Inclusive Kerbs Study

Phase 3

November 2023

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Glossary

Ambient light	Light that is spread over an area/environment.
Ambient noise	Noise that is spread over an area/environment.
Containment	Keeping errant vehicles within the carriageway.
Controlled crossings	These are road crossing points with some form of traffic control associated with them e.g. Zebra, Pelican, Toucan
Crossfall	The gradient across the breadth of a surface.
Cycle track	A length of surface dedicated to cycling e.g., cycleway or cycle path. As defined in Transport Scotland's Cycling by Design 2021
Decibel	A unit used to measure the intensity of a sound, measured on an exponential scale.
Delineation	The act of showing the exact position of a border or boundary.
Depth of flow	Depth of water above the road surface.
DMRB	Design Manual for Roads and Bridges.
Drop kerbs	Kerbs that are lowered at a road crossing or access to a property.
Flush	Two surfaces adjacent to each other and at same level.
Framework	The supporting structure for the system.
Functionally Impaired / Functional Impairment	A person who has a level of difficulty in completing daily living tasks and activities.
Gradient	The degree/steepness of a slope.
Longfall / Longitudinal	The gradient along the length of a surface.
Lux	Unit of measurement for light.
Methodology	The method used to gather information in a study or activity.

Preview distance	The distance which someone may see an object before getting close to it.
Qualitative	A study method which uses metrics which are difficult to measure or quantify e.g., information or feedback.
Quantitative	A study method which uses metrics which can be measured and quantified, e.g., survey data or population statistics.
Reflective light	The light reflected from a surface, measured in lux.
SRRB	Scottish Road Research Board
Topography	The physical landscape of an area
Uncontrolled crossings	These are road crossing points with no form of traffic control associated with them e.g., dropped kerbs and pedestrian islands, dropped kerbs only or a general road without any pedestrian facilities
Upstand	The portion of the kerb that is raised above the carriageway

Executive summary

Scope and Purpose

The Inclusive Kerbs Phase 3 research project gathered data from a representative example of kerbs within The City of Edinburgh to understand what kerbs are present in the city and how people with various impairments use them. The study was conducted by Mott MacDonald and Edinburgh Napier University's Transport Research Institute. It was commissioned by Transport Scotland on behalf of the Scottish Road Research Board (SRRB) and the Department for Transport (DfT).

Phase 1 of the project looked at existing research and found that there are few studies on inclusive kerbs considering both engineering and human factors.

Phase 2 gathered data and tried out selected methods to learn more about how people use kerbs. The study considered how kerbs are used for navigating along a street and for crossing the street.

Phase 3 collected data from eleven people with severe to moderate impairments through further online interviews and site visits with volunteer participants. The information gathered from the interviews and site visits are compared against the survey data to identify any patterns in experience.

Methodology

Phase 3 assesses the interaction of user groups against the Phase 2 selected kerb types, heights and interfaces in real world situations.

In order to do this, five locations were identified and presented to eleven participants with various functional impairments in online interviews. Then five participants volunteered to take part with the site visits: two wheelchair users, one person with a hearing impairment, one person with a visual impairment and one person with visual and hearing impairments with a guide dog. The online interviews focused on the reflective lived experiences of the volunteer participants which followed the same methodology as the Phase 2 interviews. The site visits took the participants to specific site locations to give verbal commentaries of crossings and wayfinding at a representative selection of the surveyed site locations.

Findings

The Phase 3 study focused on gathering data from both online interviews and site visits in preparation for lab-based research during Phase 4. From the data collected from both the online interviews and site visits, it was found that;

- Creating conspicuous edges is deemed essential to address the challenge of navigation for visually impaired users.
- A prevalent theme that cuts across user groups, including cane users, guide dog users and wheelchair users, was the necessity for specialised training in how to navigate newer styles of design. Enhancing training, to include ways to best navigate inclusive design to help participants understand evolving styles in placemaking.
- Ensuring that crossings are strategically located is crucial and standardised layouts will enable users to identify and engage with them in a positive manner.
- Varied designs of kerbs and raised table arrangements impacted users' ability to differentiate spaces or ability to cross safely dependant on kerb heights. Continuity in how kerbing and other road elements were provided was a challenge for participants, especially newer styles which they were not as familiar with.

Recommendations

The next stage of this study (Phase 4) will assess, in controlled conditions, the interaction of user groups against the selected kerb types, heights and interfaces. Controlled conditions allow a wider range of impairment conditions to be considered in a safer environment. This will be done through lab-based experimentation with functionally impaired volunteer participants utilising a specialised test rig. Information gathered from these tests and interviews will be compared against the findings from Phase 3 to identify any patterns in experience and inform a range of heights that is most suitable for the varying impairment types.

1 Introduction

1.1 General

This report documents the process and findings of the Inclusive Kerbs Phase 3 research project. The project was commissioned by Transport Scotland on behalf of the Scottish Road Research Board (SRRB) and the Department for Transport (DfT) and was conducted by Mott MacDonald and Edinburgh Napier University's Transport Research Institute.

The study has been designed to be as robust and rigorous as possible within project constraints to stand up to scrutiny and challenge. To achieve this, the project has used the latest available data to determine the proportions of the general population with functional impairment. This will inform future studies on sample sizes to represent the Scottish population when sampling functional disabilities.

To better serve the end user of any proposed kerb guidance, the project has a strong focus on the personal experiences of the roadside users with functional impairments. Utilising the analysed population data, the project recruited a small number of interview participants from the highest impairment severity category to assist in online pilot interviews (Phase 2). This initial feedback was used to assist in the method development for the site-based interviews (Phase 3) and future stages of this study (Phase 4).

The project surveyed a range of existing kerbs in different locations collecting data on a range of attributes on kerb properties and its setting. The data gathered was then used in the Phase 2 online interviews and allowed limited associations to be made between experiences of kerb interactions and kerb design. These associations have then been further defined during this Phase 3 study to allow more definitive conclusions to be reached with regard to the issues faced by functionally impaired users and provide clarity on what further actions will need to be undertaken during laboratory-based testing in Phase 4.

1.2 Scope and Objectives

Phase 1 of the study completed a literature review and recommended that a second phase be conducted looking at kerb boundaries between footways and carriageways, footways and cycle tracks, and cycle tracks and carriageways.

Phase 2 of the study examined the interfaces identified in Phase 1 and how users interacted with them. It gathered necessary data, from online interviews with functionally impaired volunteers using a trial methodology to form a basis for recommending future studies on inclusive road design. The interviews considered the whole setting and use of the kerb for navigation parallel along a street and as a point of uncontrolled crossing.

This Phase 3 of the study extends to the collection of data from people with moderate to mild impairments. This was done through site-based interviews with functionally impaired volunteer participants to three of the sites identified as most appropriate from Phase 2 of the study. Data was gathered using on site interviews and was compared and analysed using conventional qualitative research techniques (Neville Stanton, 2021) (J Goodman-Deane, 2010) (Flick, 2018) to identify key themes and patterns arising from participant experiences. This data was then assessed in order to form conclusions on existing holistic kerb conditions and the difficulties encountered by each of the participants. These were used to form a realistic baseline and provide further clarifications on what needs to be prepared as part of the laboratory research in Phase 4 to identify potentially suitable kerb height ranges for the purposes of inclusive design.

1.3 Methodology Overview

The project methodology is explained in greater detail throughout the report with specific focus in Section 2.

Phase 2 of the study involved assessment of twenty-six locations across the City of Edinburgh. Five of these sites were taken forward to online interviews with volunteer participants grouped by impairment and severity of impairment. The outcomes of this phase of the study were used to inform the sites to be utilised in Phase 3 as well as the interview questions used to obtain the required qualitative results and how these results were to be coded and assessed.

For Phase 3 of the study eleven participants were utilised for the purposes of the online interviews. Then five volunteer participants were available to participate in the site visits of the study.

During Phase 3 of this study three out of the twenty-six sites surveyed during Phase 2 were taken forward for use in this site visit element of the research. The chosen sites were considered to be the most representative examples that would provide the necessary qualitative and quantitative outcomes to provide suitable conclusions for this stage of the study as well as help inform and refine the methodology for the laboratory assessments to be undertaken during Phase 4 of this research.

The information gathered from these site visits was compared against the information gathered during the Phase 3 online interviews as well as the data gathered on the kerbs and locations to determine associations.

All work was conducted to Edinburgh Napier University integrity, ethical and data management standards.

1.4 Report Structure

This report has been structured in such a way as to provide the reader with the methodology used during this phase of the study as well as the background of how this method was developed and the intended outcomes. After this has been clarified the report goes on to provide the details of, and the data gathered from, the site-based interviews along with the analysis of that data. Finally, the report provides outline conclusions, recommendations for further work and closing remarks.

Section 2 of this report summarises the methodology used during Phase 2 of the study and assesses how successful it was in developing the desired outcomes, including the coding, required to provide conclusions and recommendations for further work. This section of the report will also relay to the reader how Phase 3 of the study was undertaken and how the methodology will provide the information required to provide conclusions and inform future study of kerb heights. It also outlines what sites were chosen to be taken forward from Phase 2 and why these sites were chosen. It then goes on to describe the sites and explain why they provide suitable outcomes to allow conclusions and further recommendations.

Section 3 of this report presents the results from the online interviews, broken down by the most prevalent and prominent coding of themes. It also provides the key outcomes that have been found from each participant and how this impacts our assessment of kerb heights both for this phase and going forward.

Section 4 of this report outlines the results from the site visits, broken down by most prevalent and prominent themes determined from the verbal commentary given by each participant. It also provides the key outcomes that have been found from each participant and how this impacts our assessment of kerb heights both for this phase and going forward.

Finally, Section 5 of this report provides a summary of the outcomes and conclusions from this phase of the study along with recommendations for the next phase.

2 Methodology

2.1 Introduction

Phase 3 built upon and continued the research from Phase 2 that surveyed kerb heights and profiles currently used in the Scottish urban road network. During Phase 2, to establish opportunities for improving kerb heights and characteristics a number of sites were presented to participants in online interviews. The findings from these interviews were then coded, see Section 2.4, and assessed in order to provide outcomes for Phase 2 of the study as well as to inform the methodology going forward into Phase 3.

The Phase 2 work on trial coding and assessment online have allowed for methods to be developed and improved to be used on Phase 3. The demographic study in Phase 2 allows limited site visit and laboratory testing to be compared to a known general population. As well as this the outcomes from Phase 2 allowed for the most representative sites to be chosen for use in the Phase 3 study, see Section 2.5 for more detail.

A methodology for Phase 3 has therefore been adopted to target key factors and risk groups to ensure the study is effective, manageable and attempt to deliver within the project constraints. The interview data for Phase 3 of this study was collected in two parts. Firstly, the online interviews that were based on reflective lived experiences of the volunteer participants which followed the same methodology as the Phase 2 interviews. Then site visits that took the participants to specific site locations to give verbal commentaries of crossings and wayfinding at a representative selection of the surveyed site locations.

The mixed methodology approach addressed quantitative and qualitative data collection targeted at key issues, and possible new technological developments. Road engineering approaches were combined with inclusive design and behavioural/safety paradigms to address the multidisciplinary considerations.

2.2 Online Interviews

The same methodology used during Phase 2 of this study has been used for the online interview at Phase 3, which focused on targeting key factors and risk groups.

Inclusive design is a human-centred methodology that relates the capabilities of the population to the functional demands of a design. The overall aim was to look at the role of kerb heights with a view to improving street layouts for inclusion. Hence, the project asked people who represent inclusive populations their opinions about, and experiences of, kerbs during crossings.

The online interviews were undertaken and recorded utilising Microsoft Teams online meeting software, with the available volunteer participants responding from their own homes. There were eleven participants in total.

2.3 Site Visits

A series of site 'usage cases' were prepared for navigating along and crossing kerbs consisting of various kerb heights, profiles, characteristics and settings. The usage cases will be both on-site (Phase 3) and further assessed during Phase 4 in a laboratory environment. Site visits and commentaries will be conducted at chosen locations which will allow navigation and setting to be considered. Once the data was collected from the site visits it was coded and assessed. The outcomes of this assessment were then used to inform the conclusions in Section 5. A usage case in this instance was how a person interacts with the given activity whether that be travelling along the route or carrying out a controlled, or uncontrolled crossing. This activity or usage case was then assessed using the provided feedback.

The usage cases were presented to participants who represent specific inclusion 'personas'. These personas were prepared by ENU, determined by functional impairment and severity e.g., 'visually impaired person with restricted peripheral field of view and white stick, with no impairment of physical movement, age range: twenty – seventy. The interviews were founded on the reflective "lived experience" of the individuals and data from their commentaries during the site visits.

For each persona – usage case condition data will be collected on:

- Physical difficulties in engagement with kerbs and surfaces.
- Perceived physical, social and inclusion barriers (visual, hearing, physical movement, thinking, physiological systemic)
- Physical and mental workload,
- Perceived Understanding and cognition,
- Perceived Affect, apprehension, comfort
- Perceived Cumulative effort.

During the trial, the focus was on inclusive design, identifying what demands are made by the kerb design at each stage that may make the journey phase difficult, pleasant, frightening, painful or impossible.

While Phase 2 and Phase 3 are broadly similar, Phase 2 assisted, in a controlled environment, with the development of the Phase 3 proposals which were revised to enhance the methodology in advance of on-site activities. The study ultimately aimed to produce conclusions for, and make initial recommendations to, trunk road operators, local roads authorities, planners, and architects, on possible kerb heights and characteristics that provide optimum accessibility.

The on-site activities were based on reflective lived experience from each of the participants, the data from the online interview surveys were combined with the video data recorded at each location. Two team members acted as the interviewer/camera operator and assistant. While one further team member acted as the Safety Watch for both the participant and the team, and had complete authority to stop or pause an action or the interview at any time for safety, security, or wellbeing reasons. Site visits were carried out during October and November 2022, with excessive weather being avoided. Participants met at Edinburgh Napier University and were transferred to the special purpose vehicle, either a taxi or van depending on the requirements of the participant. The routes and parking locations for each of the interview sites were planned and agreed in advance to ensure proximity to the survey site location. The participants were asked to give a verbal commentary at specific areas of how they attempted crossings to provide necessary data for the study. If the kerb seemed too challenging, they were asked to proceed with their normal approach instead and to explain this. Efforts were made to ensure a realistic situation, for example, dogs were not cued or supported by anyone other than their unsighted principal, and canes, and participants wheelchairs were not orientated or guided by researchers, other than to avoid hazards.

The duration of each site visit lasted around 45 minutes, with the travel time between site location around 10-20 minutes. In summary the following procedure was carried out with each participant at all of the sites:

1. Arrive to the site location, hi-visibility clothing was given to the participant, ENU staff and Safety Watch
2. Safety briefing given to all, and activity briefing given to the participant
3. Participant was then asked to give a verbal commentary and show how they would normally approach and then achieve crossing at specific kerb locations, this could include the use of controlled crossings dependant on the view of the participants and safety watch on the risks associated with the site conditions on the day
4. The interviewer accompanies participants during their movements, videoing progress and maintaining an audio record of the context of the participant’s verbal commentary
5. On-site recordings were taken of the ambient light levels (Lux) and ambient sound levels (dB) at each of the site locations
6. The findings were then recorded before movement to a subsequent site or completion of the on-site activities.

