Orientation using guidance surfaces
– Blind tests of tactility in surfaces with different materials and structures
PREFACE

To help seriously visually disabled or blind persons to orientate themselves, there is a need for uninterrupted routes that can be followed using a long white cane or by providing tactile information underfoot. These routes should primarily comprise natural guidance surfaces such as house walls, raised edges, railings or differing structures between dissimilar surfaces (such as asphalt adjacent to gravel or grass). Where no natural route is available, or where it is not possible to create such a route, one solution could be a special guidance route with a structure or material that deviates from surrounding surfaces. There is little knowledge of how these routes need to be designed. Various types of paving stones are used to aid orientation, but few systematic evaluations have taken place on usability for the seriously visually impaired.

The aim of this project is to improve guidance on the design of tactile routes found in the handbook "The Design of Roads and Streets" from the Swedish Road Administration and the Swedish Association of Local Authorities. We have studied materials in use today, in order to identify the structures that offer the best orientation for seriously visually impaired persons. In the next step, some of these materials will be tested in a natural environment as part of an uninterrupted guidance route.
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## 1. INTRODUCTION

1.1 Background  
1.2 Aim

## 2. METHOD AND IMPLEMENTATION

2.1 Design of the test routes  
2.2 Criteria for choosing material combinations  
2.3 Description of test routes  
2.4 Trial participants  
2.5 Trial procedure  
2.6 Method  
2.6.1 Observation  
2.6.2 Timekeeping  
2.6.3 Interview to evaluate routes  
2.6.4 Interview about personal data  
2.6.5 Video filming  
2.7 Data analysis  
2.7.1 Data quantity  
2.7.2 Analysis

## 3. RESULTS

3.1 Walking time  
3.2 Long white cane technique  
3.3 Finding the route  
3.3.1 Lateral deviations  
3.3.2 Identifying hazard warning surfaces and the start of the guidance route  
3.4 Following the route  
3.4.1 Lateral deviations  
3.4.2 Losing contact / need for assistance  
3.5 Walking on the route  
3.5.1 Foot placement  
3.5.2 Sticking with the long white cane  
3.5.3 Stopping on the route  
3.6 Identifying the end of the route  
3.7 Easy or difficult to walk on the route  
3.7.1 Easy, comfortable, safe  
3.7.2 Secure  
3.8 Sensing the difference between materials on the trial route  
3.9 Route usability

## 4. CONCLUSIONS AND RECOMMENDATIONS

4.1 Results summary  
4.2 Comments  
4.3 Continued research  
References  
Annexes
SUMMARY

All over the world, trials are taking place to make it easier for visually impaired people to orientate themselves in the physical environment. Guidance routes are being constructed using materials with many different types of structures on their surfaces. In Sweden there is a preference for certain kinds of surfaces for use on guidance routes, though their usability has not been tested in documented studies. The overriding purpose of this project is to identify structures for guidance surfaces and hazard warning surfaces that are usable for blind people who use a long white cane to navigate and orientate themselves. At the same time, however, these structured surfaces must not present an obstacle to people with diminished mobility.

The experiment involved 15 outdoor test routes, using materials for outdoor use. Every test pathway had a total length of 30 meters. The guidance surface was 20 m. Concrete paving stones or small cobblestones surrounded every guidance surface. The 14 participants were completely blind, to ensure that only the tactile design was used for orientation purposes.

The tests were conducted during October and November 2003, at the STARKA concrete company in Södra Sandby, near Lund. Two subjects took part in each trial, which lasted half a day. All subjects participated on two occasions. The following methods were used:

- Observation (objective judgment using a structured form)
- Interview for evaluating the guidelines (subjective judgment)
- Interview concerning personal information
- Video filming

Evaluations were made to determine: how easy/difficult it was to detect and follow the route; any lateral deviations from the route; whether contact was lost; whether the long white cane got stuck; whether people could identify the beginning and end of the route; and opinions about the safety, security, and usability of the route. The material gathered comprised 420 observations, 210 interviews and 9 hours of video film.

