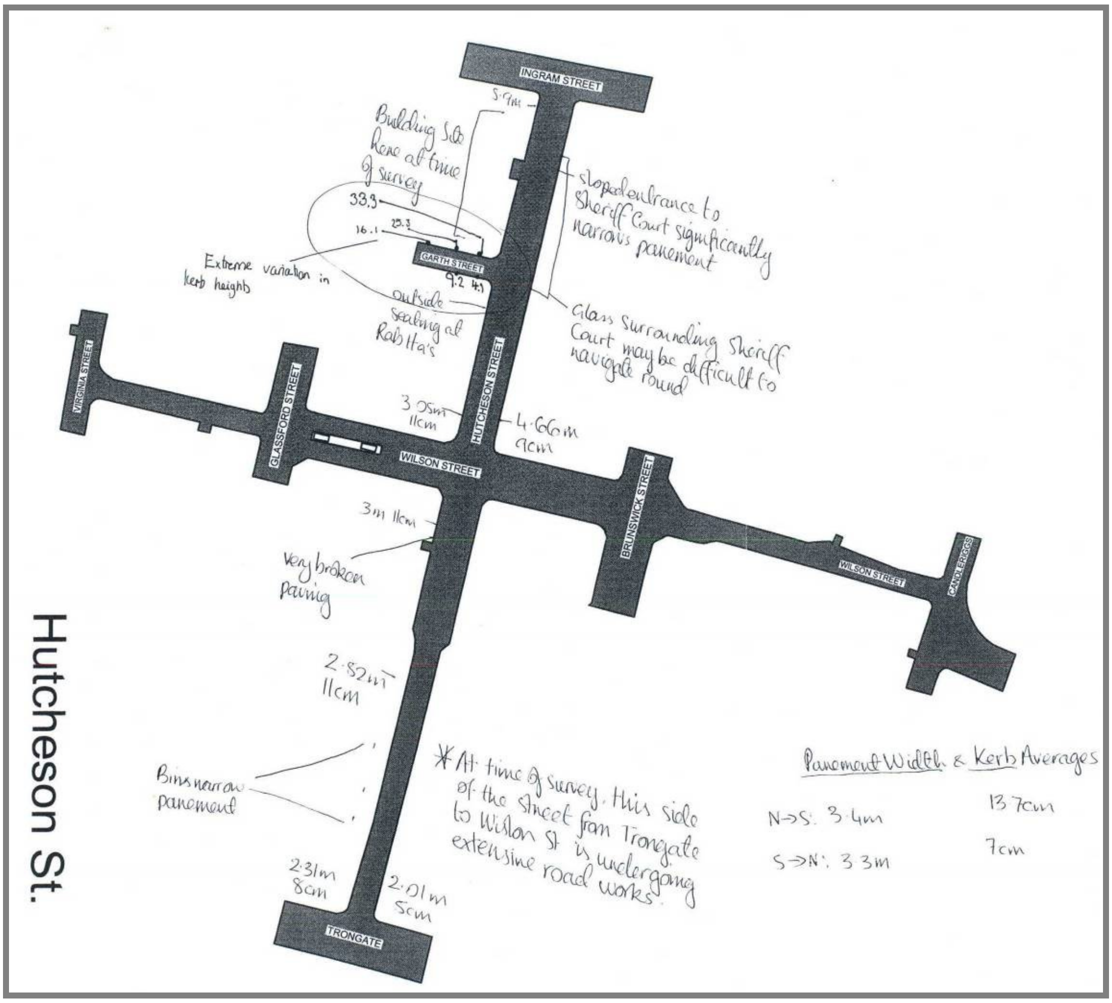
North Hanover St

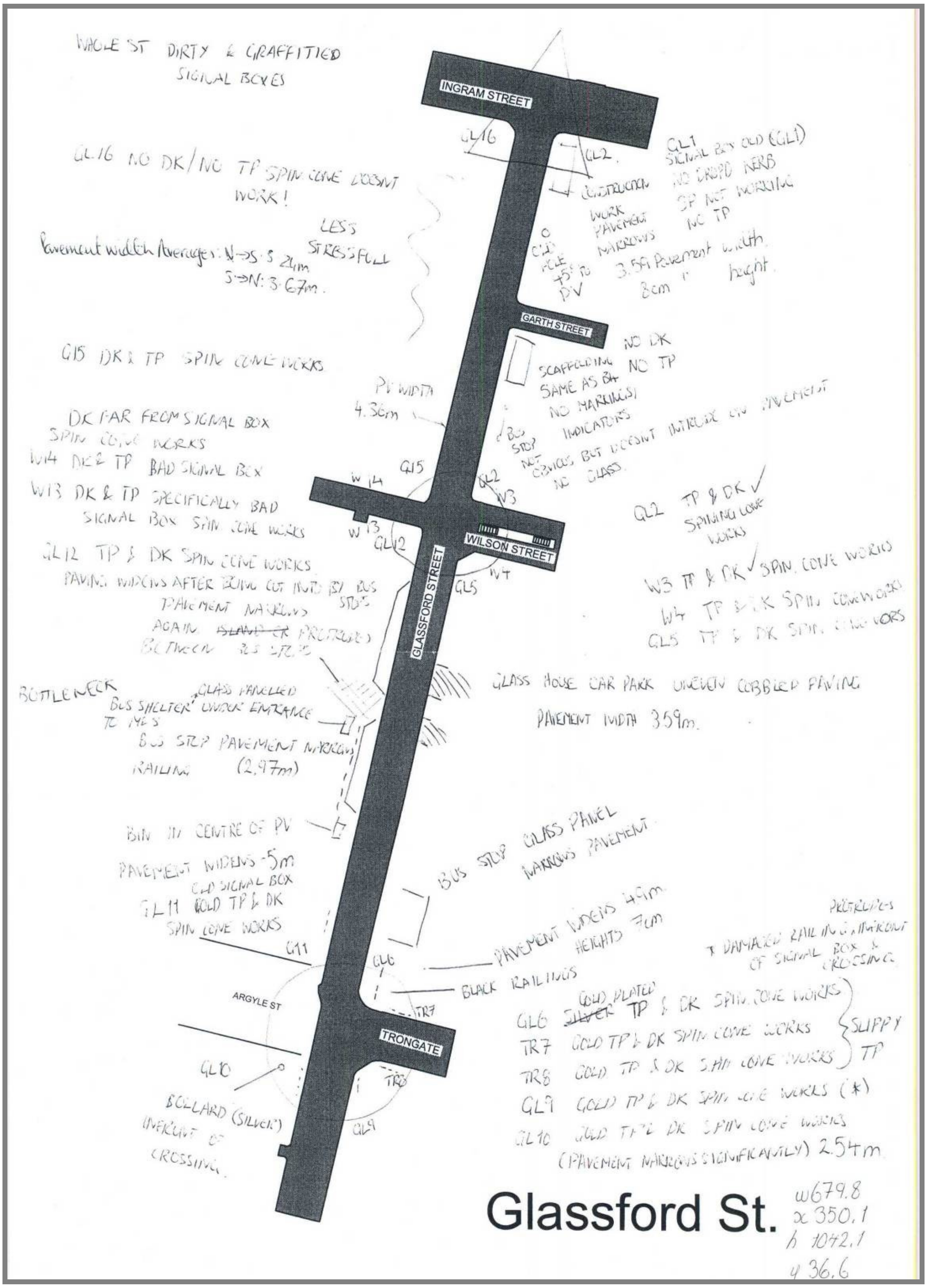

MONTROSE STREET
ROTTENROW
NORTH PORTLAND STREET
RICHMOND ST
GEORGE STREET
Pond
Rottenrow/
Portland
BP here
Pavement uneven here
lampost at handrail - hazard!
handrail here (non-continuous from Rottenrow gardens)
Steps here have good nosing
New Security camera here - right in front of dropped kerb
16cm kerb here!
DK here
tapered steps here no access across Richmond st.
dangerous double kerb here
dangerous crossing as cars come round corner. Often parked cars block view of oncoming traffic