2.4 Data Analytics - Coding

Following the online interviews and site visits the recordings were watched and the discussions coded into different types. Coding in academic terms is the process of collecting, assessing, and interpreting qualitative data to provide measurable outcomes.

The coding method used in this research project was developed during Phase 2 of the study and in summary the main themes were taken from the provided feedback using keywords which were then grouped under qualitative chosen criteria. The results of this coding can be seen in APPENDIX B – Coding Results.

2.5 Choice of Sites

Phase 3 of this study assessed three out of the twenty-six sites surveyed during the Phase 2 study. In order to provide a range of kerb types and locations whilst minimising the travel time between sites during the operation, three locations were selected for the Phase 3 study. This methodology helped to prevent exposure of participants and undue discomfort. The chosen sites are considered to be representative examples with regard to kerb designs used within Scotland that would provide the necessary qualitative and quantitative outcomes to provide suitable conclusions for this stage of the study as well as help inform and refine the methodology for the laboratory assessments to be undertaken during Phase 4 of this research. The details of each of the sites assessed during this phase are given in Table 2-1 below.

Table 2-1: Site Details

Location	Purpose in Study	Crossing	Kerb Upstand
Constitution Street	New build/drains	Controlled and uncontrolled crossing used	110mm
Picardy Place	Cycle track	Controlled crossing used	55mm
George Street	Retail area	Controlled and uncontrolled crossing used	85mm

The choice of kerb survey locations was determined by considering the urban geography, land use and street type across the City of Edinburgh. The sites listed in Table 2-1 capture a wide range of varying kerb heights and street environment to allow for a comparative assessment of results. At some of the chosen site locations the safety watch took the view that operations could only be undertaken at controlled crossings to ensure the safety of the participants.

However, there were some occasions where controlled crossings were used as a safety mechanism to allow the participants to achieve the crossing safely and for the surveyors to survey the kerb heights and other parameters. The term ‘controlled crossing’ refers to a road crossing point with some form of traffic control associated with them e.g., Zebra, Pelican or Toucan crossing. An ‘uncontrolled crossing’ refers to road crossing points with no form of traffic control associated with them e.g. dropped kerbs and pedestrian islands, dropped kerbs only or a general road without any pedestrian facilities.

2.6 Site Descriptions

2.6.1 Constitution Street

This site is located on Constitution Street between Baltic Street and Tower Street in the vicinity of a section of the Trams to Newhaven tram line in Edinburgh which was in the late stages of construction at the time of this research. Approaching the site from the intersection between Constitution Street and Tower Street walking south towards Baltic Street the area is a mix of modern and older style buildings comprising residential, commercial, and industrial uses.

On the southbound side of the road there is a stone wall with a double width gate for vehicular access after which the wall continues until it reaches a stone building with a single width roller gate vehicular access. Lighting columns are present up to this point, these are grey and set to the back of the footway. Beyond this point lighting columns are not present on this side of the road. This is followed by a building entrance and then a further length of stone wall associated with the adjacent building that features large windows and intermittent entrances. On the southbound side of the road cars were parked intermittently in the marked parking bays along the length of the kerb, except at the locations with the previously discussed gates. The footway consists of smooth grey stone slabs with light grey combined drainage kerb.

On the Northbound side of Constitution Street travelling northbound at the location of the controlled crossing there are older style stone buildings with multiple large windows and frequent building entrances until it reaches a double width gate for vehicular access. The footway consists of smooth grey stone slabs with light grey combined drainage kerb and there is an electrical column associated with the trams set to the back of the footway.

Travelling northbound on the northbound side of the road beyond the double width gate the buildings become a more modern style construction. Then the adjoining building houses residential and commercial units, with large planters on the footway and a parking bay.

The road carriageway is two lanes wide, with intermittent parking bays on both sides, and is black asphalt until it reaches the tram tracks where it is a light grey concrete with dark inset rails. Constitution Street at this point is considered to have a lighter flow of traffic suitable for the team to carry out the site research in a safe manner without the specific use of a controlled crossing, while the adjacent. Baltic Street is considered to be a busier arterial route with much greater volumes of vehicular traffic.

Figure 2-1 Constitution Street site location

2.6.2 Picardy Place

This site is located on Picardy Place where it meets Leith Street at the controlled crossing point in front of the Glasshouse Hotel, this is in the vicinity of a section of the Trams to Newhaven tram line and tram stop which was in the late stages of construction at the time of this research. Approaching the site from the northern side, from the parking bay/taxi rank on Leith Street outside of the Omni Centre there is a wide plaza featuring steps that transition to a smaller plaza with varied patterned slabs. The footway consists of various features including public art sculptures, trees, and lighting. Travelling north on a downward gradient, there is a mix of modern and older style buildings that comprise of mainly commercial uses.

On the southbound side of the road, from the parking bay there is a segregated cycleway between the footway and carriageway with intermittent raised table arrangements used for crossing points. At these points there are designated tactile paving positioned on the footway to indicate the crossing. At the controlled crossing point used for this site it then includes more tactical paving that indicates the boundary between the footway and the cycleway which then transitions to the crossing point for the road. Sequentially this arrangement utilises additional tactile paving to mark the conclusion of the cycleway crossing, a slight gap to distinguish between the crossings, more paving indicating the road crossing and then the road crossing itself. The crossing itself is of a raised table arrangement but has chamfered kerbs either side as the levels change to create the raised table arrangement. This chamfered kerb runs longitudinally with the cycleway to differentiate it from the pedestrian footway and the segregation island that runs adjacent to the southbound carriageway of the road.

The road carriageway is three lanes wide, one lane specifically for tram use only, with a detached cycleway adjacent to the southbound carriageway. Picardy Place is a busy arterial route into the centre of The City of Edinburgh with a high volume of vehicular and active travel traffic.

Figure 2-2: Picardy Place site location

2.6.3 George Street

This site is located on George Street between Hanover Street and St Andrew Square. On both sides of the carriageway there are a mix of modern and older style buildings comprising residential and commercial uses. At the time of this research the westbound side of the road was under partial closure and the eastbound carriageway was operating under normal conditions.

On the westbound side of the road, from the parking bay at the St Andrews Square end of the road heading west towards Hanover Street there are multiple buildings with large windows and entrances, along the length of the road, some that have stepped access. From the controlled crossing until halfway along the footway there is a double kerb that transitions to a single kerb. The footway consists of assorted street furniture, including bus stops, telephone boxes and bins, as well as seating for the various restaurants set to the back of footway. There are intermittent parking bays and bus stops along the length of the road. The footway consists of grey, yellow and red stone slabs that vary in condition.

On the eastbound side of the road, from the tree to the west of St Andrew's and St George's West Church travelling east towards St Andrews Square, there are multiple buildings with large windows and entrances along the length of the road. The footway consists of various street furniture including, planters, bus stops, parking meters and bins. The footway consists of grey, yellow and red stone slabs that vary in condition. There are intermittent parking bays, loading bays and bus stops along the length of the road.

The carriageway is 4 lanes wide with a cobbled parking area in the centre of the street that was full at the time of the surveys. George Street is a busy arterial route in the centre of The City of Edinburgh with a great volume of vehicular traffic.

Figure 2-3: George Street site location

3 Online Interview Feedback

3.1 Introduction

The online interviews were conducted using the methodology described in Section 2. The participants responses were coded, and this section contains a summary of the most prevalent and prominent coding of themes over the online interviews carried out for this phase of the research.

The details of each of the volunteer participants that took part in Phase 3 of this research are listed in Table 3-1 below.

In the online interviews the participants concentrated on discussing strategies for navigating the streets around them, their lived experience from interacting with different kerbs, and their methods used to navigate to a crossing point. A secondary topic of discussion was the properties of the streets that were presented. The participants' 'capabilities' referred to in Table 3-1 are with respect to the task of negotiating kerbs and are discussed further within this section of the report. For a full description of all participants capability ranges refer to APPENDIX A – Participant Capabilities.

3.2 Capabilities

As shown in Table 3-1, participants that took part in the Phase 3 online interviews included people with various levels of capabilities for the functions of vision; hearing; physical movement; thinking ability, and other systemic capability issues that affect multiple functions.

Table 3-1: Description of Participants Capabilities

Participant	Age/Gender		Capability	Notes
1	60-74	M	Low visual capability	Cane user. Took part in Phase 2 interviews
2	18-29	M	No vision. Low hearing capability	Registered blind. Hearing adequate for close speech/ Took part in Phase 2 interviews.
3	30-45	M	Low visual and hearing capability	Assisted hearing adequate for close speech Requires assistance for specific situations
4	60-74	M	Low visual and hearing capability	Low visual capability, Assisted hearing adequate for close speech. Uses subtitles on TV. Dexterity good – balance weak.
5	60-74	F	Very low physical movement	Spinal injury – arms an upper body only. Use wheelchair. Assistance required occasionally
6	30-45	F	Low physical capability	Ambulatory wheelchair user. Can walk with crutches. Electric wheelchair. Mobility Vehicle.
7	60-74	M	Very low visual capability	Registered blind with guide-dog.
8	60-74	M	Very low physical movement	Spinal injury – arms an upper body only. Use wheelchair. Assistance required occasionally
9	60-74	F	Physical movement difficulties. Thinking, systemic and hearing difficulties	Weakness, balance and vibration sensitivity. Occasional wheelchair user. Hearing aids. Mild cognitive impairment. Recent improvement in requiring assistance. Heart condition.

Table 3-1: Description of Participants Capabilities

10	75-85	F	No vision	No vision. Uses long cane. Has been a guide-dog user.
11	18-29	F	Uncoded	Incomplete data. Did not complete online interview

3.3 Coding Results

The coding method used throughout this research study has been explained in Section 2.4. The results can be seen graphically in Figure 3-1 which displays this information hierarchically based on frequency and content.

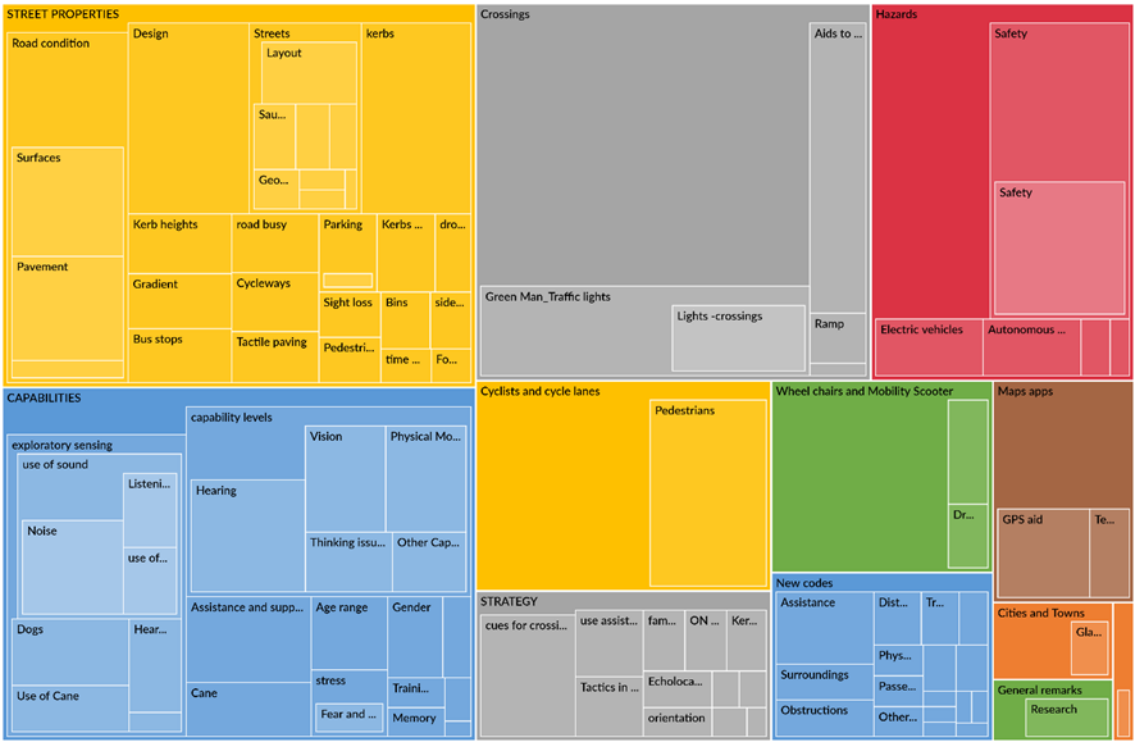

Figure 3-1: Hierarchy Area Chart of Frequency of Coding References

This information is then counted with the highest occurring themes and key criteria to provide commonalities between participants. This can be seen in Table 3-2, below. The full coding table is given in APPENDIX B – Coding Results.

APPENDIX B – Coding Results

Table 3-2: Count of Top Coding Themes

Name	Files	References
STREET PROPERTIES	9	295
Crossings	10	220
Methodology	8	215
Hazards	10	161
CAPABILITIES	10	89
STRATEGY	5	72
Wheelchairs and Mobility Scooter	6	69
Cyclists and cycle lanes	8	60
Maps apps	8	51
Cities and towns	4	15
General remarks	1	3
Policies	2	3

For more detailed descriptions of what coding is in the academic context as well as how the coding for this study was developed, please refer to the Phase 2 Study and appendices.

3.3.1 Vision

The participants that took part in the online interviews represented a range of visual capabilities, from no vision at all to those with partial vision that may still fall in the very low vision category. This category covers those who have low visual capability resulting from loss of peripheral vision, loss of central vision, and other conditions that may significantly reduce vision, depending on the retinal area affected. Many of the participants had developed this impairment later in their lives and some noted that they had full vision at some point in their history. Some participants had previously been drivers and therefore will be more familiar with roads in general, and some of the road layouts that are the subject of this research.

Navigating various crossings and diverse kerb heights present notable challenges to those with low visual capabilities. As a baseline, current standard kerbs (100mm upstand) have been noted to be of at least an acceptable height for a cane and guide dog to detect and recognise with respect to the older style footway compared to lower profile newly streetscaped footways.

The participants in the low visual capability category used various methods to recognise dropped kerbs and their angles and heights, necessary to perceive the start of a crossing at the kerb. This included the use of long canes and guide-dogs, which is discussed further in Sections 4.2 and 4.5. Successful navigation of varying kerb heights was dependant on a number of factors, such as familiarity of routes, or use of apps but cane use or dog help was required for immediate situational awareness, and to prevent life-threatening levels of risk. Assistance was invariably necessary for unfamiliar, complex, and challenging routes.

According to Participant 7:

> Quote 1: “I'm using a long cane, in the approved manner. So, I would expect to identify it with the cane. But if I didn't notice it with the cane by chance, I can tell it by what's under my feet. You can expect to feel the conspicuous edges.”