The results indicated that 6 test routes were more usable than the others. The common factor for these was that the guidance surfaces gave a sinusoidal wave effect in the long white cane. Observations indicated that the difference between guidance surfaces and hazard warning surfaces was hard to identify. The surrounding material’s evenness, i.e. that the surrounding concrete paving stones lacked chamfered edges, was extremely important for providing secure guidance. Certain materials or combinations of materials can make the long white cane stick, which resulted in disjointed walking and very often led to a loss of orientation.
Beskrivning av teststråken
1. INTRODUCTION

1.1 Background

All over the world, trials are in progress to help visually impaired people to orientate themselves in the physical environment. Guidance routes are being constructed using materials with many different kinds of structures on their surfaces. The guidance surfaces can either be natural, such as walls or edges, or be made using grass adjacent to asphalt or grass adjacent to paving. They can also be artificial, such as differing structures in paving or stones. The latter is surrounded in turn by materials with a very varied structure. Blister surfaces are also used. These are available in a variety of different blister shapes and sizes. Blister surfaces are sometimes used as directional paving when changing direction, or sometimes to warn of a danger or hazard.

There have however been very few studies or tests of how these materials and material combinations actually function as orientation aids for visually impaired people. Visually impaired people as a group includes partially-sighted, seriously visually impaired and blind people. For the first two groups, light contrasts are also important as orientation aids. People without any sight or with only slight traces of vision are completely dependent on movement sensors in the hand and their ability to perceive structure and changes in tactile surfaces. They do this by using a long white cane. Tactile perception involves physical contact with objects or surfaces at the same time as cognitive processes are involved.

Sometimes aesthetic demands are viewed as an obstacle to usability for visually impaired people. The challenge is to find tactile surfaces that are useful for seriously visually impaired and blind people using white canes, while also being attractive for others with normal sight.

Different countries in the world are developing solutions for tactile structures without any real international coordination. The European Union has since 2002 worked to standardise tactile surfaces in stone, clay and concrete. Standardisation began in early 2002. Sweden was one of only six countries that has taken part in these efforts. The starting point has been UK standards for tactile guidance surfaces. However, as the method of walking differs between the various countries for visually impaired and blind people, it is important that common studies are carried out within the frame of the EU.

In 2004, an international venture began to draw up an ISO standard, with participants from Japan, US and Sweden, among other countries.
1.2 Aim

There is a preference in Sweden to use certain types of surfaces on artificial guidance routes, though their usability has not been tested in documented studies. This project has tested several combinations of tactile surfaces chosen from Swedish and UK products. The main purpose of this project was to identify structures for guidance surfaces and stop surfaces that help blind people who use long white canes to navigate and orient themselves. At the same time, however, these structured surfaces should not present an obstacle to people with diminished mobility.

2. METHOD AND IMPLEMENTATION

2.1 Design of the test routes

The 15 test guidance routes in the trial were built outdoors using materials for outdoor use. Each test route was a total 30 m long. The guidance surface was 20 m. This length was necessary if participants were to decide whether material combinations were usable. Concrete paving stones or small cobblestones surrounded every guidance surface. Most guidance surfaces had a 1 x 1 metre hazard warning surface at both ends of the route. This was usually a blister surface. Outside this warning surface, each test route began and ended with a 4 metre area that used the same material present outside the guidance surface. If there was no hazard warning surface, then each route began and ended with a 5 metre stretch of the same material present outside the guidance surface. The tactile guidance surfaces were between 130 and 800 mm wide. The width was dependent in part on the size of the tested material, and in part on the existing width recommendations for different materials.

The start and finish stretches are necessary to discover if completely blind people can notice the difference between the guidance surfaces and surrounding surfaces, i.e. can identify the beginning and end of a guidance surface.

The size of the warning surfaces varied between 840 x 840 mm and 1 200 x 1 200 mm depending on the size of the tested paving stone. In Sweden, this surface is often only 350 mm deep, though sometimes up to 700 mm. In other countries, such as the UK, this is 1 200 mm deep. Experiences from Borås suggest that 900 mm could be a suitable depth. This could be linked to the fact that the sweep of a long white cane is about 800 mm.