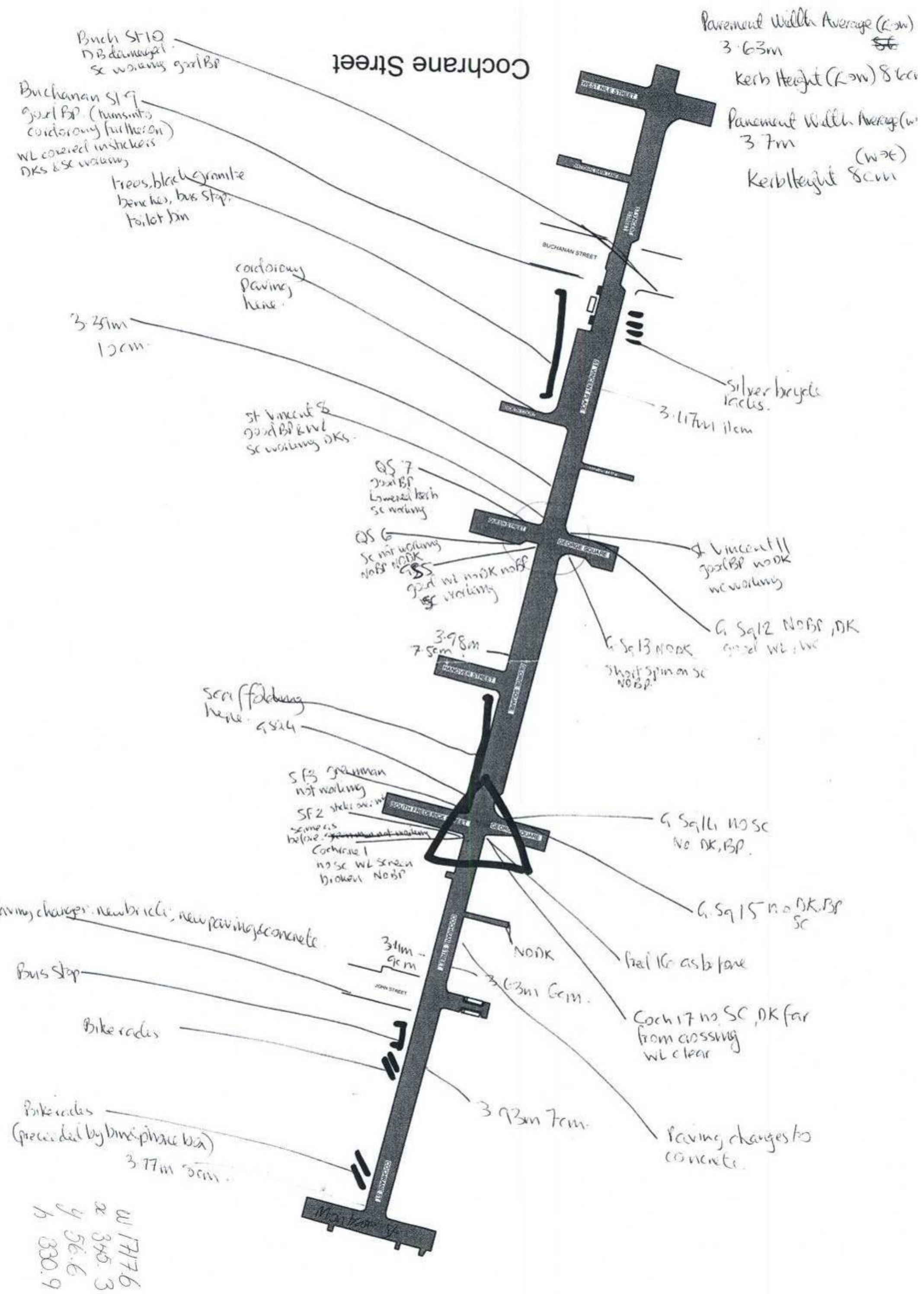

GEORGE SQUARE
HANOVER STREET
INGRAM STREET
MILLER STREET
ARGYLE STREET
DUNLOP STREET
OSBORNE STREET
Very steep slope into loading bays.
No DKs
building work here
communication boxes zoned to kerbside
new paving
SNBs still outside cruise
2 silver bins at kerbside
Kerb lowered not dropped.
SNBs + steps at Scottish Civic trust due to steps.
Paving change from new paving to new brick paving
Hanover St

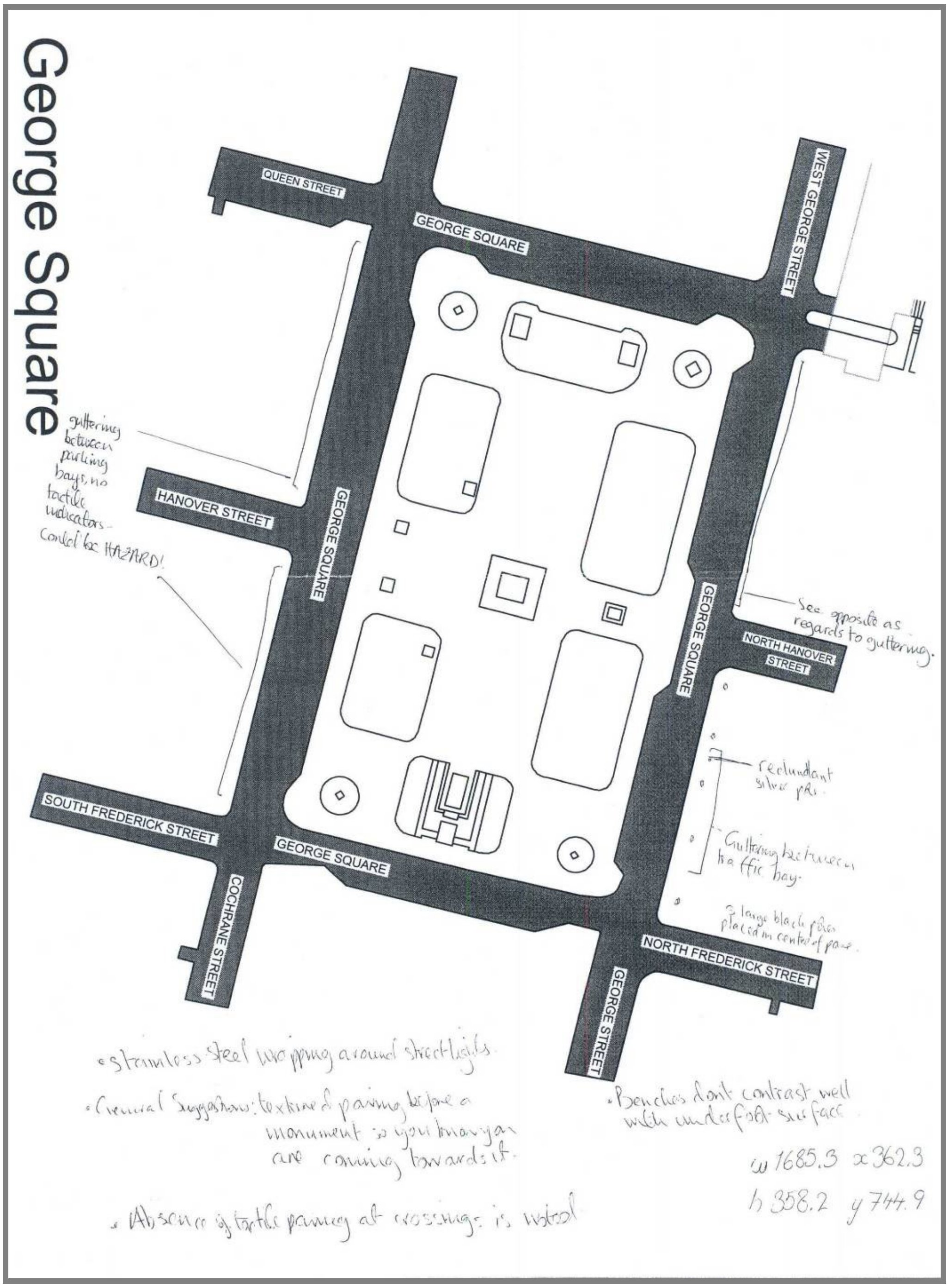

Pavement Width & Kerb Height Averages
N->S: 2.14m 9cm
S->N: 2.19m 9.5cm
SOUTH FREDERICK STREET
INGRAM STREET
This area is the back entrance to pubs, clubs & shops, marked by uneven paving, bins & skips for building site
VIRGINIA PLACE
VIRGINIA PLACE
2.49m 5cm
WILSON STREET
Steel bollard at corner of pavement
Entrance to Merchant Lodge paving break with uneven paving
VIRGINIA STREET
Building site here at time of writing
2.33m 10cm
2.16m 6cm
2.24m 12cm
ARGYLE ST
Virginia St.