They further reiterate what they meant by use of the cane in an approved manner:

> Quote *2:* “I've been trained and there's a specific long cane technique that you use, which means that you're moving your wrist so the cane follows the arc in front of you. So, it covers the width of your walking and identifies things on the ground or a reasonably low level…it doesn't identify head height obstacles”

Many of the visually impaired participants required assistance from third parties, helping to guide them. These may be relatives and carers, or passers-by. The participants are often trained in a standard way for assisters to guide them. The challenging aspect reported was that people don’t always offer their arms in the expected way that facilitates safe movement. Also, it emerged that a number of participants in this survey had not been trained by mobility instructors. This may be age-dependent considering that there is an age difference of approximately 40 years between the oldest and youngest participants.

However, for those that were trained, training provided a vocabulary for describing and articulating the preferred methods of assistance. Distress and distraction were potentially possible, when well-meaning people address the participants during an approach to the kerb, or when trying to locate a crossing on the road. This distraction could lead to misinterpretation of the road layout and result in the impaired users being hindered in travelling the route.

3.3.2 Hearing

A number of participants reported different levels of hearing capability, some simultaneously with vision issues. Hearing aids have improved as technology advances which is leading to less people being functionally impaired from hearing loss.

However, hearing capability, particularly with hearing aids, can be greatly affected by ambient noise of the street environment (e.g. masking effects), as discussed in Section 3.8.4.

According to the Participant 4:

> Quote 3: “a lot of Deaf people become deafer when they're outside so they're even more reliant on their eyes”

The main factor relating to hearing-impaired people having specific difficulties with kerbs and roads generally centred on visual issues, such as the ability to detect hazards or perceive Red-Man/Green-Man signals at controlled crossings. This was further impacted by the lack of availability of haptic signals at crossings, this is discussed further in Section 3.4.

Hearing loss could be progressive. Participant 4 further states:

> Quote 4: “But I think most hearing-impaired people have incurred their hearing loss gradually. So, I don't think they would be affected, I think unless they've got other issues, of course, like dementia, for example, or other cognitive issues. But I don't think the hearing loss per se is likely to be a major issue”

Other hearing challenges mentioned were silent cyclists and electric vehicles, which represent a hazard for someone who is deaf or near deaf to contend with. Kerbs often mark the boundary between different usage areas such as footways and cycleways which can give the user an indicator that they need to be aware of possible interactions with certain other types of traffic which may represent a hindrance to their travel or a risk to their safety.

3.3.3 Physical Movement

A number of the participants faced challenges of capability with physical movement. The participants in this category had varying degrees of physical movement constraints, for example, as resulting from spinal injuries leading to paralysis of legs requiring a wheelchair.

Experienced wheelchair users benefited from more knowledge of how to operate their equipment and interact with the surrounding environment due to greater time developing those skills. However, they required assistance with crossings and kerbs when not on familiar ground or when specific kerb heights were untraversable. A number of potential crossing hazards included the following: the descent down a kerb and the ascent up a kerb on the far side of the roadway, potentially exceeding the tipping angle of the chair; physical drops also generate shocks that could have adverse effects for some, including spasms, discomfort, or falls, in many cases this limits the participants to the use of controlled crossings only. Offers of assistance from pedestrians may be dangerous as the public understanding of the use and manoeuvring of the wheelchair is variable and if carried out incorrectly the participant may endure discomfort or injury.

According to Participant 5:

> Quote 5: “I have had situations where people have caused me to fall out of my chair. They just try and stand me up. just give me a minute. And I'll tell you what you need to do.”

Furthermore, such handling may cause anxiety because of a lack of understanding of how to support someone with spinal cord complications. It was reported that it might even become necessary to call emergency services to intervene with an ambulance. This was deemed to be a potential source of embarrassment and stigma since the participant was not obviously injured.

One solution, available to mobility drivers (See Section 3.8.4), was seen as acquiring familiarity with routes by reconnaissance driving through areas to ascertain access. However, this also had its limitations, especially regarding the distance from the origin to the destination. According to Participant 4:

> Quote 6: “I maybe would drive round a route in advance, just to check it out. But I wouldn't drive an hour to Glasgow, to drive down the street to see if I could have access.“

It was acknowledged by those with low visual capability, that assistance was often required, to plan routes or deal with potential obstacles. In addition, some of the participants with physical movement issues experienced difficulty getting in and out of their wheelchairs requiring assistance to bring them to the wheelchairs. Others, however, were able to build skills using foldable chairs, allowing them to manage, for example, driving a car unassisted.

As well as kerbs there were other roadside features and risks that were raised by the participants. There is a constant moderate risk as a result of the increasing numbers of pedestrians using mobile phones with minimal awareness of their immediate surroundings, especially at lower than head height, meaning non-impaired users are unable to see wheelchair users which could result in evasive actions being required or a collision.

Also, for those using walking sticks and canes, while negotiating steps or going down a staircase a handrail is required. Hence, they also reported difficulty dealing with, either the mild or steep steps, as steps were generally difficult to negotiate, particularly downwards and on curves.

3.4 Crossings

Both visually affected and physically affected participants noted that they have resorted to locating a nearby controlled crossing if conditions of risk proved adverse. However, controlled crossings were reported to not always be correctly configured. Different categories of crossing (Zebra, Pelican, Puffin, Toucan, etc) remained a key challenge for people with varying degrees of capability, depending on crossing equipment, operation, and layout. Controlled crossings such as these were the main resort if uncontrolled crossings were deemed too risky due to kerb heights.

3.4.1 Visually Affected Participants

One of the challenges reported by participants with low visual capability is related to the use of tactile paving and its layout relative to the controlled crossing. When the tactile paving is constructed, it may terminate at some distance before the location of the beacon post. There may be a ramp to the kerb edge which is relatively flush with the vehicle trafficked carriageway. It emerged that identifying where the actual kerb of the crossings is located could be a significant problem. The result of this is that the impaired user does not know where they are with reference to the crossing or road itself which is a risk to their safety. According to Participant 7, who narrated their experiences, and the response of their guide-dog:

> Quote 7: “But she [dog] sees that happens quite often - that the tactile paving doesn't get right up to the width stops, and even stops even before the traffic light pole, so we are standing there going…”

The account from another participant who is a cane user is slightly different. In this case, the tactile paving is used to orientate and locate the user in the space between the building’s line and the “step down” at the kerb at the crossing edge. Although ramps are normal at these crossings, the kerbs may still not be flush with the roadway and variable heights of kerb are frequently left. This can lead to critical or hazardous problems, especially in adverse weather.

According to Participant 10:

> Quote 8: “I swing working forwards and backwards, from right to left. And at the same time, I'm stepping forward on the canes going to the left, and stepping forward with that, so that I know that I'm not going to step down anything. I need to find tactile if I know I'm going to cross the road.”

As well as kerbs there were other roadside features and risks that were raised by the participants. There were accounts of tactile paving positioned in inappropriate places: tactile paving could occur in locations on the road or on footways without crossings, a potential source of confusion and apprehension.

Also, at controlled crossings, sunlight could impinge on users’ eyes, making it impossible for them to see the lantern signal of opposingly mounted Green Man signals on the far side of the road. This was considered high risk and users' reported anxiety and fear of the possibility of vehicles hitting them. This was a concern for participants with partial vision, reinforcing their overall frustrations with the challenges of the crossing locations and their positionings.

It was reported that many sets of traffic lights at controlled crossings do not have rotating haptic cones and tactile cones on the push button unit. Also, there was a false understanding that all crossings with traffic lights have audible signals to cross. Not all have the audible signal to alert people to cross. This is difficult for people with different levels of hearing or visual capability. In situations where there were multiple crossing points at adjoining crossings, for example, there were multiple sets of signals. The audible signal has the potential to be misidentified and may be of uncertain location due to the general auditory environment at busy crossings. If a sound is generated at an adjacent or connected crossing, it has the potential for confusion as the low-capability individuals at adjacent crossings tend to think that they can cross the road. It was reported that such complex crossing intersections are generally risky for users, especially those with canes, guide dogs and wheelchairs interacting or competing for space with pedestrians.

Participants also used auditory, and sensory information to assist the decision-making at crossings. It was observed that the auditory signal device could fail to operate at the crossings, creating a hazard. Other hazards included the failure of visually affected users to detect a potential collision with a car or other vehicles (motorcycle, bicycle) due to the quietness of the vehicle, possibly an electric vehicle, scooter, or bicycle.

3.5 Cyclists and cycle lanes

The interaction of people with different levels of capability and the presence of cyclists on the cycle lanes and footways introduces risk to all users. These interactions were noted to be most prominent causes of anxiety, fear, and apprehension. According to Participant 7:

> Quote 9: "They are a complete nightmare and bikes, and scooters tend to go into the pavement as well and that's really disheartening"

Participants reported that a number of newly pedestrianised areas they had experienced had minimal or undetectable kerbs. For considerable distances there is no kerb, which means there is no physical marker to prevent inadvertent excursion onto the road. In certain cases, a cycle path begins where tactile paving is positioned along the front of the cycle path. People who are of extreme visual impairment can encounter this tactile paving and become disoriented; they will search for a push button unit to press a demand button. However, due to this unanticipated arrangement it was then possible for the impaired user to be located in the middle of a cycle path, putting their safety at risk. According to Participant 7:

> Quote 10: “That's part of the problem so much of that did not have a kerb, so you didn't know when they cycled past… stuck … and for the whole street there are quite a distance there is actually no kerb, so you can actually walk onto the road, and you wouldn't really know as some people use canes”

They continue:

> Quote 11: “It’s hard to explain how the cycle path is separated with road. I have fallen over them a few times.”

Another challenge noted by the participants is that bikes and electric vehicles were not producing sounds audible enough to hear, especially for those with low or very low hearing and visual capability.

The participants who recreationally used bicycles and recumbent cycles noted a challenge in sharing facilities with other cyclists and pedestrians. While they attempted to avoid use of busy roads they were often forced to use them because the usable cycle paths provision connecting them to their destinations were exhausted. The poor condition of some cycle paths and their footways were considered to be contributory to this. Participant 5 states that:

> Quote 12: “We came across a lot of hazards on route, there are so many parts that we had to use the cycle map. But still it wasn’t clear where you were going. And we obviously tried to stay off busy main roads. But sometimes it was unavoidable.”

It was emphasised that cycle lanes should be low-risk spaces, which they are not currently perceived as being. It was perceived by the participants that fatalities had occurred, causing widespread apprehension.

Participants using wheelchairs expanded that they could get stuck between the kerbs of cycle paths as they can form a long channel. This can result in a long wheeling effort until the next suitable exit point.

As well as this there was a perception of an emerging threat from new cycle paths obstructing people on wheelchairs from safely accessing their parked cars. Participant 4 states:

> Quote 13: “They not so much with roads, but with cyclists and, cycle lanes in particular, this wave (COVID) started rolling out floating bus stops and floating parking in edge, you need to cross a cycle lane to get to your parked car…And cyclists simply don't stop… I don't know, for whatever reason. That is a concern.”

Design efforts using surface colours to differentiate the cycle paths and the roads were perceived as helpful, nevertheless, risk levels remained too high. There was a problem of using road markings with paint because of drivers' lack of compliance with the markings for cyclists. This point reinforces the importance of using kerbs to define the boundaries between footways, cycleways and the carriageway.

3.6 Hazards

Safety is the main priority for participants that have to cross the road. Numerous examples were identified which described different situations and scenarios that constitute hazards for their interactions with pedestrians, cyclists, and drivers on the roads, particularly on the shared facilities such as the footways and the controlled crossings. In many cases hazards were repeatedly described by the participants during the online interviews, as listed below:

- One hazard identified and described was the absence of kerbs in some streets which makes users with capability variation vulnerable to stress and accidents. Examples were given where individuals had inadvertently walked directly into roads and the cycle paths.
- Also, new road developments have led to increased risk, in which there were undetectable kerbs separating the footway and the cycle paths. Similarly, the participants reported incidences of collision hazards involving parked vehicles on the footways and with the disorderly café boundaries located on footways.
- The convergence of footway and cycle paths with inappropriate tactile paving and kerb interfaces exposes users to the risk of collision with cyclists. Also, there were a number of controlled crossings without tactile paving, haptic cones or other inclusive features which they noted are a form of hazard to their mobility and interactions within their urban space.
- The hazard that electric vehicles present in terms of the absence of sounds was emphasised by the participants, especially those with low visual capability as they are unable to see the oncoming vehicles and at the same time, have no form of awareness of their environment due to the lack of noise from the vehicles. Battery-operated cars produce no sound and constitute a hazard, especially in places where there is no tactile paving and kerbs separating the different traffic streams.
- There were moderate hazards from people using mobile phones rendering them inattentive. More serious were collisions resulting from the opening of car doors. Issues of obstructions on the footways were raised in different forms as for instance, that of unfixed rubbish bins constituting hazards on the way.

Also, identified as a general factor raising risk were the potholes on the roads and footways which can trap the wheelchairs, sticks, canes, and feet. Uneven slabs were noted to be enough to knock down users. According to Participant 8:

> Quote 14: “I nearly had a quite bad accident with bad pavement because my front caster caught the pavement, and it tipped me forward. And it was only lucky that, there was a bus going by, so I managed to push myself back off the moving bus. If it had been about two seconds later, I would have been under it.”

They continue:

> Quote 15: “As a wheelchair user, I've had very few problems because the buttons tend to be at a sensible height. And I don't tend to have to go into the road to press them and things like that. As a (recumbent) cyclist. They're dreadful, the Toucan crossing ones because I'm so low down, and quite often, I have to roll slightly into the road to be able to get up and reach them.”

Negative psychological effects resulting from participants perceptions of hazards and levels of risk. This was reported as potentially incremental, and location related. This was reported to potentially lead to restlessness and fear. In other situations, anxiety at crossings could be generated by other coincident causes, including aircraft noise, roadworks, other pedestrians, dogs, and cyclists.

3.7 Maps Apps and Navigation

A number of participants reported using route finding apps such as Google maps and various apps aiming to aid impaired users. The advantages were noted, while the challenges they faced using the various apps were also narrated especially by the visually impaired participants. In general, most of the participants reported finding the use of a map app helpful for planning routes and finding crossings, especially if designed for visual or mobility impaired users.

Participants who have low physical capability reported using in-car navigation and reconnaissance drives for routes in unfamiliar areas. Notable among the apps being reported as useful were Google and Apple maps, however, these do not help with orientation in the street or with the location of appropriate landmarks.

There are apps under development for the use of those with varying degrees of capability. According to Participant 7:

> Quote 16: “I was invited to the Forth Valley sensory impairment unit and there is… something that's been developed at Glasgow University”

Also, the participants noted that some apps are difficult to understand despite accessibility features and as such were not user friendly. There were other apps developed to aid crossings, especially for people with low dexterity. Participant 4 states:

> Quote 17: "The idea is to carry that little app on your smartphone. And to have some technology in the crossing. If you stand near the box, for five seconds, it activates the Green Man. Just press the button. And it's designed for people who for whatever reason, to access the green, then it might be people with dexterity issues that aren't able to push the button."