Surrounding surfaces were smooth concrete paving stones with or without chamfered edges. The paving stones without chamfered edges were from 350 x 350 mm and smaller. Concrete slabs with chamfered edges were all 350 x 350 mm.
Figure 2.1. Schematic image of the test route with and without hazard warning surfaces
Figure 2.2. Schematic image of the entire test surface.
2.2 Criteria for choosing material combinations

There are many things that need to be tested: different varieties of tactile materials, various surrounding materials, different techniques for movement and different tips for long white canes. The tests need to be carried out by both blind and severely visually impaired persons. This project has created tests based on the most difficult possible situations.

The aim was to test the combinations of surface structure that are most commonly used. Materials and combinations are chosen based on Swedish experiences, experiences from EU standardisation work, knowledge gained from literature, and research studies through a project run by the Swedish Association of Local Authorities and based on a Norwegian project, which compared the use of tactile materials in different countries.

Following initial tests, concrete slabs with a rough, elevated surface lower than 2.5 mm were excluded as guidance surfaces. Based on existing experiences, these slabs were judged as impossible to identify with a long white cane even if the surrounding surface is completely smooth.

Paving stones with chamfered edges, with straight edges, and for one test route small cobblestones were used as surrounding material for the tactile test surfaces. Asphalt can also be used to surround test surfaces. We believed, however, that in these tests it was most important to study how useful concrete slabs are as surrounding material, as asphalt is the smoothest alternative of all and various types of concrete slabs are widely used today.

Granite slabs with a variety of surface finishes – such as fan-shaped, diamond-shaped or hewn - are sometimes used today as surrounding material. Old hewn slabs are also often found in use today. These are usually quite uneven and experience has shown that these are not suitable as surrounding material. Granite slabs are often about 300 x 900 mm without chamfered edges, which means this type of surrounding material has few joints. Both fan and diamond shaped granite slabs have a smooth surface, which means the degree of disturbance compared with the tactile guidance surface is about the same as with other types of paving. A conscious decision was made not to use a guidance surface of granite slabs surrounded by small cobblestones, in part because of price.
2.3 Description of test routes

The test surface comprised:
- 13 routes for tactile guidance and warning, routes 1-13
- 2 routes for separating pedestrian and cycle paths, routes 14-15.

Of these:
- 9 routes used materials only from Sweden
- 3 routes used materials from both Sweden and the UK
- 3 routes used materials only from the UK

Figure 2.3. View of the entire test area with the layout of the trials.

The following is a description of test routes 1-13 including:
- the appearance of the guidance route
- the appearance of the hazard warning surface
- the appearance of the surrounding materials

Descriptions for routes 14-15 include:
- separation between pedestrian and cycle way surfaces
- appearance of the pedestrian and cyclist surfaces
Test route nr 1
- sinusoidal surface on concrete paving
- wave height 5 mm
- c/c bar top 50 mm
- slab size 350 x 350 mm, (chamfered edges on the short side)
- width 700 mm
- chamfered edges

- blister surface on concrete paving
- dome height 5 mm
- dome diameter 55 mm
- c/c domes 88 mm
- slab size 350 x 350 mm
- surface 1 050 x 1 050 mm
- chamfered edges

- concrete slabs without chamfered edges

Test route nr 2
- sinusoidal surface on concrete paving
- wave height 5 mm
- c/c bar top 50 mm
- slab size 350 x 350 mm, (chamfered edges on the short side)
- width 700 mm
- chamfered edges

- blister surface on concrete paving
- dome height 4 mm
- dome diameter 33.5 mm
- c/c domes 66.5 mm
- slab size 200 x 200 mm
- surface 1 000 x 1 000 mm
- chamfered edges