Pavement Width Average E→W 2.37m
Kerb Height Average E→W 8cm
Pavement Width Average W→E 4.72m
Kerb Height Average W→E 10.5cm
Street sign before crossing potential hazard.
Crossing sticks out.
Geo St
Greenman facing up george st not visible from opposite crossing
DK, BP SC,
Pave 6.69m kerb 9cm
No DK at North Port St
10cm kerb
Outside dining at Joanna Goodtalk
Street dining outside Campus
Lalfs paving
DK far down from Geo St crossing.
Bus Shelter opposite GH building
uneven paving between Campus & Beneficial finance
Pave 6.77m kerb 9cm
RBS steps jutt into pavement
uneven, rubbly paving due to building work
SC working No BP, DKs
Bus Stop + Roadsign Create bottleneck effect on pave 160cm kerb 11cm
15cm kerb height
bicycle rack & road sign
bikerack here
Good DKs.
DK 283cm away from db.
Geo 29 - SC Not working No BP
Mont 27+28
Geo 26
24,825 - Nth Fred.
All accessible except Wetherspoons Pub side no SC (Queen St)
DK/LK 3.15m away from DB. No BP.
Not working at date of survey (9/11/07)
Working at end of survey.
kerb lowered not fully dropped
Queen St.
Bollards along dundas/west George St
same on this side
lip in pavement at BP can be hazardous - take picture of this
w 1685.3 x 362.3
h 358.2 y 744.9


INGRAM STREET
GARTH STREET
HUTCHESON STREET
VIRGINIA STREET
GLASSFORD STREET
WILSON STREET
BRUNSWICK STREET
WILSON STREET
CANDLERIGGS
TRONGATE
Hutcheson St.
Building Site here at time of survey
Sloped entrance to Sheriff Court significantly narrows pavement
Extreme variation in kerb heights
Outside seating at Rab Ha's
Glass surrounding Sheriff Court may be difficult to navigate round
3.05m 11cm
4.66m 9cm
3m 11cm
Very broken paving
2.82m 11cm
Bins narrow pavement
2.31m 8cm
2.01m 5cm
*At time of survey this side of the street from Trongate to Wilson St is undergoing extensive road works.
Pavement Width & Kerb Averages
N->S: 3.4m 1.37cm
S->N: 3.3m 7cm


INGRAM STREET
GARTH STREET
WILSON STREET
GLASSFORD STREET
ARGYLE ST
TRONGATE
Glassford St.
WHOLE ST DIRTY & GRAFFITIED SIGNAL BOXES
GL16 NO DK/NO TP SPIN CONE DOESNT WORK!
LESS STRESSFULL
GL5 DK & TP SPIN CONE WORKS
DK FAR FROM SIGNAL BOX
GL12 TP & DK SPIN CONE WORKS
BOTTLENECK
BUS STOP PAVEMENT NARROWS
RAILING (2.97m)
BIN IN CENTRE OF PV
PAVEMENT WIDENS -5m
GLASS HOUSE CAR PARK UNEVEN COBBLED PAVING
PAVEMENT WIDTH 3.59m
BUS STOP GLASS PANEL NARROWS PAVEMENT
GL2 TP & DK ✓
W3 TP & DK ✓ SPIN CONE WORKS
BLACK RAILINGS
GL6 GOLD PLATED TP & DK SPIN CONE WORKS
TR7 GOLD TP & DK SPIN CONE WORKS
GL9 GOLD TP & DK SPIN CONE WORKS (*)
BOLLARD (SILVER)
w679.8
x350.1
h 1042.1
y 36.6


Cochrane Street
Pavement Width Average (C→W) 3.63m
Kerb Height (C→W) 8cm
Pavement Width Average (W→E) 3.7m
Kerb Height (W→E) 8cm
Buch St 10 DB damaged SC working good BP
Buchanan St 9 good BP (turns into corduroy further on) WL covered in stickers DKs & SC working
trees, black granite benches, bus stop, toilet bin
corduroy paving here
3.25m 12cm
Silver bicycle racks
3.17m 11cm
St Vincent St 8 good BP & WL SC working DKs
QS 7 good BP Lowered kerb SC working
QS 6 SC not working No BP No DK
St Vincent 11 good BP no DK WL working
G Sq 12 No BP, DK good WL
G Sq 13 No DK Short spin on SC No BP
3.98m 7.5cm
Scaffolding here
G Sq 4
SF 3 green man not working
SF 2
Cochrane 1 no SC WL screen broken No BP
G Sq 14 no SC No DK, BP
G Sq 15 no DK, BP SC
Paving changes: new bricks, new paving & concrete
Bus Stop
Bike racks
Bike racks (preceded by bins/phone box)
3.77m 5cm
3.1m 9cm
NO DK
3.63m 6cm
Coch 17 no SC, DK far from crossing WL clear
3.93m 7cm
Paving changes to concrete
Montrose St
W 1777.6
x 385.3
y 56.6
b 830.9
WEST NILE STREET
BUCHANAN STREET
QUEEN STREET
GEORGE SQUARE
HANOVER STREET
SOUTH FREDERICK STREET
JOHN STREET
COCHRANE STREET


George Square
QUEEN STREET
GEORGE SQUARE
WEST GEORGE STREET
HANOVER STREET
GEORGE SQUARE
GEORGE SQUARE
NORTH HANOVER STREET
SOUTH FREDERICK STREET
GEORGE SQUARE
COCHRANE STREET
NORTH FREDERICK STREET
GEORGE STREET
See opposite as regards to guttering.
redundant
Guttering between traffic bay.
placed in centre of pave.
w 1685.3 x 362.3
h 358.2 y 744.9