Several other apps were mentioned that were based on specifying routes using disability landmarks and exact distance descriptions. The Google "street view feature" was reported as helpful in looking for parking, assessing kerbs and the layout of the road ahead of crossings on route as it gives a static camera view in different directions from a given point in the street (360 degree cameras).

From the discussions in the online interviews, it can be seen there is a desire within the functionally impaired community to integrate the use of technology in how they travel. Technology was seen as a key element in reducing stress and ensuring the participant would be able to easily travel from their origin to their destination. Also, the participants made it clear that reconnaissance was a key element in how participants plan their journeys and interact with spaces whether that be from technological sources such as apps or in person events such as drive or walk throughs.

3.8 Street properties

The key properties of the streets mentioned by the participants undertaking the online interviews included the layout of the street, the type and condition of the road, footways, and kerbs, and any specific issues. The layout of the roads and conditions of kerbs and footways were described as giving a form of identity to respective streets. The participants noted that in some streets the footways were broken, and the kerbs functionally deficient. Street layout can further influence the interactions with every type of traffic, much of which has already been described in earlier sections. Again, the lack of clear separation of roadways and cycleways from the sufficient use of kerbs to delineate the boundary of the footways was prominent.

3.8.1 Ambiguity of Tactile Footways and Gutters

Ambiguity of tactile footways near kerbs were seen as sources of confusion and disorientation because it was perceived as being used for multiple purposes, many of which were unclear to those with capability variation. The clear use of consistent kerb types and heights to highlight boundaries could provide a solution to this ambiguity.

Other significant properties of streets are sloping kerbs and drainage gutters which are noted to be acceptable but depends on the angle and the height. According to Participant 2:

> Quote 18: "…a very shallow kerb that then sloped down to a shallow angle might not be as easily identifiable as some as a steeper or higher one. But, I recognize the need to have dropped out kerbs and that users are fine, as long as they are sufficiently conspicuous"

Relating to the slope, Participant 5 states:

> Quote 19: "...up to 30 degrees. Certainly, I do take that a lot and I haven't been for quite a while, but George Street I think, I remember it poses great problems because it's such a high kerb drop"

3.8.2 Design inconsistency

The participants further highlighted some inconsistencies in the design of kerb environments on the roads assessed during the online interviews. For instance, it was noted that in Edinburgh, temporary cycleways had been bounded by intermittent rubber kerb elements, each containing a 1.5m baton. The rubber kerbs and batons were seen as potential crossing obstacles and the gaps between batons were reported as not easily identified, leading to a dangerous exposure as no physical boundary existed at that point between cycleways/parking and the roadway. It was perceived that efforts to make streets congenial for pedestrians, had generated inconsistencies which negatively impact the level to which impaired users can interpret the route. In some cases, the road has been narrowed and parking reduced to allow for faster throughput of cyclists, with the overall intention of making the streets more visually pleasing as well as usable for all categories of users. This, however, led to restructuring of the typical layouts and the creation of additional problems for impaired users that have not been fully considered and communicated, which included issues of delineation of different traffic types and inconsistent use of kerb styles and heights.

The designs of kerbing in specific roads was frequently mentioned. For example, multiple references were made to new developments in streetscaping. According to Participant 2:

> Quote 20: "There's a site, being remodelled with a cycleway and a more restricted roadway. ……. they've narrowed that down and they're going to reduce the amount of parking so that the idea is to have a quicker throughput of cyclists and that the intention is to make it more congenial for pedestrians and cyclists and all road users. But safer presumably because of

> parked vehicles……. But the way they've managed it is not good in terms of kerbs. So, there is virtually no delineation, no marking, no tactile marking between the cycleway and the pavement. I mean, it's quite difficult to detect even when it's new. So, it's virtually a shared surface between pedestrians and cyclists at that point"

Participant 2 continues:

> Quote 21: "And there's a particular intersection that I've looked at. That you have to worry if you want to cross the whole width of the cycleway and the road. There are no kerbs. There are kerbs where you don't want to cross. But they've raised because of the table. What do you call it raised table on the road? Yeah. Which of course eliminates the kerb. Because they haven't raised the pavement. So, it's sort of a ramp for the traffic, but no kerb, it ends up making the road the same height as the pavement. Therefore, you don't know when you've crossed the cycleway, and you don't know when you're on the vehicle bit."

The height of the kerbs at these newly streetscaped examples attracted widespread criticism from the participants. The general consensus was for a consistent and distinctive layout without excessive height kerbs. The existing provision was described as highly inconvenient and hazardous for wheelchairs as well as for people with other types and levels of impairment. A particular difficulty occurred for those who were of high physical impairment with respect to movement; and with high visual impairment, who expect the kerb to be detectable and dropped at the point of crossing.

3.8.3 Design Inconsistency with Street Furniture, Obstacles, and Roadworks

With respect to the pedestrianised areas, the participants highlighted the key issues of congesting street space with street furniture and other objects that are typical of such areas. Participants described their expectation of a typical footway was to have lamp posts on the building side, with perhaps dust bins, and to the roadside a cycleway. However, this expectation can no longer be relied on with the development of new streetscaping techniques. According to Participant 2:

> Quote 22: "they tend to be littered with street furniture that's one problem. And the other problem is if it's a pedestrian street that was a traffic street before and has been pedestrianised. Normally, they would leave the pavements in place. But you

> wouldn't be expected to walk on them, because they have all sorts of clutter on them."

Navigation and situational awareness were affected on the kerbed footways resulting from obstructions which include planters, bollards, bike racks and shops. In some cases, it was no longer adequate to proceed along the centre part of the footway with the expectation that the traffic sound will be detected before crossing the road. Some newly developed pedestrianised areas were considered by the participants as challenging for individuals with capability variations.

Tactile paving was a familiar property of the streets and encouraged confident progress through areas with tactile indicators for the impaired users. However, this trust was broken in cases where the tactile indicators were removed due to utility work and omitted or incorrectly fixed back.

It was frequently reported that temporary roadworks presented a considerable hazard, particularly when they changed their position and form. In some cases, road markings bore no relationship to the layout of kerbs and were considered by the participants as a hazard to cyclists and those with functional impairments, alike.

The participants observed the need for appropriate combinations of kerb height for a given longitudinal gradient, noting that this is not clear. New and legacy parking bay markings for physically affected drivers were considered to be often dangerous or inappropriate, as the information in the road markings were missing, incomplete or inadequate for the width of modern vehicles.

3.8.4 Traffic noise and Echolocation

Traffic noise was noted as an issue to some of the survey participants. They noted that at times the noise can be helpful for the visually impaired, especially the noise from oncoming vehicles. Also, the use of echolocation was reported as a key element of cane users. In particular, trained users were capable of detecting the noise from the cane when it hits many objects, contributing to situational awareness. Traffic noise and subtle changes in noise reflection were routinely used as locators for the shop frontage and the roadway, respectively.

Conversely traffic noise or lack thereof was also noted to be a distraction to participants. Hearing impaired users noted that peripheral noise often caused their remaining hearing capability to decrease, this has been discussed in Section 3.3.2. As well as this traffic which is silent or near silent was noted as a hazard, e.g. electric cycles.

3.9 Wheelchairs and Mobility Scooters

The participants using wheelchairs reported challenges getting in and out of the wheelchairs and using the shared kerbside facilities with other users such as cyclists and pedestrians. These challenges are divided below into the initial in and out of the wheelchair and the issues the wheelchair designs have with the street environment.

These issues can be considered for manual wheelchairs, electric wheelchairs and mobility scooters.

3.9.1 Getting In and Out of the Wheelchair

The design of the wheelchair can facilitate ingress and egress of the wheelchair. Older, more rigid designs can prove more difficult than newer more flexible designs. However, not all users have newer designs. Participant 5 describes their particular type of wheelchair:

> Quote 23: “it's what's called a rigid frame wheelchair. instead of folding in sideways, the back comes down onto the seat, and the wheels come off just pressing a button. I put the wheels safely in behind the passenger seat and find my seat and I move the body over me, and it sits in the passenger seat”

The ease at which the participants can transfer between their wheelchair and their car will influence how they travel to and from any point of interest. This in turn will influence the roads and footways they are required to navigate. This could impact parking locations and pick up/drop off points as it relates to kerbs.

3.9.2 Design and Features of Wheelchairs

The design and the features of the wheelchair or scooter can determine the ease of manoeuvring and traversing various heights of kerbs, and the comfort level in use.

Participant 8 describes their wheelchair, stating:

> Quote 24: “It's a lightweight chair. With Spinergy wheels. So, it's got these carbon fibre ones. They're, great. So, they sort of absorbed I mean, they've had them for years”

Participants described their experiences with traversing kerbs at different places. This was managed with varying degrees of difficulty, with some athletic participants comfortable with traversing the kerbs of standard height. However, other participants perceived these as a hazard and they were not able to ascend standard kerbs with their wheelchairs and aborted the manoeuvre as too risky.

Tyre technology was potentially a factor according to Participant 8:

> Quote 25: “The tires are relatively smooth, and you can get like mountain bike tires. But the ones I've got are relatively smooth, just probably run-at-the-mill wheelchair tires. They are

> expensive ones that I've got a special coating inside to try and prevent punctures”

This highlights that the participant’s familiarity and confidence in their wheelchair can influence when and how they will navigate kerbs and where they perceive the risk is low enough to attempt a crossing.

These findings were supported by participants, reinforcing the importance of the kerb height factor as a key challenge to wheelchair and scooter users. Participants indicated that it may be that the greatest problem faced while using a wheelchair is the height of the kerb due to the potential tipping hazard or inability to crest the kerb and move from the carriageway to the pedestrian footway. A steep familiar kerb could be negotiated with assistance from somebody by tilting back the wheelchair and pushing. However, significant height required a high degree of tilt to get down or up to the footway. This could also result in issues as described in Section 3.3.3.

Participant 6 reported it to be easier descending kerbs with an electric wheelchair; without the small castors but identified a greater hazard in ascending the kerbs to the footway.

Some wheelchairs have available accessories for increasing stability that consist of forward-facing larger wheels or anti-tip wheels that can be fitted to project at the rear. Participants reported these to be assistive but difficult to fix to the chair, leading to a requirement to add at the beginning of a journey or risk hook-up trouble later as they could not easily be removed on the streets by a single person. Participant 9 continues:

> Quote 26: “I've got on the wheelchair that I've got is stabilisers, which are good, because that would prevent you from tipping right back. But in general, it would be quite difficult to negotiate, I'd probably have to look for something like a crossing, which has got a, you know, a ramp down”

Another area of comment regarded the design of wheelchair suspension to reduce vibration and shocks. With prolonged use, the uneven condition of the footways, kerbs, and roadway generated vibrations and oscillation that caused severe back pain. Extreme acceleration shocks, and vibrations from casters, could lead to immediate significant pain and muscle spasm.

3.10 Strategy

Participants explained that side roads and private accesses which cross or interrupt the footway were common locations for them to negotiate changes in kerbs heights, and as such were considered by the participants as hazards. This was particularly evident at gaps for business entrances and private housing driveways for example.

For the visually impaired participants they detected these changed using a number of methods, for example, elements such as cane use, dog assistance and physical touch.

During the online interviews participants described their approach to such crossings. Participants agreed they would initially look for a controlled crossing, and if a controlled crossing was unavailable, they would attempt an uncontrolled crossing where they felt personally safe to do so.

Situational awareness, built internally using tools such as apps, sensory scanning, or human assistance were discussed as being helpful to inform these decisions.

Visually impaired participants reported a strategy generally involved progression along the middle of the footway while taking in navigational information and assessing crossing points and potential hazards. The current traffic situation would also be taken into account. According to Participant 2:

> Quote 27: “I wouldn't normally expect to use the kerb to navigate along the pavement as it were. Unless it's a very narrow pavement, when you can't avoid locating the kerb with your stick and, and you can use that the ones not to accidentally step out into the road, for a wide pavement with plenty of room, I would, I would try to walk along in the middle of the pavement as far as possible, because if you were to follow the kerb, there are lamp posts and all sorts of other stuff, usually on the outside”

To maintain a centreline in such excursions, progress was made in centre of the footway using a mixture of indicators. This included echolocation to identify solid shopfronts and footway obstacles.

For example, Participant 2 states:

> Quote 28: ”it’s a mixture of the noise of the cane and your footfall as well. I think those are the main things, you're getting a signal from solid objects, especially solid objects beside you. It's easy to detect objects next to you rather than in front of you, interestingly. So, Echolocation is very useful for navigating a straight line along a pavement in built-up areas where you generally have an assortment on your left or right or whatever it is”.

However, not all visually impaired participants were trained in the use of this strategy or able to use it. They relied upon the use of their primary aid, e.g. a cane or guide dog, to maintain their central position and assess hazards.

4 Site Visit Feedback

4.1 Introduction to Video Study Findings

The site visits were conducted using the methodology described in Section 2 of this report. Each of the participants gave a verbal commentary at each of the site locations and this section contains a summary of the most prevalent and prominent themes determined from the site visits carried out for this phase of the research. Five of the participants from the online interviews were available to undertake the on-site phase of the works. The numbering system used to identify the participants, as seen in Table 3-1, has continued to be used for this element of the study.

4.2 Participant 2

Participant 2 had no vision and was a younger person requiring the use of a cane; they also have some hearing impairments. However, assisted hearing with hearing aids were adequate for close speech. This section gives a summary of the key themes the participant highlighted during their site visits at the sites discussed in Section 2.6.

4.2.1 Crossings

During the site visit at Constitution Street, Participant 2 was able to identify the kerb with the use of their cane and noted they would be comfortable to traverse this kerb and crossing the road with the use of their cane.

They were also able to identify the newly installed tram track while crossing the carriageway. The participant was able to detect the crossing point and the Pedestrian Demand Unit (PDU) from the footway with the use of the tactile paving, as shown in Figure 4-1.

Figure 4-1: Controlled crossing with tactile paving at Constitution Street

The participant reported relying on people to guide or help on occasions when crossing cycleways. During the site visit at Picardy Place, they noted that it was impossible to tell when they were approaching the cycleway from the footway, see Figure 4-2. They reported that the tactile paving was not providing any detectable difference to the participant using the cane at that location.

Figure 4-2: Cycleway crossing at Picardy Place

From observation and listening to the feedback from the participant the level of conspicuousness of tactile paving and kerbs can be considered to be a key factor in their ability to complete the safe use of these areas.

4.3 Participant 4

Participant 4 has hearing impairments; however assisted hearing through the use of hearing aids is adequate for close speech. They also have some balance issues. This section gives a summary of the key themes the participant highlighted during their site visits at the sites discussed in Section 2.6.

4.3.1 Longitudinal Kerbs

A recurring issue raised by this participant was the height of the kerb from the footways to the roadway and cycleways. The participant considered that the height of the kerb was not distinct along the newly constructed cycleway between the footway and the segregation island. However, this was a subjective impression based on the lived experience of multiple functional impairments.

The participant made observations regarding kerb height during the site visit to George Street. It was evident that the conspicuous double kerbs of varying height were present at the disabled on-street parking markings as shown in Figure 4-3. This area is understood to be constructed pre-2010 and the Designing Streets policy. Other participants observed that these older disabled parking areas were too narrow for safe use as a wheelchair was forced to approach from the roadside where little separation from traffic was available. This was considered hazardous for disabled users. However, it was noted the kerbs present at the bus stop at this site were good for pedestrians and wheelchairs.