- concrete slabs with chamfered edges
Test route nr 3
- ribbed surface on concrete paving
- rib height 2.5 mm
- rib width 25 mm
- c/c ribs 85 mm
- slab size 350 x 350 mm
- width 700 mm
- chamfered edges

- blister surface on concrete paving
- flat-topped blisters with a dome height of 2.5 mm
- dome diameter 25 mm
- c/c domes 85 mm
- slab size 350 x 350 mm
- surface 1050 x 1050 mm
- chamfered edges

- concrete slabs without chamfered edges

Test route nr 4
- sinusoidal surface on concrete paving
- wave height 5 mm
- c/c bar top 51 mm
- slab size 210 x 210 mm
- width 630 mm
- without chamfered edges

- blister surface on concrete paving
- flat-topped blisters with a dome height of 5 mm
- dome diameter at base 30 mm and top 25 mm
- c/c domes 70 mm
- slab size 210 x 210 mm
- surface 840 x 840 mm
- chamfered edges

- concrete slabs without chamfered edges
Test route nr 5
- sinusoidal surface on concrete paving
- wave height 5 mm
- c/c bar top 51 mm
- slab size 210 x 210 mm
- width 630 mm
- without chamfered edges

- blister surface on concrete paving
- flat-topped blisters with a dome height of 5 mm
- dome diameter at base 30 mm and top 25 mm
- c/c domes 70 mm
- slab size 210 x 210 mm
- surface 840 x 840 mm
- chamfered edges

- concrete slabs with chamfered edges

Test route nr 6
- ribbed rubber surface
- rib height 4 mm
- rib width 30 mm
- c/c ribs 50 mm
- width 700 mm
- without chamfered edges

- blister rubber surface
- flat-topped blisters with a dome height of 4 mm
- dome diameter at base 35 mm and top 25 mm
- c/c domes 50 mm
- surface 1 000 x 1 000 mm
- without chamfered edges

- concrete slabs without chamfered edges

Rubber slabs of an appropriate size were attached to the ground surface.
Test route nr 7
- three rows of small cobblestones
- width 350 mm
- “blister paving” using small cobblestones
- surface 1 000 x 1 000 mm
- concrete slabs without chamfered edges

Test route nr 8
- stormwater metal drain, width 130 mm with grating opening 10 mm transversely across the direction of pedestrian travel
- concrete slabs without chamfered edges bordered grating for 10 m
- row of small cobblestones on either side of the grating for 10 m, total width 350 mm
- blister slabs of concrete
- flat-topped blisters with a dome height of 7 mm
- blister diameter at base 54 mm and top 40 mm
- c/c domes 88 mm
- slab size 350 x 350 mm
- surface 1 050 x 1 050 mm
- chamfered edges
- concrete slabs without chamfered edges
Test route nr 9
- UK Directional Guidance Paving in concrete (ribbed paving with arched, flat-topped ribs)
- rib height 5 mm
- rib width base 40 mm, top 30 mm
- distance between the rib and flat edge about 11 mm
- c/c ribs 80 mm
- slab size 400 x 400 mm
- width 800 mm
- without chamfered edges
- no blister paving
- small cobblestones

Test route nr 10
- ribbed surface on concrete paving with halfcircle flat-topped ribs
- rib height 4 mm
- rib size base area 25 x 80 mm and top area 15 x 50 mm
- c/c ribs long side 60 mm and short side 115 mm
- slab size 230 x 230 mm
- width 700 mm
- without chamfered edges
- blister surface paving or UK Platform Edge Paving in concrete i.e. flat-topped blisters, every other row offset by half a dome.
- flat-topped blisters with a dome height of 5 mm
- dome diameter at base 23 mm and top 20 mm
- c/c domes 65 mm
- slab size 400 x 400 mm
- surface 1 200 x 1 200 mm
- without chamfered edges
- concrete slabs without chamfered edges
Test route nr 11
- UK Hazard Warning Paving ("blister") in concrete
- rib height 6 mm
- rib width 20 mm
- c/c ribs 50 mm
- distance between the rib and slab edge about 11 mm longitudinally
- slab size 400 x 400 mm.
- width 800 mm
- without chamfered edges