B.2. Average Pavement Widths and Kerb Heights

Street No.	Streets	Pavement Widths Minimum	Pavement Widths Maximum	Pavement Widths Average	Kerb Height Minimum	Kerb Height Maximum	Kerb Height Average
1	Albion St	2.64	5.83	3.93	7.0	10.5	8.5
2	Argyle St	6.62	17.04	11.90	0.0	10.0	5.0
3	Bell St	2.99	5.60	4.06	6.0	10.0	8.2
4	Blackfriars St	1.95	2.98	2.38	0.0	0.0	0.0
5	Brunswick St	1.77	5.60	3.79	0.0	14.0	8.0
6	Buchanan St	1.68	21.17	16.67	0.0	0.0	0.0
7	Candleriggs	2.82	3.70	3.36	4.0	10.5	7.9
8	Cathedral St	2.77	4.38	3.43	9.0	19.0	12.6
9	Cochrane St	3.40	3.98	3.74	6.0	9.0	7.5
10	College St	3.13	3.90	3.58	12.0	24.5	17.6
11	Dundas St	1.87	7.50	4.49	5.0	12.0	9.2
12	N. Fredrick St	2.10	6.60	3.96	2.0	13.0	7.3
13	S. Fredrick St	3.16	6.35	4.30	5.5	12.5	8.8
14	Garth St	2.78	3.02	2.88	4.0	33.0	17.4
15	W./ George St	1.50	6.77	3.69	8.0	15.0	10.8
16	Glassford St	3.09	3.72	3.40	7.0	9.0	7.8
17	Hanover St	3.23	4.11	3.70	7.0	10.0	9.4
18	N. Hanover St	3.33	6.94	4.39	4.0	11.0	7.8
19	High St	0.73	3.59	2.46	4.5	13.0	9.6
20	Hutcheson St	2.01	5.90	3.69	5.0	11.0	8.8
21	Ingram St	3.38	4.11	3.70	5.0	9.0	7.9
22	John St	2.89	13.52	5.94	0.0	12.0	8.4
23	Martha St	1.57	2.15	1.84	4.0	10.0	7.1
24	Miller St	2.54	3.05	2.77	8.0	10.0	9.0
25	Montrose St	3.47	3.73	3.64	7.0	14.5	10.0
26	N. Portland St	1.72	2.61	2.21	4.0	10.0	7.6
27	Queen St	3.08	6.84	4.65	9.0	15.0	11.4
28	Richmond St	1.68	2.51	2.28	8.0	13.0	9.3
29	Rottenrow	1.96	2.90	2.36	1.0	8.5	5.6
30	Shuttle St	2.03	4.56	3.42	9.0	11.0	10.0
31	St. Vincent Place	3.39	8.50	5.42	9.5	11.0	10.2
32	Trongate	2.39	8.00	5.54	2.8	7.4	4.7
33	Virginia St	2.06	2.52	2.28	5.0	11.0	8.3
34	Walls St	2.31	2.47	2.41	1.0	16.0	10.0
35	Wilson St	1.88	5.60	3.42	3.0	12.0	8.0
		1.57	21.17	4.16	0.0	33.0	8.6
	Squares						
1	George Sq						
2	Royal Exchange Sq						

Appendix C: Navigational Experiment Documentation

C.1. Briefing Session

C.2. Consent Form

C.3. Stage One – Route Planning

C.4. Stage Two – Pointing Task

C.5. Stage Three – Debriefing Session

C.1. Briefing Session

Name: ______________________ Date: _____________

Start time: ___________________ Day: ______________

Weather condition: ____________________________________

Briefing information

So we're standing at the side entrance of Queen St Station on Dundas St. This will be the starting point. You will be asked to independently navigate (accompanied by me at all times), to the Trongate Theatre; this journey should be a maximum of 15mins. If the journey time exceeds 30mins the experiment will be stopped. During the experiment a digital recorder will record any verbal utterances during the experiment and you will also be required to wear a pedometer. Navigate how you would if you were travelling independently. At any time you can opt out of the experiment, just tell me. Also if at any time you require any detailed information please ask me. Are there are any specific features you wish to be made aware of before you approach them?

Now we will ask you to sign a consent form.

Pre-experiment tasks

Task 1: Participant to plan route
Task 2: Pointing task

Start Readings

Experiment Start Time:__________________

Pedometer Start Reading:________________

Experiment End Time:___________________

Pedometer End Reading:_________________

C.2. Consent Form

I __________________ understand that my participation in this study is voluntary and I am aware of any potential risks. Any questions that I have had regarding the study have been satisfactorily answered.

I understand that I can terminate my participation at any time during the study without giving a reason and without any of my rights being affected. I can request for my data to be withdrawn from the study. I am under no obligation to respond to all questions or complete all tasks; I may refrain where I feel uncomfortable.

I understand that all information I give will be treated with the utmost confidentiality and that my anonymity will be respected at all times. I grant permission to the investigator to maintain records of the study should a follow-up study be conducted in the future.

Signature: __________________ Date:_______

I grant permission for any voice recordings taken during the experiment to be used in full or in part in an audio format when presenting the findings from the experiment. All transcripts will be anonymous.

Signature: __________________ Date:_______

C.3. Stage One – Route Planning

Now we will ask you to describe how you plan to travel from Queen St to the Trongate theatre, please include in as much detail as possible what streets you would take & why and where you would cross the road and why. This will be recorded.

Queen St Station

____

____

____

____

____

Trongate Theatre

____

____

____

____

____

C.4. Stage Two – Pointing Task

A: There are two pointers on this compass. This pointer is facing North as you are now, please move the second pointer so that it points towards the direction of Queen St Station.

Measured Angle: _______________

B: Imagine now, you are at Queen Street Station facing South, this pointer is facing South, please move the second pointer so that it points towards the direction of Trongate Theatre.

Measured Angle: _______________

C.5. Stage Three – Debriefing Session

Post-experiment Discussion

Talk through the route the participant actually took, asking the following questions as relevant, on a street-by street basis. This discussion will be recorded.

(1) Which streets they found the hardest to navigate along?

(2) If they avoided any area/ street, which they had previously planned to navigate along, why was this?

(3) What features, if any, did they find most problematic?

(4) What features, if any, did they particularly like or find useful?

(5) To explain any specific decision point as requested.

(6) At what point along the journey were they most stressed?

Any other comments

Appendix D: Street Hazard Rating Documentation

D.1. Formulae & Calculations

D.2. Street Percentage Rating Tables

D.1. Formulae & Calculations

Street Hazard Rating Calculation (%)

$$total = p + sf + rc$$

Where:
p = pavements total (30%)
sf = street furniture total (30%)
rc = road crossings total (40%)

Pavement Calculation (30% of total)

$$p = \frac{\sum c_x}{C} x30$$

Where:
p = pavement total (out of 30)
c_x = pavement characteristic *x* (out of 3)
C = potential total of *c* (if all characteristics acquire the highest valuation of 3)

Score	1	2	3
General Condition	Consistently bad	Sporadic patches	Consistently good
Paving Type	Patterned	Mixed	Plain
Surface Reflectance when wet	Reflective	Mixed	Non-reflective
Width	Consistently narrow / wide	Inconsistent	Adequate
Kerb Height	Highly variable	Variable	Consistent
Level Changes	Present without assistive features	Present with assistive features	Not present
Potential Total		**18**	
Weighting		**30%**	

Street Furniture Calculation (30% of total)

$$sf = pr + cl + z$$

Where:
sf = street furniture total (out of 30)
pr= presence of street furniture total (out of 10)
cl = colour of street furniture total (out of 10)
z = zoning of street furniture total (out of 10)

Presence of street furniture (10% of *sf*)

$$pr = \frac{\sum i_x}{I} x10$$

Where:
pr= presence of street furniture total (out of 10)
i_x = item valuation of street furniture *x* (out of 11)
I = potential total of *i* (if all characteristics acquire the highest valuation of 11)

Item of street furniture	Rating	Item of street furniture	Rating
Bollards	1	**Bus stops**	7
Bins	2	**Railings**	8
Outside dining areas	3	**Trees**	9
Signage	4	**Telephone boxes**	10
Lampposts	5	**Not present**	11
Seating	6		
Potential Total		**110**	
Weighting within street furniture		**33.3 %**	

Colour of street furniture (10% of *sf*)

$$cl = \frac{\sum cs_x}{CS} x10$$

Where:
cl= colour of street furniture total (out of 10)
cs_x = colour of street furniture *x* (out of 8)
CS = potential total of *s* (if all colours acquire the highest valuation of 8)

Colour	Rating	Item of street furniture	Rating
Silver	1	**White**	5
Green	2	**Orange**	6
Blue	3	**Red**	7
Black	4	**Yellow**	8
Potential Total		**64**	
Weighting within street furniture		**33.3 %**	

Zoning of street furniture (10% of *sf*)

$$z = \frac{\sum n_x}{N} x10$$

Where:
z = zoning of street furniture total (out of 10)
n_x = zoning valuation of street furniture *x* (out of 3)
N = potential total of *n* (if all zoning acquires the highest valuation of 3)

Rating	1	2	3
Item of street furniture	Poor zoning	Inconsistent Zoning	Good zoning
Potential Total		**30**	
Weighting within street furniture		**33.3 %**	