Figure 4-3: Kerbs of varying height at disabled on-street parking

This participant did not have issues with the kerbs due to their functional impairments, however, they made valuable observations based on their lived experience and using their local knowledge. Their lived experience with non-inclusive design with regard to their own impairments had given them insight to the needs of other functionally impaired users.

4.3.2 Crossings

Another issue raised by this participant was the inconsistencies in road markings during the site visit at Picardy Place. It was demonstrated that the cycleway crossed the carriageway with some inconsistencies in the road markings. For instance, the painted cycle picture is only in one part of the cycleway junction, as shown in Figure 4-4. They noted these inconsistencies were present where the cycleways are connecting with the carriageway and that the intended directionality was unclear, presenting a substantial hazard of collision with vehicle traffic and other cyclists. It was also observed that footway obstructions by cycle parking facilities were potentially hazardous on small buffer areas between the carriageway and cycleway, as shown in Figure 4-4.

Figure 4-4: Road and cycleway markings noted as unclear

Although these observations represent the lived experience of the participant due to their multiple functional issues, the observations also relate to the issues faced by other users. Observations in this site were subject to temporary road works and this was taken into account when considering the live (usable areas).

4.3.3 Surface Type Contrast

Some observations were made regarding the road surface colour during the site visit at Picardy Place. The contrast in colour between the footway, carriageway and tram surfaces was described as good by the participant. In addition, the kerb stones developed increased contrast in colour when wet but the contrast was also reduced where the wet surface darkened. Similarly, the participant noted the contrast in the colour of the footway and the cycleways as shown in Figure 4-5.

Figure 4-5: Contrast in colour between footway and cycleway

Again, this participant was referring to their lived experience and the observation about the contrast is useful as it relates to all users.

4.4 Participant 5

Participant 5 had very low physical movement and required the use of a wheelchair, representing the approximate mean level of capability in this group, and occasionally requiring assistance. This section gives a summary of the key themes the participant highlighted during their site visits at the sites discussed in Section 2.6.

4.4.1 Controlled Crossings

During the site visit at Constitution Street using the temporary controlled crossing at the signalised junction, Participant 5 noted that the kerb height and the sloping towards the carriageway between the road and the footway at the traffic junction, as shown in Figure 4-6: Constitution Street controlled crossing point could cause the wheelchair to tip over if there was a stabiliser on the wheelchair.

Figure 4-6: Constitution Street controlled crossing point

From observation and listening to the feedback from the participant a key problem for wheelchair users as it relates to the kerbing arrangements is the drop height more than the shape. Figure 4-6 also clearly shows the difficulty in assessing the kerb height on the other side of the road. These could be measured as this is the determining factor on whether they will be able to traverse them without tipping over.

4.4.2 Cycleway Crossings

This participant was not comfortable with crossing the cycleway during the site visit at Picardy Place. It was evident that they were unable to hear approaching cyclists and considered them a significant hazard while crossing the cycleway, as shown in Figure 4-7 by a passing electric cyclist.

Figure 4-7: Electric cyclist approaching at speed

From observation and direct feedback from the participant there was clearly a strong perception of the risk of collision from cyclists and the perception that the outcome of any collision has the potential to be more serious for mobility impaired users who often experience fragility, as discussed in Section 3.3.3.

As it relates to kerbs it has be seen that the chamfered arrangement can allow mobility impaired users to enter down onto the cycleway. But depending on momentum, wheel type, and user it can result in difficulties getting up and out. This is particularly true if there is psychological pressure due to the presence or perception of cyclists approaching.

4.4.3 Notable Kerb and Road Arrangements

During the site visits at all locations Participant 5 expressed difficulty ascending and descending from various kerbs. Specifically at George Street where there was on-street parking that they considered to be untraversable.

Some kerbs on the non-managed area of the Constitution Street site were considered to be hazardous by the participant. For example, a cobbled footway section for a private access caused painful vibration of the wheelchair and was difficult to traverse as shown in Figure 4-8.

Figure 4-8: Constitution Street, cobbled entranceway

Another noticeable issue with regards to cobbled surfaces was observed at the George Street site where the car parking areas in the middle of the road are cobbled. The participant noted that the cobbles separating the roads are difficult to traverse as they caused the wheelchairs to wobble (pitch and lateral acceleration). Similarly, the participant noted that uneven cracked footways were hazardous to wheelchair users, which was a theme that was frequently recorded from statements of other participants in the overall study.

Furthermore, the interactions between pedestrians and people in wheelchairs was seen as problematic on the footway, particularly where street furniture and restaurant seating used footway space as pedestrian and other footway traffic was mixed.

4.5 Participant 7

Participant 7 had low visual capability that required the assistance of a guide dog. The dog with him at the site visit was a relatively recent (6 months) and he considered it to be “still learning”. They also had hearing impairments; however, their hearing through the use of hearing aids was adequate for close speech, although they used subtitles when watching TV. This section gives a summary of the key themes the participant highlighted during their site visits at the sites discussed in Section 2.6.

4.5.1 Longitudinal Kerbing

During the site visit at Picardy Place the participant noted that they could recognise the kerbs adjacent to the cycleway and felt that the kerb was useful and beneficial for the crossing of the cycleway as it provided a physical boundary that could be felt between the provisions.

However, there was a part of the route where they could not detect the boundary between the footway and the cycleway, which resulted in them moving into the cycleway by accident, which could have resulted in a collision. This happened at the location where the kerbs along the footway flattened out to the level of the cycleway with no tactile paving present to indicate a change.

They also reported that it is difficult to know if any cyclists were approaching them as they were unable to hear them approaching.

Another noticeable and potentially problematic issue identified at the same site was that the footways in the area were graded in such a way that at crossings the footway and cycleway would be at the same level, in a raised table format, as shown in Figure 4-9. The participant noted that this was not their preferred crossing arrangement, and they considered it to be problematic; regardless of whether tactile paving was provided on both sides of the crossing.

From the online interviews it was noted that the raised table format of crossing was not the preferred type of arrangement for many types of impaired user due to the previously discussed risks. The participant did not find the tactile paving helpful in this case onsite because it is entirely at the same grade and level as the cycleway and does not provide them any directional information or feedback that would allow them to safely utilise it. They highlighted that they felt that it was purely designed for cyclists and had not considered the needs of road users such as themselves.

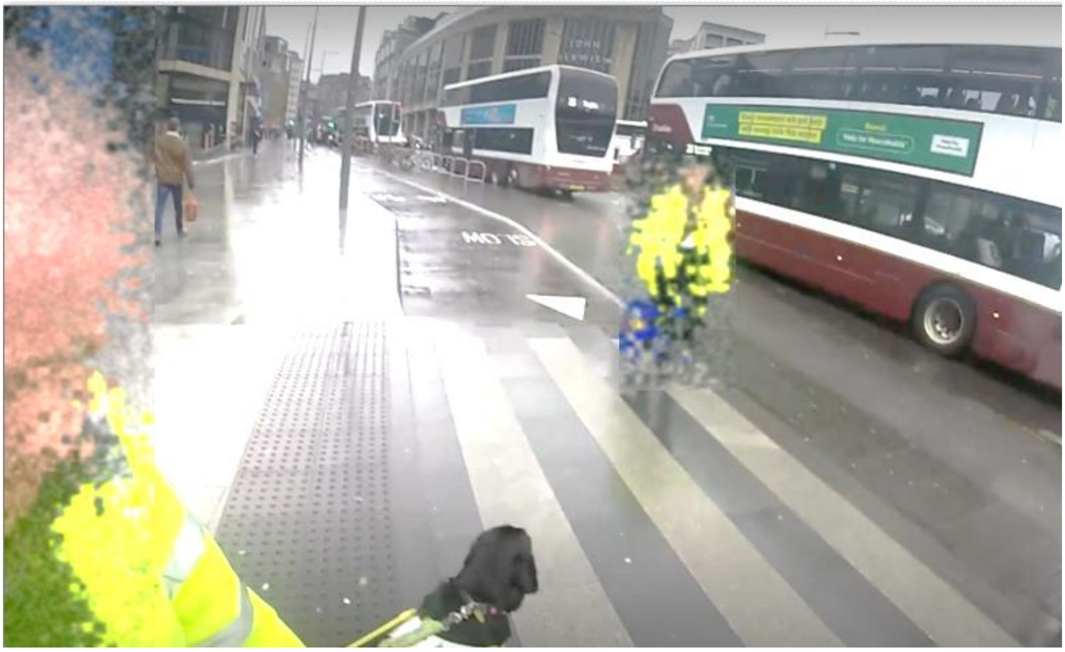

Figure 4-9: Raised table cycle crossing Picardy Place

The participant noted that the kerb height separating the road and the cycleway was acceptable, in general, except for the previously described raised table arrangement crossing.

4.5.2 Road Crossings with Guide Dog

An important issue noted at all the site visit locations was when the guide dog, that was suitably trained, found it difficult to walk straight across the road several times during the visit. As shown in Figure 4-10, the guide dog frequently adopted a diagonal route across the road, potentially due to its perception of hazards. George Street contained a central area used for parking, and this may have been an unfamiliar arrangement to the guide dog. However, this is not unusual in Edinburgh.

Figure 4-10: Guide dog crossing diagonally without clear crossing point

Furthermore, in addition to the inability of the guide dog to walk directly across during informal crossings, the guide dog was also evidently confused and unable to guide the participant to the push button unit at the crossing point as shown in Figure 4-11. This was potentially due to the presence of temporary signage but the dog also did not appear to detect the tactile paving.

Figure 4-11: Guide dog guiding participant at push button unit

There is potential that these arrangements are causing confusion to the participants and their guide dogs. This makes them less confident in travelling along the routes and undertaking informal crossings. This can be further compounded by inconsistent kerbing arrangements that may not fully meet the needs of functionally impaired users.

4.5.3 Cycleway Crossings with Guide Dog

The guide dog tended to walk around pedestrians and cyclists. Specifically, the participant noted that his guide dog would usually not stop for the cyclists but would walk around them as shown in Figure 4-12. It should be noted that the cyclists did not stop and often did not slow. The guide dog crossed toward the cyclist and had to take evasive action to avoid a collision as the cyclist passed.

Figure 4-12: Guide dog interaction with cyclist (Cyclist not stopping)

Closely related to the interaction of the guide dog, pedestrians and cyclists, the guide dog was further confused walking toward a parked Taxi as shown in Figure 4-13. This may be potentially be due to the parking area not being clearly defined as separated from the carriageway.

It was, however, also possible that the guide dog was confused about the intention of the visually impaired participant. The participant described how he had developed micro signals to the guide dog over time, conveyed with hand and finger movements, but was unclear regarding the nature of these signals. He reported that the dog; that was relatively new to them, was “still learning” these and therefore considered that the results could be variable.

Figure 4-13: Guide dog mistakenly crossing opposing traffic stream

As can be seen in the figures above these interactions often happened in areas where there is a lower profile chamfered kerb to distinguish the separation between the pedestrian footway and the cycleway.

From observation and interpretation of the feedback from the participant it was possible that the guide dog and participant did not find these kerbs sufficient to assist in the differentiation between the routes. This confusion could lead to functionally impaired users becoming confused and travelling into opposing traffic streams.

4.6 Participant 8

Participant 8 has very low physical movement with no movement of the legs (Paraplegia) and required the use of a wheelchair with occasional need for assistance. However, they were physically able to manoeuvre their wheelchair and confident in their ability to do so. This section gives a summary of the key themes the participant highlighted during their site visits the sites discussed in Section 2.6.

4.6.1 Crossing Signalised Junctions

This wheelchair user noted that the push button unit at the temporary signalised junction used during the site visit on Constitution Street was too high for them to use comfortably at wheelchair height, as can be seen in Figure 4-14. As can be seen in the picture the push button unit on the permanent crossing that was newly installed but not yet in use at the time of the interview was at approximately the same height.

Figure 4-14: Wheelchair user perceived push button unit to be too high

There was also a possibility of the wheelchair rolling forward into the road traffic as there was a gradient leading to the kerb edge shown in Figure 4-15. The proximal kerb was flush with the roadway and the farthest was within capability. It was noted that the tactile paving could not stop the wheelchair from rolling down and that both arms were required for stable braking.

Figure 4-15: Possibility of wheelchair user rolling down graded tactile paving

The observations raised by this participant when considered in the context of this study is that there are a lot of factors working against the impaired user as they attempt to cross at these controlled crossings. It should be remembered that they are subject to timed signal changes and have to be traversed with other pedestrians. As such standardised arrangements would help as it would give them less to consider and assess as they make their attempt to cross safely.

4.6.2 Uncontrolled Crossings

The participant demonstrated the difficulty of crossing the road where there was no controlled crossing on Constitution Street, as shown in Figure 4-16. They noted that the front wheels of the wheelchair were smaller than the kerb which meant they couldn't roll over the kerb. They demonstrated the physical manoeuvre which involved to traverse the kerb by rolling back on the two large wheels, lifting the two front wheels off the ground and onto the kerb top, and then pushing off with the two large wheels. It was noted by the participant that the kerb heights were higher where there was on-street parking.

As a confident and highly able wheelchair user they reported being happy with this manoeuvre and height of the kerb. However, it was noted that the kerb was likely to be hazardous for many wheelchair users that were perhaps less experienced, less confident, or less physically able in their manoeuvring.

Figure 4-16: Participant demonstrating how they go up/down kerbs

With respect to the kerbs bordering the cycleway at Picardy Place, the participant noted that they would attempt the kerbs along the cycleway without a crossing. This was demonstrated during the site visit by negotiating the kerbs with the wheelchair. It was raised by the participant that the kerb, shown in Figure 4-17, cannot be easily seen due to poor contrast between the kerb and cycleway surfacing.

Figure 4-17: Poor contrast between kerb and cycleway surfacing

The sloping footway, drainage covers, sloping footway and crossing paths, shown in Figure 4-18, were perceived as hazards that could cause the wheelchair to turn over or tumble.

Figure 4-18: Sloping footway perceived as hazard by participant

From observation and listening to the feedback from the participant a key problem for wheelchair users as it relates to the kerbing arrangements is the height more than the shape. These could be measured as this is the determining factor on whether they will be able to traverse them without tipping over.

4.7 Noise and light information measurements

Information on ambient noise and light were collected at the three site visit location at the time of the site visits. The maximum and minimum noise and light levels at the time of the site visit were taken using hand-held noise and light meters. The ambient light was recorded in the 40k range, while ambient noise was taken over 1 minute to allow sufficient width of time window and band-width for data sampling.

It is noted that the ambient background noise in typical urban areas varies from 60 to 70 dB. Though, for some streets it reached 80dB.

Figure 4-19 shows the maximum and the minimum noise levels for the three locations (Constitution Street, Picardy Place and George Street) at the time of the site visit with the study participants. The chart shows that the noise levels measured at Picardy Place ranged from a minimum 62.4 dB to the maximum of 79.6dB.