- no blister paving

- concrete slabs without chamfered edges

Test route nr 12
- UK Directional Guidance Paving in concrete (ribbed paving with arched, flat-topped ribs)
- rib height 5 mm
- rib width base 40 mm, top 30 mm
- distance between the rib and slab edge about 11 mm longitudinally
- c/c ribs 80 mm
- slab size 400 x 400 mm
- width 800 mm
- without chamfered edges

- UK Platform Edge Paving in concrete
- flat-topped blisters with a dome height of 5 mm
- dome diameter at base 23 mm and top 20 mm
- c/c domes 65 mm
- slab size 400 x 400 mm
- surface 1 200 x 1 200 mm
- without chamfered edges

- concrete slabs with chamfered edges
Test route nr 13

- UK Cycleway Paving, ribbed surface on concrete slabs
- Rib height 3 mm
- Rib width 30 mm
- C/c ribs 100 mm
- Slab size 400 x 400 mm
- Width 800 mm
- Without chamfered edges

UK ribbed slabs are laid in the direction of pedestrian travel to act as guidance slabs. In the UK these are used at the beginning of pedestrian and cycle paths, see Route 15.

- No blister paving

- Concrete slabs with chamfered edges

The ribs of these slabs have the same width and c/c distance as the granite slabs used as a guidance route at Odenplan in Stockholm. The ribs at Odenplan are 5 mm high, however.

Test route nr 14

- Five rows of small cobblestones
- 20 mm arch at centre
- Width 500 mm

- No blister paving

- Concrete slabs without chamfered edges

This small cobblestone surface is a central delineator between pedestrian and cycle paths and is wide, which means even when the surface is used for guidance the long white cane does not land on the cycle path.
Test route nr 15

- white road marking line in three layers widths 150 mm, 100 mm and 50 mm
- total height of road marking line 10 mm

- UK Cycleway Paving (see test route nr 13) placed transversely on a 2 400 mm long and 1 200 mm wide surface (walkway)
- UK Cycleway Paving lengthways on a 2 400 mm long and 1 200 mm wide surface (parallel with the above route; cycle path).
- about 15 m of concrete slabs with chamfered edges
- UK Cycleway Paving as above

- no blister paving

- concrete paving with chamfered edges

UK ribbed paving was placed transversely at the beginning and end of the walkway informing users that they were entering a guidance route, which was in turn next to a cycle path. At the beginning and end of the cycle path there was similar ribbed paving lengthwise (as used in the UK).
2.4 Trial participants

Fourteen people took part in the trial. All of these were completely blind, to ensure that it was the tactile design that was used for orientation. It clearly shows how the participants navigated using a long white cane aided by the tactility of the ground material. Persons with partial sight can in addition to tactility also make use of luminance contrast incorporated into guidance routes.

Most participants in the trial live in one of the 33 counties of Skåne, which was a conscious choice to reduce costs for travel and lodging. The short preparation time made it difficult however to find fourteen completely blind people in Skåne able to take part in the project. Two participants were therefore from Göteborg and two from Halmstad. The test participants can have varying abilities in orientating themselves. This is not primarily a result of where people are from but usually an outcome of the type of rehabilitation received.

Nine test participants were women and five men. Ages varied between 17 and 66. All have grown up in Sweden. One of the participants has been blind since birth and the others have been blind for between 7 and 39 years. For some of the participants this has been for much of their adult life. Five of the test participants had some form of impaired mobility, such as pain or stiff joints, which for some also result in problems with balance. Four of the participants had slightly impaired hearing.

All of the participants used winter shoes, such as boots with thick soles, during the tests. Five of the participants were diabetic. Of these, three had little or no sensitivity in their feet. All of the people move about outdoors, most of them every day. Six of the test persons used a guide dog, and one had used a guide dog until immediately prior to the trials. Five of the participants use both gliding and sweeping movements when they walk outdoors, one uses only gliding and eight use only sweeping movements. Gliding involves moving the long white cane backwards and forwards while walking, constant touching the surface to be identified. When sweeping, the long white cane only touches the ground at the outer limits of its sweep. Two of the participants had not received any rehabilitation outdoors, one had received rehabilitation ”many years ago”, and one had received “a little”.