Road Crossings Calculation 1 (40% of total)

$$rc = \frac{\sum af_x}{AF} x40$$

Where:
rc = crossings total (out of 40)
af = no. of assistive features *x* (out of total no. of crossing points in street)
AF = potential total no. of assistive features (when all crossing points are fully equipped)

Criteria	Rating System
No. of crossing points	No. of road intersections along length of street
Accessible Crossings	No. of controlled crossing points with tactile cone or audio signal
Dropped Kerb	No. of controlled crossings with dropped kerb
Tactile Paving	No. of controlled crossings with tactile paving
Weighting	**40%**

D.2. Street Percentage Rating Tables

Rating	Street Name	Total (%)
1	Argyle St	80.74
2	Queen St	73.89
3	Buchanan St	70.38
4	S. Frederick St	69.36
5	St Vincent Place	67.99
6	Candleriggs	67.43
7	Virginia St	66.61
8	Royal Exchange Sq	65.79
9	Martha St	64.67
10	Glassford St	63.16
11	Cathedral St	61.84
12	Shuttle St	58.08
13	Ingram St	58.02
14	West George St	57.29
15	Trongate	55.65
16	N. Frederick St	54.09
17	Walls St	52.99
18	Hanover St	51.67
19	Albion St	50.86
20	Blackfriars St	48.08
21	Wilson St	47.50
22	Montrose St	46.63
23	Cochrane St	45.07
24	Miller St	44.52
25	George St	44.36
26	George Sq	44.25
27	North Hanover St	43.53
28	Bell St	39.10
29	College St	37.70
30	High St	37.56
31	Garth St	37.52
32	Hutcheson St	36.36
33	Richmond St	33.55
34	North Portland St	33.11
35	Dundas St	32.50
36	Rottenrow	31.61
37	Brunswick St	27.73
38	John St	25.71
Average Overall Rating		**50.7**

Albion Street			
PAVEMENTS (30%)	**25.00**		
General condition	3		
Paving Type	3		
Surface Reflectance when wet	2		
Width	3		
Kerb height	1		
Level changes	3		
STREET FURNITURE (30%)	**17.86**		
	Presence	Colour	Zoning
Bollards	1	1	2
Bins	2	1	3
Outside dining areas	11		
Signage	11		
Lampposts	11		
Seating	11		
Bus stops	11		
Railings	11		
Trees	11		
Telephone Boxes	11		
Subtotal (10%)	8.27	1.25	8.33
ROAD CROSSINGS (40%)	**8.00**		
No. of crossing points	5		
Accessible crossings	1		
Dropped kerb	1		
Tactile Paving	1		
TOTAL RATING (%)	**50.86**		

Argyle Street

PAVEMENTS (30%)	**23.33**		
General condition	3		
Paving Type	2		
Surface Reflectance when wet	1		
Width	2		
Kerb height	3		
Level changes	3		
STREET FURNITURE (30%)	**17.41**		
	Presence	Colour	Zoning
Bollards	1	1	1
Bins	2	4	3
Outside dining areas	11		
Signage	4	1	1
Lampposts	11		
Seating	6	4	3
Bus stops	7	1	3
Railings	8	4	3
Trees	11		
Telephone Boxes	10	1	3
Subtotal (10%)	6.45	2.86	8.10
ROAD CROSSINGS (40%)	**40.00**		
No. of crossing points	3		
Accessible crossings	3		
Dropped kerb	3		
Tactile Paving	3		
TOTAL RATING (%)	**80.74**		

Bell Street

PAVEMENTS (30%)	**16.67**		
General condition	2		
Paving Type	1		
Surface Reflectance when wet	2		
Width	2		
Kerb height	2		
Level changes	1		
STREET FURNITURE (30%)	**15.76**		
	Presence	Colour	Zoning
Bollards	1	1	3
Bins	2	4	3
Outside dining areas	3	1	1
Signage	4	1	1
Lampposts	11		
Seating	11		
Bus stops	11		
Railings	11		
Trees	11		
Telephone Boxes	11		
Subtotal (10%)	6.91	2.19	6.67
ROAD CROSSINGS (40%)	**6.67**		
No. of crossing points	4		
Accessible crossings	1		
Dropped kerb	1		
Tactile Paving	0		
TOTAL RATING (%)	**39.10**		

Blackfriars Street

PAVEMENTS (30%)	**21.67**		
General condition	3		
Paving Type	1		
Surface Reflectance when wet	2		
Width	1		
Kerb height	3		
Level changes	3		
STREET FURNITURE (30%)	**13.08**		
	Presence	Colour	Zoning
Bollards	1	1	1
Bins	2	1	1
Outside dining areas	3	1	3
Signage	11		
Lampposts	11		
Seating	6	1	1
Bus stops	11		
Railings	11		
Trees	9	2	1
Telephone Boxes	11		
Subtotal (10%)	6.91	1.50	4.67
ROAD CROSSINGS (40%)	**13.33**		
No. of crossing points	1		
Accessible crossings	0		
Dropped kerb	1		
Tactile Paving	0		
TOTAL RATING (%)	**48.08**		

Brunswick Street

PAVEMENTS (30%)	**16.67**		
General condition	2		
Paving Type	2		
Surface Reflectance when wet	2		
Width	2		
Kerb height	1		
Level changes	1		
STREET FURNITURE (30%)	**11.06**		
	Presence	Colour	Zoning
Bollards	1	1	1
Bins	2	1	1
Outside dining areas	3	1	1
Signage	4	1	1
Lampposts	11		
Seating	6	1	1
Bus stops	11		
Railings	11		
Trees	9	2	1
Telephone Boxes	11		
Subtotal (10%)	6.27	1.46	3.33
ROAD CROSSINGS (40%)	**0.00**		
No. of crossing points	1		
Accessible crossings	0		
Dropped kerb	0		
Tactile Paving	0		
TOTAL RATING (%)	**27.73**		

Buchanan Street			
PAVEMENTS (30%)	**20.00**		
General condition	3		
Paving Type	2		
Surface Reflectance when wet	1		
Width	2		
Kerb height	3		
Level changes	1		
STREET FURNITURE (30%)	**10.38**		
	Presence	Colour	Zoning
Bollards	1	1	1
Bins	2	1	1
Outside dining areas	3	1	1
Signage	4	1	1
Lampposts	5	1	1
Seating	6	1	1
Bus stops	11		
Railings	11		
Trees	9	2	1
Telephone Boxes	10	1	1
Subtotal (10%)	5.64	1.41	3.33
ROAD CROSSINGS (40%)	**40.00**		
No. of crossing points	4		
Accessible crossings	4		
Dropped kerb	4		
Tactile Paving	4		
TOTAL RATING (%)	**70.38**		

Candleriggs

PAVEMENTS (30%)	**26.67**		
General condition	3		
Paving Type	3		
Surface Reflectance when wet	1		
Width	3		
Kerb height	3		
Level changes	3		
STREET FURNITURE (30%)	**14.10**		
	Presence	Colour	Zoning
Bollards	1	1	1
Bins	2	1	3
Outside dining areas	3	1	1
Signage	4	4	1
Lampposts	11		
Seating	11		
Bus stops	11		
Railings	11		
Trees	11		
Telephone Boxes	11		
Subtotal (10%)	6.91	2.19	5.00
ROAD CROSSINGS (40%)	**26.67**		
No. of crossing points	2		
Accessible crossings	1		
Dropped kerb	2		
Tactile Paving	1		
TOTAL RATING (%)	**67.43**		

Cathedral Street

PAVEMENTS (30%)	**18.33**		
General condition	1		
Paving Type	3		
Surface Reflectance when wet	3		
Width	2		
Kerb height	1		
Level changes	1		
STREET FURNITURE (30%)	**14.62**		
	Presence	Colour	Zoning
Bollards	1	4	2
Bins	2	4	3
Outside dining areas	11		
Signage	4	1	1
Lampposts	5	1	3
Seating	6	1	3
Bus stops	7	1	1
Railings	8	1	1
Trees	9	2	3
Telephone Boxes	10	1	1
Subtotal (10%)	5.73	2.22	6.67
ROAD CROSSINGS (40%)	**28.89**		
No. of crossing points	6		
Accessible crossings	5		
Dropped kerb	4		
Tactile Paving	4		
TOTAL RATING (%)	**61.84**		