According to Participant 4, a hearing-impaired participant, they stated “a lot of Deaf people become deafer when they're outside” (see details in Sections 3.3.2 and 3.8.4). This was explained as being a masking effect of ambient noise for hearing aids; possibly resulting from automatic noise threshold compensation), and also for masking occurring in regular hearing itself, and particularly in amplified hearing where frequency filtering is not present.

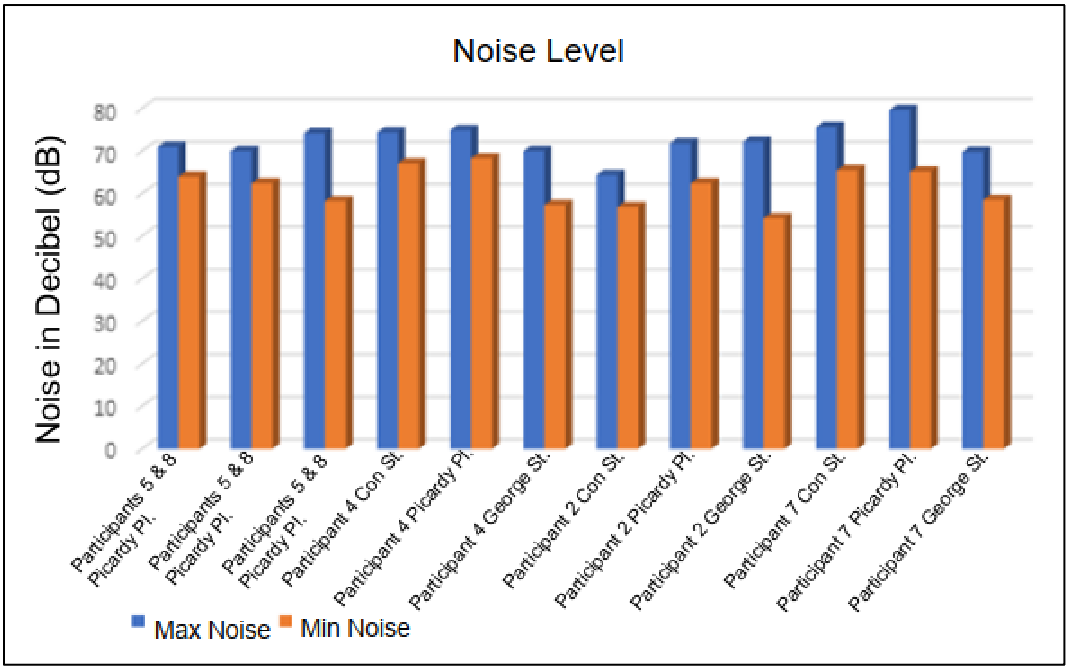

Figure 4-19: Noise Levels for Each Site Visit

4.7.1 Kerb Luminance and Contrast Analysis

Figure 4-20 shows the maximum and the minimum light levels for the three locations (Constitution Street, Picardy Place and George Street) with participants with varying degrees of capabilities. Light level varies season to season, even day to day.

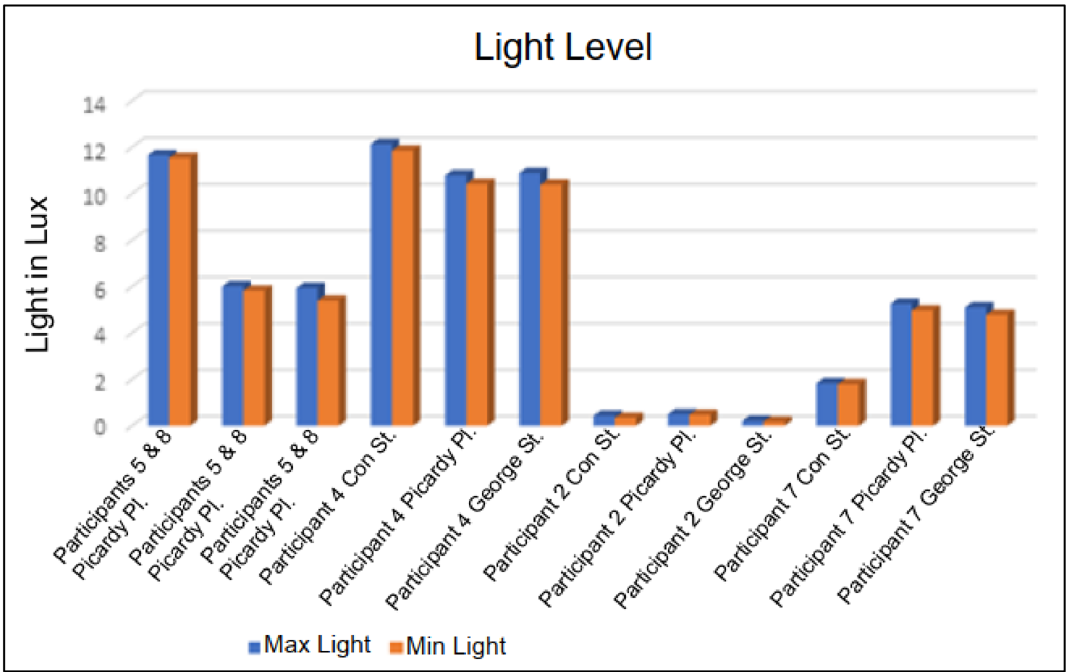

Figure 4-20: Light Levels for Each Site Visit

There is little evidence that the influence of the light level or resulting contrasts of kerbs and roadways or cycleways affect the visually-impaired participants and guide dogs from seeing or identifying the kerbs (see Section 3.3). The reported transcript sections where visibility issues were identified are given in Table 4-1.

Table 4-1: Transcript Occurrences of Visual Issues

Section	Issue	Reason
3.3	It emerged that identifying where the actual kerb of the crossings are located could be a significant problem	When the tactile pavement is constructed, it may terminate at some distance before the location of the beacon post
3.3	Sunlight causing difficulty to see lantern signal at controlled crossings	A concern for participants with partial vision, reinforcing their overall frustrations with the challenges of locations and the positionings.
3.4.1	Ambiguity of tactile pavements near kerbs were seen as sources of	A very shallow kerb that then sloped down to a shallow angle might not be as easily identifiable as some as a steeper or higher one

Section	Issue	Reason
	confusing and disorientation	
4.5.1	Flattened tactile paving with the kerbs along the cycleways	The kerb height separating the road and the cycleway was fine except for what he described as a "mess" having pavement and cycleway flattened at the cycleway crossing with the push button unit
4.3.3	It was highlighted that the kerb cannot be easily seen	Kerbs bordering the cycleway (See Figure 4-5)
4.5.3	The appropriateness of the drop-down in those locations was unclear.	The participant considered that the dropdown of the kerb was not distinct along the newly constructed cycleway and the adjacent road.
4.4.3	A corresponding hazard for the visually affected	Ascending and negotiating the kerb at the far side of the crossing point is also affected by the visibility of the distal (exit) kerb.

4.7.2 Key Sound and Vision Measurement Themes

In summary, ambient sound levels are critical to the formation of situational awareness, particularly for very low vision people dependent on canes or guide dogs. The sound of traffic was reported to be used to locate the main roadway, thus orientating the pedestrian to the direction and location of building frontage.

In the case of very high ambient noise from traffic, pedestrians, shops and buildings, it was established that this could disorientate and impair function for those relying on hearing aids, due to the effect of frequency masking on unassisted (but low capability hearing), and on hearing aids. In addition, the directionality and audibility of audible crossing signals were affected by high levels of noise particularly at complex multi-section crossings where more than one signals was present. This was hazardous as it was possible to commence crossing the incorrect section when a signal from a nearby crossing was perceived as being adjacent.

High ambient sound (dB) levels and the complexity of noise can also mask quieter sounds, such as approaching cyclists, which were reported by the participants as a highly perceived hazard.

Taking the qualitative reported issues, photographic and video evidence and the objective illumination and contrast evidence together, it was concluded that the visibility of kerbs was dependent on a number of factors such as: distance of viewing, ambient light levels, weather conditions, colour, material dryness, and incidence of viewing angle. This principally affected wheelchair participants but was not significant in the case of very low vision individuals who relied on cane or dog assistance. The visual contrast of kerbs was not reported as a major problem but was part of a number of hazards that contributed to the overall perception of risk. This reflected the complexity of high-level visual perception and remains an area where further research could benefit the evidence base.

4.8 Discussion of Findings (Integrated Interview and On-site)

There were a number of findings reinforced by both interviews and site visits. For this integrated section the multi-capability issues are dealt with in a combined format, reflecting the entire experience, enriched by the site visit videos and commentaries.

The qualitative analysis of the combined corpus of transcripts for interviews of the participants revealed a number of difficulties and issues that were specific to capability (vision, hearing, thinking). However, it also emerged that many of these considerations were linked as a result of the effect of design and nature of kerbs and crossings and were, in fact, impacting multiple capabilities at the same time. For example, perception of the steepness (drop) of the kerb was a concern for visual impairment, when using sticks and guide dogs, but was also an issue for wheelchair users negotiating kerbs within the engineering parameters of safety of their wheelchair designs. The issues for both vision and hearing capabilities were therefore frequently co-located such that location and alignment of the participant for visual impairment was also linked to the form, layout and visibility of the nearside and far side kerb descent and ascent.

The purpose of the Phase 3 study was to investigate the role and configuration of actual kerbs within the build environment, building upon the foundations of the overall programme:

- Phase 1 Literature review and determination of research credentials;
- Phase 2 Formative methodology development and surveying of sites.

The Phase 3 investigations carried out consisted of:

1. A collection of interviews with people with differing capability variations sampled from a matrix sample encompassing high, medium and low levels of capability, as defined by functional scales of vision, hearing and physical movement, thinking and systemic capability.
2. A selection of site visits during which participants were asked to report on the considerations of crossing at identified sites, in situ, with video and audio recordings of their commentary as they progressed. Researcher participation in the site visits was confined to pre-decided schedule of basic questions and any utterances that were to ensure safety.
3. The transcribed recordings of both interviews and site visit commentaries were thematically coded and then recoded once integrated together. The resulting summaries of the themes were prioritised on frequency or reference and the power of the method.

4.8.1 Multi-capability Issues with Crossings

Participants reported challenges with controlled pedestrian crossings which cross both a cycleway and carriageway. These issues were associated with relatively recently constructed pedestrianised crossings where they perceived the tactile paving was positioned too close to the crossing point, with no ramp or tail to the kerb edge. The users, both physically and visually impaired perceived this as a safety concern to people with reduced capabilities.

Those participants with reduced physical movement noted that kerbs they perceived as high with steep crossfalls to the carriageway crossing were the key challenges. For wheelchair users the dropped kerbs at the start of crossing; whether at controlled or any other area, constitutes a focus for stress in crossing the road due to the potential for tipping or falling over if the drop is too steep. In particular, the front caster wheels of wheelchairs are small in diameter and may jam into the kerb corner, even or especially when stabilisers were fitted that might foul the surface. Causally, the centre-of-gravity of the chair with user combined may be passed, causing tipping and falls. Wheelchair restraint straps were assumed to be in use.

Equally, ascending and negotiating the kerb at the far side of the crossing point (controlled or otherwise) presented similar issues. In this case, the centre of gravity could lead to tipping backwards during attempts to lift the smaller front wheels onto the kerb top. This was seen as particularly dangerous, as tipping backwards inevitably led to injury or unseating and presented a difficult recovery position in a live roadway that was dangerous, embarrassing, and could require assistance.

A corresponding hazard for both the visually affected and wheelchair users whose visual capability was good, was perceiving the kerb dimensions on the far side of the chosen crossing point. This was a risk issue as the individual who was crossing was committed once the crossing started and may not perceive kerb hazards until reaching the far side.

Additional complications accrued because of standing water in drain gullies, while snow or ice had the potential of visually obscuring the kerb dimensions, increasing the perceived risk. This was reported to be aggravated by poor visual contrast between kerbs and roadway and between kerb and pavement in various conditions.

All participants reported that if they judged the risk of crossing as at a specific location was too great they would look for nearby controlled crossings to achieve a safe crossing.

Concern was directed towards the timing of a crossing attempt because reorientation or visually searching the far side of the crossing while traversing was time consuming. When traffic signals changed or some undetected hazard approached this could lead to being stranded in the road. This generated some anxiety and apprehension, often leaving the potential user of the crossing waiting by the kerb, interacting with other crossers or blocking the passage of those behind, until they had a sufficient certainty they could cross safely.

Other challenges raised around the controlled crossings include broken or cracked, uneven, slab pavements and potholes. Participants reported incidents of the wheelchairs becoming jammed in potholes and being unable to extricate themselves without assistance. Potholes were particularly hazardous when close to kerbs where the wheels could stick in the holes. The participants noted that metal, slotted drains were perceived as a hazard and were occasionally sited at crossings. Such drains were also reported as an issue in negotiating kerbs and footways elsewhere as they trapped wheels.

However, no adverse reports were associated with tram lines. In some cases wheelchair users reported that they did not notice crossing them.

For wheelchair users in particular it was noted that sometimes there was insufficient time allowed for them to traverse controlled crossings comfortably. The insufficient crossing timing was reported to lead to difficulties and increased risk and stress. Psychologically, such time limited, countdown, situations are known to generate anxiety, stress and poor decision making.

For visually impaired users this is compounded when the auditory signals stops before they have reached the far side and they are unable to orientate themselves. They reported that at locations with multiple adjacent crossings the overlapping and changing of location of non-directional auditory signals can be disorientating and confusing. This could cause users to become lost or enter the carriageway at the wrong time.

Manoeuvring to locate and press the demand button was reported to lead to instability and disorientation. There was the potential for uncontrolled or involuntary incursion into the roadway, especially on the descent to the carriageway. Some push button unit positioning could require the wheelchair user to stop on the slope close to the carriageway leading them to attempt braking with one hand and pressing the button with the other, in an unstable configuration.

Where these crossings were shared between multiple different user types, such as cyclists and pedestrians, it was raised that reaching the button or aligning for crossing was challenging. The participants also noted that, while many citizens were accommodating and helpful, sometimes other crossing pedestrians were a hazard particularly if inattentive because of mobile devices. According to Participant 9:

> Quote 29: “I would say sometimes, the other pedestrians can be a bit of a problem. Because sometimes when I’m using the

> walking stick (CANE), sometimes people can be really good and give you a wide berth and give you enough space to get over. But if there's somebody trying to cross, you know, either with the chair or stick, that can be problematic, but that's just people."

There is a common emergent strategy that was necessary for most categories of capabilities when crossing at formal crossing points:

1. Orientation to and location of crossing drop kerbs and push button units (avoiding pavements obstructions such as service chambers and potholes),
2. Visual or auditory sensing for vehicles and the actions of other pedestrians,
3. Visually and physically assessing the kerb depth on nearside and far side,
4. If no present danger of vehicles were detected, crossing was initiated.
5. If an immediate hazard was detected the user would wait in place for these to pass before crossing.