Cochrane Street			
PAVEMENTS (30%)	**28.33**		
General condition	3		
Paving Type	3		
Surface Reflectance when wet	2		
Width	3		
Kerb height	3		
Level changes	3		
STREET FURNITURE (30%)	**16.73**		
	Presence	Colour	Zoning
Bollards	11		
Bins	2	1	3
Outside dining areas	11		
Signage	11		
Lampposts	11		
Seating	11		
Bus stops	7	1	1
Railings	11		
Trees	11		
Telephone Boxes	11		
Subtotal (10%)	8.82	1.25	6.67
ROAD CROSSINGS (40%)	**0.00**		
No. of crossing points	2		
Accessible crossings	0		
Dropped kerb	0		
Tactile Paving	0		
TOTAL RATING (%)	**45.07**		

College Street

PAVEMENTS (30%)	**20.00**		
General condition	2		
Paving Type	2		
Surface Reflectance when wet	3		
Width	3		
Kerb height	1		
Level changes	1		
STREET FURNITURE (30%)	**17.70**		
	Presence	Colour	Zoning
Bollards	11		
Bins	11		
Outside dining areas	11		
Signage	4	4	1
Lampposts	11		
Seating	11		
Bus stops	11		
Railings	11		
Trees	11		
Telephone Boxes	11		
Subtotal (10%)	9.36	5.00	3.33
ROAD CROSSINGS (40%)	**0.00**		
No. of crossing points	0		
Accessible crossings	0		
Dropped kerb	0		
Tactile Paving	0		
TOTAL RATING (%)	**37.70**		

Dundas Street

PAVEMENTS (30%)	**16.67**		
General condition	2		
Paving Type	1		
Surface Reflectance when wet	3		
Width	2		
Kerb height	1		
Level changes	1		
STREET FURNITURE (30%)	**15.83**		
	Presence	Colour	Zoning
Bollards	1	1	1
Bins	2	4	2
Outside dining areas	11		
Signage	4	4	1
Lampposts	11		
Seating	11		
Bus stops	11		
Railings	11		
Trees	11		
Telephone Boxes	11		
Subtotal (10%)	7.64	3.75	4.44
ROAD CROSSINGS (40%)	**0.00**		
No. of crossing points	1		
Accessible crossings	0		
Dropped kerb	0		
Tactile Paving	0		
TOTAL RATING (%)	**32.50**		

North Frederick Street

PAVEMENTS (30%)	**18.33**		
General condition	1		
Paving Type	3		
Surface Reflectance when wet	3		
Width	2		
Kerb height	1		
Level changes	1		
STREET FURNITURE (30%)	**15.76**		
	Presence	Colour	Zoning
Bollards	11		
Bins	2	4	3
Outside dining areas	11		
Signage	4	4	1
Lampposts	5	1	1
Seating	11		
Bus stops	7	1	1
Railings	11		
Trees	11		
Telephone Boxes	11		
Subtotal (10%)	7.64	3.13	5.00
ROAD CROSSINGS (40%)	**20.00**		
No. of crossing points	2		
Accessible crossings	2		
Dropped kerb	0		
Tactile Paving	1		
TOTAL RATING (%)	**54.09**		

South Frederick Street

PAVEMENTS (30%)	**25.00**		
General condition	2		
Paving Type	3		
Surface Reflectance when wet	2		
Width	3		
Kerb height	2		
Level changes	3		
STREET FURNITURE (30%)	**24.36**		
	Presence	Colour	Zoning
Bollards	11		
Bins	11		
Outside dining areas	11		
Signage	4	4	3
Lampposts	11		
Seating	11		
Bus stops	11		
Railings	11		
Trees	11		
Telephone Boxes	11		
Subtotal (10%)	9.36	5.00	10.00
ROAD CROSSINGS (40%)	**20.00**		
No. of crossing points	2		
Accessible crossings	1		
Dropped kerb	1		
Tactile Paving	1		
TOTAL RATING (%)	**69.36**		

Garth Street

PAVEMENTS (30%)	**20.00**		
General condition	2		
Paving Type	2		
Surface Reflectance when wet	3		
Width	1		
Kerb height	1		
Level changes	3		
STREET FURNITURE (30%)	**17.52**		
	Presence	Colour	Zoning
Bollards	11		
Bins	2	4	1
Outside dining areas	11		
Signage	11		
Lampposts	11		
Seating	11		
Bus stops	11		
Railings	11		
Trees	11		
Telephone Boxes	11		
Subtotal (10%)	9.18	5.00	3.33
ROAD CROSSINGS (40%)	**0.00**		
No. of crossing points	2		
Accessible crossings	0		
Dropped kerb	0		
Tactile Paving	0		
TOTAL RATING (%)	**37.52**		

George Street

PAVEMENTS (30%)	20.00		
General condition	2		
Paving Type	2		
Surface Reflectance when wet	3		
Width	2		
Kerb height	2		
Level changes	1		
STREET FURNITURE (30%)	**13.69**		
	Presence	Colour	Zoning
Bollards	11		
Bins	2	4	3
Outside dining areas	3	1	1
Signage	4	1	1
Lampposts	5	1	2
Seating	11		
Bus stops	7	1	1
Railings	11		
Trees	11		
Telephone Boxes	10	1	1
Subtotal (10%)	6.82	1.88	5.00
ROAD CROSSINGS (40%)	**10.67**		
No. of crossing points	5		
Accessible crossings	2		
Dropped kerb	1		
Tactile Paving	1		
TOTAL RATING (%)	**44.36**		

West George Street

PAVEMENTS (30%)	**23.33**		
General condition	3		
Paving Type	2		
Surface Reflectance when wet	2		
Width	2		
Kerb height	2		
Level changes	3		
STREET FURNITURE (30%)	**16.17**		
	Presence	Colour	Zoning
Bollards	11		
Bins	2	4	2
Outside dining areas	11	1	1
Signage	4	4	2
Lampposts	11		
Seating	11		
Bus stops	7	1	1
Railings	11		
Trees	11		
Telephone Boxes	10	1	1
Subtotal (10%)	8.09	2.75	5.33
ROAD CROSSINGS (40%)	**17.78**		
No. of crossing points	3		
Accessible crossings	2		
Dropped kerb	1		
Tactile Paving	1		
TOTAL RATING (%)	**57.29**		

George Square

PAVEMENTS (30%)	21.67		
General condition	3		
Paving Type	2		
Surface Reflectance when wet	3		
Width	1		
Kerb height	1		
Level changes	3		
STREET FURNITURE (30%)	**13.69**		
	Presence	Colour	Zoning
Bollards	11		
Bins	2	4	1
Outside dining areas	11		
Signage	4	4	1
Lampposts	5	1	1
Seating	6	2	1
Bus stops	7	1	1
Railings	8	1	1
Trees	9	2	3
Telephone Boxes	11		
Subtotal (10%)	6.73	2.68	4.29
ROAD CROSSINGS (40%)	**8.89**		
No. of crossing points	6		
Accessible crossings	4		
Dropped kerb	0		
Tactile Paving	0		
TOTAL RATING (%)	**44.25**		

Glassford Street

PAVEMENTS (30%)	**20.00**		
General condition	1		
Paving Type	2		
Surface Reflectance when wet	3		
Width	1		
Kerb height	2		
Level changes	3		
STREET FURNITURE (30%)	**16.49**		
	Presence	Colour	Zoning
Bollards	1	1	3
Bins	2	4	3
Outside dining areas	11		
Signage	11		
Lampposts	11		
Seating	11		
Bus stops	7	1	1
Railings	8	1	1
Trees	11		
Telephone Boxes	11		
Subtotal (10%)	7.64	2.19	6.67
ROAD CROSSINGS (40%)	**26.67**		
No. of crossing points	4		
Accessible crossings	3		
Dropped kerb	2		
Tactile Paving	3		
TOTAL RATING (%)	**63.16**		