The strategy described above was not sensitive to quiet vehicles, such as cyclists or electric vehicles, for visually impaired users. This increases their perceived risk levels and chances of collisions with such vehicles. It was reported by all participant categories that it was their perception that cyclists frequently do not signal or stop to allow the people who are challenged in capabilities to cross. There was a belief that, in some instances, cyclists would continue through red lights on the carriageway when people were crossing the road with a green-man. Similarly, to the earlier discussion regarding adjacent multiple crossings, it was generally reported that there was a challenge where crossings were shared between cyclists, pedestrians, baby carriages, dogs, and other capability limited users. However, despite this, participants considered this combined risk as "expected as normal".

4.8.2 Kerb strategies

For visually impaired participants kerb detection involved cane use or other means of developing or maintaining situational awareness such as sensory scanning, prior reconnaissance, the use of Apps, or assistance. This was particularly related to gaps at business entrances and private housing driveways, for example. The reported strategies involved choosing to progress along the pavement in a particular direction according to navigational information to assess crossing points and potential hazards. This was situationally related, depending on known orientation, familiarity and perceived location with respect to a mental, actual, or virtual map. Routes may have been planned in advance or could be informed by mobile applications using distance and landmark identification reports.

To maintain a centreline on the footway in such excursions visually impaired participants used a mixture of indicators. This included echolocation to identify solid shopfronts and pavement obstacles. However, necessary deviation was common and immediate in the case of the very low visually capable, even using guide dogs (See Section 4.5).

The finding of orientation for direction could also be managed by directional location of traffic noise and maintaining gradients. However, this strategy was reported as less effective in larger open spaces, such as complex pedestrianised areas. Participants reported that it was sometimes possible to orientate themselves directionally by using a crossfall towards the carriageway. Kerbs were usable as an indicator of the boundary if they could be detected using the cane, especially for individuals with low hearing capability.

Notably, the height of the kerb was deemed to be of low importance, the requirement was only that the kerb was detectable. A mental map was reported in some cases based on prior experience or for those comfortable with the use of compass directions and a prior knowledge of locale.

For all participants road construction work, or implementation of new layouts and designs, were identified as a source of frustration. For visually impaired users this changed their mental map of an area resulting in confusion and disorientation. For physically impaired users the temporary crossing points and passages were reported as being often poorly placed or constructed.

4.8.3 Weaknesses of the Study

The ambition of Phase 3 was to represent the proportions of the Scottish population who reported difficulties in daily life at various levels of severity in the functional areas (see Figure 4-21). These statistics were calculated and presented in Phase 2 report along with the sampling approach and capability levels.

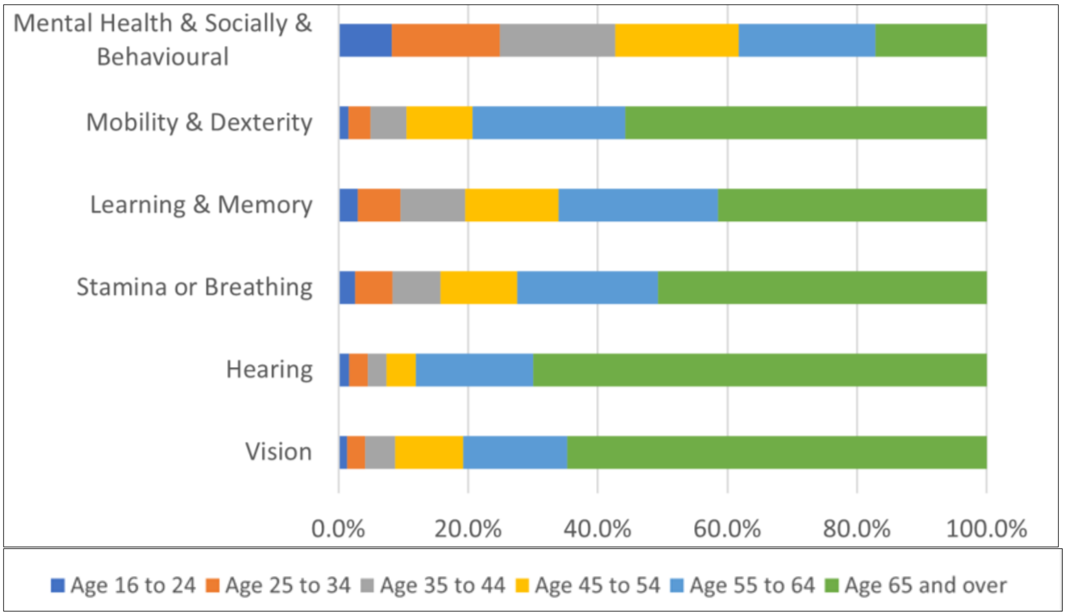

Figure 4-21: Breakdown of Functional Impairments in Scottish Population

The participants in Phase 3 were consistent with the analysed data from the Family Resources Survey (2019-2020) in that difficulties in daily life due to specific functional origins were strongly related to age with vision, hearing and mobility being predominant in the 55+ age groups.

This is important as; depending on location, more than 50% of the UK population is now over the national average age of 43. Priority was therefore given to low and very low level of capability in vision, physical movement, hearing, systemic and thinking (see Figure 4-21). It was also important to represent age groups and gender.

However, identifying and arranging the range of participants for site visits with the study period was challenging. Participants were volunteers who were agreed to participate during a normal working day.

The site visits were carried out within October and November, although site visits were planned and agreed for later months over the subsequent winter and spring these were cancelled due to personal participant and weather conditions. This led to a reduction of data gathering opportunities. In original matrix sampling in online interviews there were ten participants, as described in Table 3-1, of which five participants joined the site visits.

As can be readily seen in the video analysis section, weather conditions and ambient light were variable, and the kerbs were often wet. Traffic conditions, and so noise, also varied.

The study could not deliver a complete set of results without a high level of generalisability, as was discussed in Phase 2. This is particularly true if all the potential variables, such as: weather, time of day, season, site characteristics, and individual variabilities (within and between individuals) are taken into account.

The study in Phase 3 only sampled individuals with low to very low capabilities. However, it is considered likely that individuals with higher levels of capability might encounter similar, if attenuated, effects as those found from the participants. The possession of higher levels of capability could be expected to reduce levels of stress, reduce the requirement for prior preparation and real-time assistance, and increase the tolerance for other users'. In particular, thinking issues might occur in conjunction with the identified design issues discussed, leading to higher levels of risk and reduced overall capability.

Although numerical ranges and specific kerb parameters were recorded, many comments pertaining to kerbs were qualitative. Further trials of people exposed to physical kerb layouts would be necessary to converge on accurate numerical values for kerb properties. This could be achieved safely in a laboratory environment using systematic variation of parameters such as: variable surfaces, gradients, materials, shapes, and variable heights.

However, a number of findings were robust and reliable in the thematic analysis and are backed up by qualitative evidence (recorded statements and actions) at the sites. These constitute a set of robust, explainable, repeatable and complete findings linking individual capabilities to kerb and site properties, that were backed by a documented evidence trail, and represent lived experience.

4.8.4 Key findings

It was clear that despite the initial focus on crossing at site with particular selected properties, most participants immediately fell back on default behaviour. Typically, on being required to cross at a specific point they would decline and begin a commentary on alternative strategies, often finding a more acceptable place to cross, and demonstrating how it was better. These commentaries provided rich and detailed insights about the lived experience of individuals' capability variation. The holistic results then can be summed up as covering a wide range of interrelated physical contexts and considerations.

We determine that this more closely resembles the actuality than considerations of single factors, such as kerb height or shape, alone. Salient inferences are listed here:

1. A number of difficulties and issues were identified that were specific to capability (movement, vision, hearing, thinking).

2. Many of these considerations were linked as a result of the effect of the design and nature of kerbs and crossings and were, in reality, impacting multiple capabilities at the same time.
3. The kerb height was a concern for visual impairment but only for detection when using sticks and guide dogs. It was also an issue for wheelchair users negotiating kerbs within the parameters of safety of their wheelchair designs and capabilities.
4. The issues for movement, vision and hearing capabilities were, therefore, frequently collocated, such that location and alignment of the participant for visual impairment was also linked to the form, layout and visibility of the near-side and far-side kerb descent and ascent of a roadway.

The general strategy employed by those with low capabilities, whether visual, physical or other, was driven by the necessity for safety when faced with challenging kerb sites. In general, this started with a search for a safer location to cross, the search based on noise, surface properties and perceived safety of the road layout. This often defaulted to seeking in either direction for an established or controlled crossing. Since complexity and hazards increased at such “safe” crossing points, they had to be discovered anew – with apprehension; or dealt with based on prior experience of specific or similar crossing points.

This was well illustrated by considering the common crossing issues that were recounted (and demonstrated) by the low capability individuals. Many of these issues were also likely to present challenges to higher capability and combined capability individuals.

Manoeuvring and orientating with respect to the crossing was a pre-eminent initial requirement. Physical and perceptual challenges resulted from complex crossings where pedestrians, cycleways and street traffic were forced to interact dynamically. Key challenges that were reported included physical dimensional and mechanical issues with wheelchairs (see Section 3.9) and a range of tactile and perceptual issues related to the detection of hazardous layouts and assistive road markings and signal equipment. It was reported that significant negative emotions and apprehension was generated by these situations.

Perceiving the kerb haptically or visually was vital but making a judgement about the traverse-ability of the kerb on the other side of the road was deemed equally as important. Guide dogs were useful but capable of being confused and sometimes made actions whose usefulness were dependent on the quality of communication with their participant.

Controlled crossings presented a complex set of interrelated difficulties which could raise anxiety levels. However, controlled crossings were also considered to be relatively safe.

5 Conclusions

5.1 Conclusion

The study focused on gathering data from both online and site visits in preparation for lab-based research during Phase 4. At this stage, despite strict qualitative and quantitative methodology, not all data or information can be linked to a conclusion and the findings produced are tentative. However, they provide indicative, holistic information which may be developed and refined with further investigations.

The limitations of the Phase 3 study should be noted when considering the results provided. All the site locations used were located in one city and the total sample of sites is five for the online interviews and three on-site locations, resulting in only a limited range of locations being surveyed. Due to the availability of participants, the majority of the participants that volunteered at this stage of the study aligned with the more severe impairment categories.

The main themes that have come out of both the online and site visits are as follows:

Creating conspicuous edges is deemed essential to address the challenge of navigation for visually impaired users. This was particularly noticeable for cane users, as the height of the kerb plays a crucial role in helping them navigate and differentiate spaces. The significance of this issue can also be connected to raised table arrangements, which are further discussed below. This highlights the need to further explore and refine the usage cases in order to find suitable kerb height ranges for these types of participants in Phase 4.

Raised edges, such as kerbs, can form barriers to mobility which can trap users within a channel, such as a cycleway or carriageway, or prevent them from entering an area. Both may lead to user risk, and distress as well as travelling additional distances to reach their destination safely.

Another prevalent theme that cut across user groups, including cane users, guide dog users and wheelchair users, was the necessity for specialised training. Enhancing training, to include ways to best navigate inclusive designs, could prove instrumental in meeting the needs of the users and facilitating a better understanding of evolving styles in placemaking.

Addressing the placement of crossings is crucial, recognising that the users tend to prefer controlled crossings when accessible and convenient. However, it is essential to ensure that these crossings are strategically located and adhere to standardised layouts that enables impaired users to identify and engage with them in a positive manner. This ties back to elements such as, height of the push button unit, tactile pacing, entry gradients, and conspicuous edges, all in which aid distinguishing spaces.

A prevalent concern, from the participants, revolves around differentiating spaces effectively. Modern streetscaping trends to favour flattened kerbs to allow for free movement of people. However, these can pose a challenge for individuals with low visual capabilities, where individuals might inadvertently enter spaces with conflicting traffic such as cyclists or cars without proper awareness. This highlights the need to further explore and refine the usage cases in order to find suitable kerb height ranges for these types of participants in Phase 4.

Related to differentiation of spaces and a common issue raised across the participant groups was the varied designs of kerbs and raised table arrangements. These were observed to pose a disadvantage for the visually impaired users, impacting their wayfinding abilities and increasing the risk of tripping or falling due to inconsistent kerb heights. Notably, the visually impaired participants heavily rely on the conspicuous edges to differentiate spaces. Equally, the participants with mobility issues faces a different set of challenges, primarily related to physical wellbeing and the need to avoid risks like tipping when navigating the kerbs. This often limited their ability to cross conveniently and safely dependant on kerb heights.

It was observed that hearing impaired users did not face substantial challenges with kerb arrangements due to their impairment during this phase of the study. Their valuable feedback contributes to our understanding of usability for all user groups.

The overarching theme of route planning warrants further development, potentially incorporating considerations about kerbing arrangement, mapping, Apps, and inclusive descriptions.

Moving into Phase 4, an in-depth exploration should aim to find the optimal kerb height that allow visually impaired users to effectively differentiate spaces while not imposing undue difficulty for wheelchair users.

5.2 Recommendations

Due to the nature of the Phase 3 study no definitive recommendations on kerb heights and layouts can be made at this stage.

However, it is recommended that there is continued research utilising the data gathered from the online interviews and site visits.

Future studies should continue to acquire data in the moderate, and mild to moderate categories where possible. The studies should aim to address the range of impairments across physical movement, hearing and thinking capabilities, as well as systemic difficulties as far as is practicable.

A focus should be placed on determining a range of kerb heights that are of use to both the visually impaired users with regard to providing a conspicuous edge while not disadvantaging movement impaired users, particularly those using a form of wheelchair.

5.3 Next Steps

The previous phases of this study need to be validated in Phase 4 under controlled conditions which allow determined parameters (e.g. height, contrast, chamfer) to be adjusted. Controlled conditions also allow a wider range of impairment conditions to be considered in a safer environment.

Phase 4 aims to expand the study by conducting tests on kerb usage within laboratory conditions at ENU. A dedicated test rig will be constructed, allowing users to safely traverse kerbs with varying height, shape, and contrast under carefully controlled conditions. The team will accurately prepare a series of site-specific 'usage cases' for navigating the test rig, encompassing crossing of kerbs, featuring various heights, profiles, characteristics, and settings. ENU will construct an ideal platform located within a controlled indoor facility, facilitating participants to traverse kerbs with different heights and characteristics securely.

During the trial, inclusive design will take centre stage, focusing on understanding the demands imposed by kerb designs at each stage of the journey, which might render the action difficult, frightening, painful, or even impossible for individuals. A NASA TLX workload questionnaire will be used to baseline effort. A comprehensive design analysis will thus be conducted, leveraging trial findings to explore and develop mitigations that address inclusion issues, considering factors such as age, capability, and workload analysis. Design alternatives will be evaluated based on trial analysis; utilising metrics derived from multivariate statistical analysis of the collected data.

This study is poised to enhance comprehension regarding the impact of kerb design and usage on mobility, providing substantial evidence for robust kerb design; a domain that has been comparatively underexplored. The findings may pave the way for evidence-backed standards development, not only in Scotland, but also in the broader UK and beyond. The potential applications extend to related domains like crossings, signage, road markings, and vehicle automation, making this research a valuable asset for advancements in multiple related topics.

6 References

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APPENDIX A – Participant Capabilities

Full Description of Participants Capabilities

Participant	Age/Gender		Capability Range (1-7)	Notes
1	60-74	M	Very low visual capability (6)	cane user (PILOT)
2	18-29	M	No vision (7) Very Low hearing capability (7)	Blind. Assisted hearing adequate for close speech (PILOT)
3	30-45	M	Very low visual capability (7) Low hearing capability (6) Physical (1) Thinking (1) Assistance (3)	Assisted hearing adequate for close speech Requires assistance for specific situations
4	60-74	M	Vision (3) Very low hearing capability (5) Physical (2) Thinking (1)	Low visual capability, Assisted hearing adequate for close speech. Uses subtitles on TV. Dexterity good – balance weak.
5	60-74	F	Very low visual capability (5) Vision (1) Hearing (1) Thinking (1) Systemic (1) Assistance (3)	Spinal injury – arms an upper body only. Use wheelchair. Assistance required occasionally
6	30-45	F	Low physical capability (4)	Ambulatory wheelchair user. Can walk with crutches.

Participant	Age/Gender		Capability Range (1-7)	Notes
			Requires assistance (3)	Electric wheelchair. Mobility Vehicle.
7	60-74	M	Very low visual capability (3) Hearing (1) Physical (1) Thinking (1) Assistance (1)	Reg blind with some useful sight- wife with guide-dog.
8	60-74	M	Very low physical movement [5] Vision[1] Hearing[1] Thinking[1] Systemic[1] Assistance[2]	Spinal injury – arms an upper body only. Use wheelchair. Assistance required occasionally
9	60-74	F	Physical movement difficulties[3] Requires assistance [4] Thinking [4] Systemic [5] Hearing[6] Vision	Weakness, balance and vibration sensitivity. Occasional wheelchair user. Hearing aids. Mild cognitive impairment. Recent improvement in requiring assistance. Heart condition.
10	75-85	F	Vision[7] Hearing [1] Physical [1] Assistance [2] Systemic[1]	No vision. Uses long cane. Has been dog user. Can walk 15 miles.

Participant	Age/Gender		Capability Range (1-7)	Notes
11	18-29	F	Uncoded	Incomplete data

APPENDIX B – Coding Results

Full Coding Results

Name	Files	References
CAPABILITIES	10	89
Age range	8	10
Assistance and supports from people	6	19
Cane	6	12
capability levels	5	13
Hearing	5	27
Other Capability issues	6	9
Physical Movement	7	18
Thinking issues	6	11
Vision	6	18
exploratory sensing	2	2
Dogs	5	16
Hearing aids	3	10

Name	Files	References
Use of Cane	2	11
use of feet	1	2
use of sound	4	12
Listening	2	10
Noise	2	10
Sound	5	14
use of sound	2	9
Gender	6	8
Memory	2	3
Other capability needs	1	2
PUBLIC TRANPORT	1	1
stress	2	3
Fear and frustrations	4	6
training	2	4
Training (2)	3	3
Cities and Towns	4	15
Glasgow	2	5

Name	Files	References
Crossings	10	220
Aids to crossing	7	29
Green Man_Traffic lights	6	31
Lights -crossings	7	22
Highway codes	1	1
Ramp	2	5
Cyclists and cycle lanes	8	60
Pedestrians	7	41
General remarks	1	3
Research	3	9
Hazards	10	161
Autonomous vehicles	1	10
Electric vehicles	5	11
Safety	6	74
Safety	5	36
Vehicle drivers	2	2
Weather	2	3

Name	Files	References
Maps apps	8	51
GPS aid	3	16
Technology	1	7
Policies	2	3
Active Travel	1	2
STRATEGY	5	72
cues for crossing	2	23
Echolocation	2	5
familiarity	2	5
Journey	2	2
Kerb uses	2	5
need for crossing point	1	2
ON STREET	1	5
orientation	2	4
Point of Reference	1	1
Tactics in street	2	8
use assistance	2	9

Name	Files	References
Vision	1	2
STREET PROPERTIES	9	295
Bins	2	5
Bus stops	4	10
Cycleways	2	9
Design	5	41
drop down kerbs	4	5
Footways	1	2
Gradient	4	10
Kerb heights	4	11
kerbs	5	37
Kerbs function	2	8
Parking	4	8
Disabled Space	2	2
Pedestrianised areas	2	5
road busy	3	9
Road condition	9	75

Name	Files	References
Pavement	4	24
Road Work	3	4
Surfaces	6	25
side streets	2	4
Sight loss	2	5
Streets	7	38
George Street	2	4
Lamp posts	3	5
Layout	1	13
Living street	1	1
London road	1	2
Sauchihall Street (Glasgow)	2	6
Weldon street	1	2
York Street	1	4
Tactile paving	2	8
time of use	3	3

Name	Files	References
Wheelchairs and Mobility Scooter	6	69
Driving Adapted Car and Mortability cars	2	5
Mobility Scooter	2	8

APPENDIX C – Full Quotes

Online Interview Feedback Full Quotes

Quote 1: “I'm using a long cane, in the approved manner. So, I would expect to identify it with the cane. But if I didn't notice it with the cane by chance, I can tell it by what's under my feet. You can expect to feel the conspicuous edges”

Quote 2: “I've been trained and there's a specific long cane technique that you use, which means that you're moving your wrist so the cane. follows the arc in front of you. So, it covers your, the width of your, your you're walking, okay, occupy when you're walking and identifies things on the ground or a reasonably low level…it doesn't identify head height obstacles, obviously”

Quote 3: “a lot of Deaf people become deafer when they're outside when they're out and about so they're even more reliant on their eyes”

Quote 4: “But I think most hearing-impaired people have incurred their hearing loss gradually. So, I don't think they would be affected, I think unless they've got other issues, of course, like dementia, for example, or other cognitive issues. But I don't think the hearing loss per se is likely to be a major issue”

Quote 5: “I have had situations where people have caused me to fall out of my chair”. I'm on my own, they try to get you back into the chair, but they wouldn't listen to what I'm saying. They just try and stand me up. So please, just give me a minute. And I'll tell you what you need to do. But the girl that just wants to grab you and put you back into your chair, but they don't feel I can actually stand”

Quote 6: “Well, I suppose, maybe would drive round a route in advance, just to check it out. But that's far away. You know, I wouldn't drive an hour to Glasgow, to drive down the street to see if I could have access. But normally, if I was going to a meeting in Glasgow, you know, whoever invited me to the meeting would normally see, you know, give us a call “

Quote 7: “But she [dog] sees that happens quite often - that the tactile paving doesn't get right up to the width stops, and even stops even before the traffic light pole, so we are standing there going…"

Quote 8: "I swing working forwards and backwards, from right to left. And at the same time, I'm stepping forward on the canes going to the left, and stepping forward with that, so that I know that I'm not going to step down anything. Because the key that's for how it works for me, so I need to find tactile if I know I'm going to cross the road. Yeah, you know, it doesn't come to the building line, and there's a gap with just slabs, then I'm not going to know exactly where the tiers are"

Quote 9: "They are a complete nightmare and bikes, and scooters tend to go into the pavement as well and that's really disheartening"

Quote 10: "That's part of the problem with the Sauchiehall street, that was so much of that that did not have a kerb, so you didn't know when they cycled past… stuck … and for the whole street there are quite a distance there is actually no kerb, so you can actually walk onto the road, and you wouldn't really know as some people use canes"

Quote 11: "It's hard to explain how the cycle path is separated with road. I have fallen over them a few times."

Quote 12: "We came across a lot of hazards on route, there are so many parts that we had to use the cycle map. But still it wasn't clear where you were going. And we obviously tried to stay off busy main roads. But sometimes it was unavoidable. And some of the big roundabouts are very good in the fact that they have (inaudible) for bikes and pedestrians in that they do zigzag and managed to get you round with to go on to the main road at drop downs and proper places for crossing"

Quote 13: "They not so much with roads, but with cyclists and you know, cycle lanes in particular, this wave (COVID) started rolling out floating bus stops and floating parking in edge, you need to cross a cycle lane to get to your parked car…And cyclists simply don't stop… I don't know, for whatever reason. That is a concern."

Quote 14: "I nearly had a quite bad accident with bad pavement in (inaudible location) because my front caster caught the pavement, and it tipped me forward. And it was only lucky that, there was a bus going by, so I managed to push myself back off the moving bus. If it had been about two seconds later, I would have been under it. And they would have said, why did he commit suicide under the bus?”

Quote 15: “As a wheelchair user, I've, I've had very few problems. I mean because the buttons tend to be at a sensible height. And I don't tend to have to go into the road to press them and things like that. As a (recumbent) cyclist. They're dreadful, the Toucan crossing ones because I'm so low down, it's very difficult quite often to reach them. And quite often, I have to roll slightly into the road to be able to get up and reach them. And so, of cars coming by, I'll think, oh, he's just going to pull out in front of me. So, I have to be very careful about that.”

Quote 16: “Sometimes when there's a dog barking it can be I can find that difficult though because sometimes I don't know the dog is coming over here and the barking may actually put me off and sometimes what's happened is I don't realize that I may think the dog is coming near me, but actually it may be behind the fence. So sometimes it can take me off guard and I might get off a bit”

Quote 17: “I was invited to the Forth Valley sensory impairment unit and there is ‘Schwinn’, something that's been developed at Glasgow University”

Quote 18: “The idea is to carry that little app on your smartphone. And to have some technology in the crossing. So, it knows when you've stood there for something like five seconds, there's a timer. It doesn't activate the crossing. But if you stand near the box, for five seconds, it activates the Green Man. Just press the button. And it's designed for people who for whatever reason, yeah, to access the green, then it might be people with dexterity issues that aren't able to push the button. Exactly. So, there's a lot of technology being developed in that area”

Quote 19: “…a very shallow kerb that then sloped down to a shallow angle might not be as easily identifiable as some as a steeper or higher one. But, but, you know, I recognize the need to have dropped out kerbs further, and that users are fine, as long as they are sufficiently conspicuous”

Quote 20: “...up to 30 degrees. Certainly, I do take that a lot and I haven't been for quite a while, but George Street I think, I remember it poses great problems because it's such a high kerb drop"

Quote 21: "There's a site in Sauchiehall Street, I think all the non-pedestrianised bit is being remodelled with a cycleway and a more restricted roadway. ……. they've narrowed that down and they're going to reduce the amount of parking so that the idea is to have a quicker throughput of cyclists and that the intention is to make it more congenial for pedestrians and cyclists and all road users. But safer presumably because of parked vehicles……. But the way they've managed it is not good in terms of kerbs. So, a little bit I'm thinking about there is virtually no delineation, no marking, no tactile marking between the cycleway and the pavement. There is a very small, very low, sort of strip raised, about two centimetres or something. No, no, much less than that. Maybe one centimetre. I mean, it's virtually useless and quite difficult to detect even when it's new. And will get worn away and stuff. So that's bad. So, it's virtually a shared surface between pedestrians and cyclists at that point"

Quote 22: "And there's a particular intersection that I've looked at which is intersection with Elm Bank Street. That you have to worry if you want to cross the whole width of the cycleway and, and the road and the roadway. There are no kerbs. You get really mean there are kerbs where you don't want to cross. But they've raised because of the table.. Which of course eliminates the kerb. Because they haven't raised the pavement. So, it's sort of a ramp rate terrible? Yeah. Well, yes, a ramp for the traffic, but no kerb, it ends up making the road the same height as the pavement. Therefore, you don't know when you've crossed the cycleway, and you don't know when you're on the vehicle bit. And it's absolutely awful"

Quote 23: "Well, yes, but that's because they tend to be littered with street furniture and stuff. Oh, I see. Yeah, that's one problem. And the other problem is if it's a pedestrian street that was a traffic street before and has been pedestrianised. Normally, they would leave the pavements in place. Yeah. But you wouldn't be expected to walk on them, because they have all sorts of clutter on them."

Quote 24: "it's what's called a rigid frame wheelchair. instead of folding in sideways, the back comes down onto the seat, and the wheels come off just pressing a button… because I drive so to take this chair to pieces on the road and put it in. So, I put the wheels safely in behind the passenger seat and find my seat and I move the body over me, and it sits in the passenger seat"

Quote 25: "It's a lightweight chair. With Spinergy wheels. So, it's got these fibre ones. They're, they're great. much carbon fibre. They're their fibre spokes. Wow. So, they sort of absorbed I mean, they've had them for years"

Quote 26: "I've got on the wheelchair that I've got is stabilisers, which are good, because that would prevent you from tipping right back. Okay. But in general, it would be quite difficult to negotiate, I'd probably have to look for something like a crossing, which has got a, you know, a ramp down"

Quote 27: "This occurred to me when I was reading your descriptions, it depends on the pavement, it obviously depends a lot on the pavement, how wide it is, and that sort of stuff, I wouldn't normally expect to use the kerb to navigate along the pavement as it were. Unless it's a very narrow pavement, when you can't avoid locating the kerb with your stick and, and you can use that the ones not to accidentally step out into the road, for a wide pavement with plenty of room, I would, I would try to walk along in the middle of the pavement as far as possible, because if you were to follow the kerb, there are lamp posts and all sorts of other stuff, usually on the outside"

Quote 28: "it's a mixture of the noise of the cane and your footfall as well. I think those are the main things., you're getting a signal from solid objects, especially solid objects beside you. It's easy to detect objects next to you rather than in front of you, interestingly. So, Echolocation is very useful for navigating a straight line along a pavement in built-up areas where you generally have an assortment on your left or right or whatever it is".

Site Visit Feedback Full Quotes

Quote 29: "I would say sometimes, the other pedestrians can be a bit of a problem. Because sometimes when I'm using the walking stick (CANE), sometimes people can be really good and give you a wide berth and give you enough space to get over. But if there's somebody trying to cross, you know, either with the chair or stick, that can be problematic, but that's just people."

APPENDIX D – Light and Noise Data

Participants 5 & 8 Data. 04/10/2022

Location		Light (40k range)	Noise (dB)
Constitution Street	Max	11.66	71.0
	Min	11.54	64.0
Picardy Place	Max	6.01	70.0
	Min	5.82	62.4
George Street	Max	5.94	74.2
	Min	5.39	58.2

Participant 4 Data. 12/10/2022

Location		Light (40k range)	Noise (dB)
Constitution Street	Max	12.13	74.4
	Min	11.86	67.1
Picardy Place	Max	10.79	74.9
	Min	10.42	68.3
George Street	Max	10.89	70.0
	Min	10.39	57.3

Participant 2 Data. 15/11/2022

Location		Light (40k range)	Noise (dB)
Constitution Street	Max	0.43	64.4
	Min	0.34	56.8
Picardy Place	Max	0.50	71.8
	Min	0.47	62.4
George Street	Max	0.21	72.2
	Min	0.17	54.2

Participant 7 Data. 22/11/2022

Location		Light (40k range)	Noise (dB)
Constitution Street	Max	1.83	75.6
	Min	1.79	65.5
Picardy Place	Max	5.26	79.6
	Min	4.97	65.2
George Street	Max	5.10	69.8
	Min	4.78	58.5

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