Hanover Street

PAVEMENTS (30%)	**21.67**		
General condition	3		
Paving Type	2		
Surface Reflectance when wet	3		
Width	3		
Kerb height	1		
Level changes	1		
STREET FURNITURE (30%)	**30.00**		
	Presence	Colour	Zoning
Bollards	11		
Bins	11		
Outside dining areas	11		
Signage	11		
Lampposts	11		
Seating	11		
Bus stops	11		
Railings	11		
Trees	11		
Telephone Boxes	11		
Subtotal (10%)	10.00	10.00	10.00
ROAD CROSSINGS (40%)	**0.00**		
No. of crossing points	2		
Accessible crossings	0		
Dropped kerb	0		
Tactile Paving	0		
TOTAL RATING (%)	**51.67**		

North Hanover Street

PAVEMENTS (30%)	**20.00**		
General condition	2		
Paving Type	3		
Surface Reflectance when wet	3		
Width	2		
Kerb height	1		
Level changes	1		
STREET FURNITURE (30%)	**16.87**		
	Presence	Colour	Zoning
Bollards	11		
Bins	2	4	3
Outside dining areas	11		
Signage	4	4	1
Lampposts	11		
Seating	11		
Bus stops	7	1	1
Railings	8	1	2
Trees	11		
Telephone Boxes	11		
Subtotal (10%)	7.91	3.13	5.83
ROAD CROSSINGS (40%)	**6.67**		
No. of crossing points	4		
Accessible crossings	2		
Dropped kerb	0		
Tactile Paving	0		
TOTAL RATING (%)	**43.53**		

High Street

PAVEMENTS (30%)	**13.33**		
General condition	1		
Paving Type	2		
Surface Reflectance when wet	2		
Width	1		
Kerb height	1		
Level changes	1		
STREET FURNITURE (30%)	**14.70**		
	Presence	Colour	Zoning
Bollards	11		
Bins	2	1	3
Outside dining areas	11		
Signage	4	1	1
Lampposts	5	1	2
Seating	11		
Bus stops	7	1	1
Railings	8	4	2
Trees	11		
Telephone Boxes	10	1	1
Subtotal (10%)	7.27	1.88	5.56
ROAD CROSSINGS (40%)	**9.52**		
No. of crossing points	7		
Accessible crossings	3		
Dropped kerb	1		
Tactile Paving	1		
TOTAL RATING (%)	**37.56**		

Hutcheson Street

PAVEMENTS (30%)	**20.00**		
General condition	1		
Paving Type	2		
Surface Reflectance when wet	3		
Width	2		
Kerb height	1		
Level changes	3		
STREET FURNITURE (30%)	**16.36**		
	Presence	Colour	Zoning
Bollards	1	1	1
Bins	2	1	3
Outside dining areas	3	1	2
Signage	4	4	3
Lampposts	5	1	3
Seating	11		
Bus stops	11		
Railings	11		
Trees	11		
Telephone Boxes	11		
Subtotal (10%)	6.36	2.00	8.00
ROAD CROSSINGS (40%)	**0.00**		
No. of crossing points	1		
Accessible crossings	0		
Dropped kerb	0		
Tactile Paving	0		
TOTAL RATING (%)	**36.36**		

Ingram Street

PAVEMENTS (30%)	**21.67**		
General condition	3		
Paving Type	2		
Surface Reflectance when wet	1		
Width	3		
Kerb height	3		
Level changes	1		
STREET FURNITURE (30%)	**14.69**		
	Presence	Colour	Zoning
Bollards	1	1	1
Bins	2	1	3
Outside dining areas	3	1	2
Signage	4	1	3
Lampposts	5	1	1
Seating	11		
Bus stops	7	1	3
Railings	11		
Trees	9	2	1
Telephone Boxes	10	4	3
Subtotal (10%)	5.73	1.88	7.08
ROAD CROSSINGS (40%)	**21.67**		
No. of crossing points	8		
Accessible crossings	4		
Dropped kerb	5		
Tactile Paving	4		
TOTAL RATING (%)	**58.02**		

John Street

PAVEMENTS (30%)	**13.33**		
General condition	1		
Paving Type	2		
Surface Reflectance when wet	2		
Width	1		
Kerb height	1		
Level changes	1		
STREET FURNITURE (30%)	**12.37**		
	Presence	Colour	Zoning
Bollards	1	1	1
Bins	2	1	1
Outside dining areas	3	1	3
Signage	4	1	1
Lampposts	11		
Seating	6	1	1
Bus stops	11		
Railings	11		
Trees	9	2	2
Telephone Boxes	10	1	1
Subtotal (10%)	6.18	1.43	4.76
ROAD CROSSINGS (40%)	**0.00**		
No. of crossing points	2		
Accessible crossings	0		
Dropped kerb	0		
Tactile Paving	0		
TOTAL RATING (%)	**25.71**		

Martha Street			
PAVEMENTS (30%)	**13.33**		
General condition	1		
Paving Type	2		
Surface Reflectance when wet	2		
Width	1		
Kerb height	1		
Level changes	1		
STREET FURNITURE (30%)	**16.33**		
	Presence	Colour	Zoning
Bollards	11		
Bins	2	4	1
Outside dining areas	11		
Signage	4	4	1
Lampposts	5	4	1
Seating	11		
Bus stops	11		
Railings	11		
Trees	11		
Telephone Boxes	11		
Subtotal (10%)	8.00	5.00	3.33
ROAD CROSSINGS (40%)	**35.00**		
No. of crossing points	0		
Accessible crossings	0		
Dropped kerb	0		
Tactile Paving	0		
TOTAL RATING (%)	**64.67**		

Miller Street

PAVEMENTS (30%)	**25.00**		
General condition	3		
Paving Type	2		
Surface Reflectance when wet	3		
Width	1		
Kerb height	3		
Level changes	3		
STREET FURNITURE (30%)	**19.52**		
	Presence	Colour	Zoning
Bollards	1	1	3
Bins	2	1	3
Outside dining areas	11		
Signage	11		
Lampposts	11		
Seating	11		
Bus stops	11		
Railings	11		
Trees	11		
Telephone Boxes	11		
Subtotal (10%)	8.27	1.25	10.00
ROAD CROSSINGS (40%)	**0.00**		
No. of crossing points	1		
Accessible crossings	0		
Dropped kerb	0		
Tactile Paving	0		
TOTAL RATING (%)	**44.52**		

Montrose Street

PAVEMENTS (30%)	**16.67**		
General condition	2		
Paving Type	2		
Surface Reflectance when wet	2		
Width	2		
Kerb height	1		
Level changes	1		
STREET FURNITURE (30%)	**13.97**		
	Presence	Colour	Zoning
Bollards	11		
Bins	2	1	1
Outside dining areas	11		
Signage	4	1	1
Lampposts	11		
Seating	11		
Bus stops	11		
Railings	8	1	2
Trees	11		
Telephone Boxes	11		
Subtotal (10%)	8.27	1.25	4.44
ROAD CROSSINGS (40%)	**16.00**		
No. of crossing points	5		
Accessible crossings	2		
Dropped kerb	2		
Tactile Paving	2		
TOTAL RATING (%)	**46.63**		

North Portland Street

PAVEMENTS (30%)	**16.67**		
General condition	1		
Paving Type	3		
Surface Reflectance when wet	3		
Width	1		
Kerb height	1		
Level changes	1		
STREET FURNITURE (30%)	**16.45**		
	Presence	Colour	Zoning
Bollards	11		
Bins	11		
Outside dining areas	11		
Signage	4	3	1
Lampposts	11		
Seating	11		
Bus stops	11		
Railings	11		
Trees	11		
Telephone Boxes	11		
Subtotal (10%)	9.36	3.75	3.33
ROAD CROSSINGS (40%)	**0.00**		
No. of crossing points	2		
Accessible crossings	0		
Dropped kerb	0		
Tactile Paving	0		
TOTAL RATING (%)	**33.11**		

Queen Street

PAVEMENTS (30%)	**25.00**		
General condition	3		
Paving Type	2		
Surface Reflectance when wet	1		
Width	3		
Kerb height	3		
Level changes	3		
STREET FURNITURE (30%)	**17.78**		
	Presence	Colour	Zoning
Bollards	1	1	3
Bins	2	1	2
Outside dining areas	11		
Signage	4	1	3
Lampposts	11		
Seating	11		
Bus stops	11		
Railings	11		
Trees	11		
Telephone Boxes	11		
Subtotal (10%)	7.64	1.25	8.89
ROAD CROSSINGS (40%)	**31.11**		
No. of crossing points	3		
Accessible crossings	3		
Dropped kerb	2		
Tactile Paving	2		
TOTAL RATING (%)	**73.89**		

Richmond Street

PAVEMENTS (30%)	**16.67**		
General condition	1		
Paving Type	3		
Surface Reflectance when wet	3		
Width	1		
Kerb height	1		
Level changes	1		
STREET FURNITURE (30%)	**16.88**		
	Presence	Colour	Zoning
Bollards	11		
Bins	2	4	1
Outside dining areas	11		
Signage	4	4	1
Lampposts	11		
Seating	11		
Bus stops	11		
Railings	11		
Trees	11		
Telephone Boxes	11		
Subtotal (10%)	8.55	5.00	3.33
ROAD CROSSINGS (40%)	**0.00**		
No. of crossing points	1		
Accessible crossings	0		
Dropped kerb	0		
Tactile Paving	0		
TOTAL RATING (%)	**33.55**		

Rottenrow Street			
PAVEMENTS (30%)	**13.33**		
General condition	1		
Paving Type	1		
Surface Reflectance when wet	3		
Width	1		
Kerb height	1		
Level changes	1		
STREET FURNITURE (30%)	**18.27**		
	Presence	Colour	Zoning
Bollards	1	4	1
Bins	2	4	2
Outside dining areas	11		
Signage	11		
Lampposts	11		
Seating	11		
Bus stops	11		
Railings	11		
Trees	11		
Telephone Boxes	11		
Subtotal (10%)	8.27	5.00	5.00
ROAD CROSSINGS (40%)	**0.00**		
No. of crossing points	1		
Accessible crossings	0		
Dropped kerb	0		
Tactile Paving	0		
TOTAL RATING (%)	**31.61**		

Royal Exchange Square

PAVEMENTS (30%)	**18.33**		
General condition	3		
Paving Type	2		
Surface Reflectance when wet	1		
Width	1		
Kerb height	3		
Level changes	1		
STREET FURNITURE (30%)	**12.45**		
	Presence	Colour	Zoning
Bollards	1	1	1
Bins	2	1	1
Outside dining areas	3	1	1
Signage	4	4	2
Lampposts	11		
Seating	6	1	1
Bus stops	11		
Railings	11		
Trees	11		
Telephone Boxes	11		
Subtotal (10%)	6.45	2.00	4.00
ROAD CROSSINGS (40%)	**35.00**		
No. of crossing points	0		
Accessible crossings	0		
Dropped kerb	0		
Tactile Paving	0		
TOTAL RATING (%)	**65.79**		

Shuttle St Street			
PAVEMENTS (30%)	**26.67**		
General condition	3		
Paving Type	1		
Surface Reflectance when wet	3		
Width	3		
Kerb height	3		
Level changes	3		
STREET FURNITURE (30%)	**18.08**		
	Presence	Colour	Zoning
Bollards	11		
Bins	11		
Outside dining areas	11		
Signage	4	1	3
Lampposts	5	1	3
Seating	11		
Bus stops	11		
Railings	11		
Trees	9	2	1
Telephone Boxes	11		
Subtotal (10%)	8.64	1.67	7.78
ROAD CROSSINGS (40%)	**13.33**		
No. of crossing points	1		
Accessible crossings	0		
Dropped kerb	1		
Tactile Paving	0		
TOTAL RATING (%)	**58.08**		

St Vincent Place

PAVEMENTS (30%)	**25.00**		
General condition	3		
Paving Type	3		
Surface Reflectance when wet	1		
Width	2		
Kerb height	3		
Level changes	3		
STREET FURNITURE (30%)	**16.33**		
	Presence	Colour	Zoning
Bollards	11		
Bins	2	4	1
Outside dining areas	11		
Signage	4	4	1
Lampposts	11		
Seating	11		
Bus stops	7	1	3
Railings	11		
Trees	9	2	1
Telephone Boxes	10	4	1
Subtotal (10%)	7.91	3.75	4.67
ROAD CROSSINGS (40%)	**26.67**		
No. of crossing points	2		
Accessible crossings	2		
Dropped kerb	1		
Tactile Paving	1		
TOTAL RATING (%)	**67.99**		

Trongate

PAVEMENTS (30%)	**15.00**		
General condition	1		
Paving Type	2		
Surface Reflectance when wet	1		
Width	1		
Kerb height	1		
Level changes	3		
STREET FURNITURE (30%)	**11.76**		
	Presence	Colour	Zoning
Bollards	1	1	2
Bins	2	1	1
Outside dining areas	3	4	1
Signage	4	1	1
Lampposts	5	1	1
Seating	11		
Bus stops	7	1	1
Railings	11		
Trees	11		
Telephone Boxes	11		
Subtotal (10%)	6.00	1.88	3.89
ROAD CROSSINGS (40%)	**28.89**		
No. of crossing points	6		
Accessible crossings	5		
Dropped kerb	4		
Tactile Paving	4		
TOTAL RATING (%)	**55.65**		

Virginia Street

PAVEMENTS (30%)	**15.00**		
General condition	1		
Paving Type	3		
Surface Reflectance when wet	2		
Width	1		
Kerb height	1		
Level changes	1		
STREET FURNITURE (30%)	**16.61**		
	Presence	Colour	Zoning
Bollards	1	4	1
Bins	2	4	1
Outside dining areas	11		
Signage	11		
Lampposts	11		
Seating	11		
Bus stops	11		
Railings	11		
Trees	11		
Telephone Boxes	11		
Subtotal (10%)	8.27	5.00	3.33
ROAD CROSSINGS (40%)	**35.00**		
No. of crossing points	0		
Accessible crossings	0		
Dropped kerb	0		
Tactile Paving	0		
TOTAL RATING (%)	**66.61**		

Walls Street			
PAVEMENTS (30%)	**20.00**		
General condition	1		
Paving Type	2		
Surface Reflectance when wet	3		
Width	1		
Kerb height	2		
Level changes	3		
STREET FURNITURE (30%)	**19.66**		
	Presence	Colour	Zoning
Bollards	1	1	3
Bins	2	1	3
Outside dining areas	11		
Signage	11	4	2
Lampposts	11		
Seating	11		
Bus stops	11		
Railings	11		
Trees	11		
Telephone Boxes	11		
Subtotal (10%)	8.27	2.50	8.89
ROAD CROSSINGS (40%)	**13.33**		
No. of crossing points	1		
Accessible crossings	0		
Dropped kerb	1		
Tactile Paving	0		
TOTAL RATING (%)	**52.99**		

Wilson Street

PAVEMENTS (30%)	**18.33**		
General condition	2		
Paving Type	2		
Surface Reflectance when wet	2		
Width	3		
Kerb height	1		
Level changes	1		
STREET FURNITURE (30%)	**19.16**		
	Presence	Colour	Zoning
Bollards	1	1	3
Bins	2	4	3
Outside dining areas	11		
Signage	4	4	1
Lampposts	11		
Seating	11		
Bus stops	11		
Railings	11		
Trees	11		
Telephone Boxes	11		
Subtotal (10%)	7.64	3.75	7.78
ROAD CROSSINGS (40%)	**10.00**		
No. of crossing points	4		
Accessible crossings	1		
Dropped kerb	1		
Tactile Paving	1		
TOTAL RATING (%)	**47.50**		

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