In addition, four physically disabled persons also took part in the trial. The reason for this was to see if these tactile materials gave rise to mobility problems for physically disabled persons. One person used an electric wheelchair, one a manual wheelchair, one used a walking frame, and one person who used crutches.
2.5 Trial procedure

The tests were carried out in October and November 2003 at the STARKA concrete company in Södra Sandby, near Lund. The 15 trial routes were created outdoors and together formed a 1 000 square metre test surface in a sheltered area on the industrial estate. The test participants arrived at the STARKA head office and were transported to the test area by car.

Two participants took part in each trial. Each trial lasted half a day and each subject took part twice and tested eight and seven routes respectively. After the first four routes, there was a break with refreshments at the STARKA head office. The test subjects were interviewed during this break following the first series of tests. The order in which the routes were tested was chosen at random so that each person had a unique order of test routes in his or her series. The test routes were numbered 1 – 15.

The tests were carried out as follows:

- The test participant was placed at the edge of the test area in front of the randomly chosen test route, with feet facing the test route.
- The long white cane was checked. If the long white cane did not have a plastic tip, then this was fitted.
- The test subject was informed of what he or she was expected to do: The test route is directly ahead of you, find and follow the route, glide the long white cane, think aloud, comment on everything you experience, say when you have reached the end of the route, and inform the observers of any changes in the surface structure. We will time the exercise, but this is not a competition, we will step in if you stray from the route.
- The test participant was then encouraged to walk the route.
- Short break (to allow two independent observers to complete an assessment questionnaire).
- The test subject was then placed at the other end of the test area, with feet facing the test route.
- The test participant was then encouraged to walk the route back.
- The test subject was interviewed by independent interviewers. During this time, the second test subject walked the test routes.
2.6 Method

The method was chosen to allow for both subjective evaluations from the test subjects, and object assessments from the observers. The following method was used:

- observation
- interview to evaluate routes
- interview about personal information
- video filming

2.6.1 Observation

The objective assessment through observation used a structured form which included 26 points in total, see Annex 1. Two observers walked on either side of the test subject, watched what happened and then completed one assessment form each independently of each other, for both directions on the route. The assessment included information about the actual walk, i.e. about the test subject

- finding the route
- following the route
- lateral deviations (> 0.7 m)
- using feet on the route
- losing contact with the route
- needing help following route
- identifying the end of the route
- using the long white cane
- sticking with the long white cane

The assessment also included an evaluation on a scale of 1-5 of how easy or difficult and secure or insecure it was for the test subject to

- find the route
- follow the route
- walk on the route.

2.6.2 Timekeeping

Both observers used a stopwatch to measure how long it took each test subject to walk each way on the test route.
2.6.3 Interview to evaluate routes

A structured form was used with a total of nine questions to provide a subjective assessment of the route. An interview was held after every test route, i.e. after the test participant had walked both ways on the test route. The interviewer had not seen how the test person had walked. The interview was held away from the test area. The questions concerned how easy or difficult the test had been and how the test subject rated the various factors for the test route. The answers were on a scale of 1-5. The final question about the usability of the test route was on a scale of 1-10. Each question also allowed comments from the test subjects. The entire questionnaire is included as Annex 2. The interview included questions about how difficult or easy it was to

- find the route
- follow the route
- walk on the route.
- discover the differences between materials.

Participants were also asked to estimate their

- feeling of safety
- feeling of security
- feeling of comfort
- feeling of usability

2.6.4 Interview about personal data

During the break in the trial, participants were interviewed about personal data, Annex 3. This interview included questions about

- background data, (such as gender, age, how long the person has been blind)
- physical disabilities or illnesses
- type of footwear worn during the trial
- level of experience in moving outdoors and the type of long white cane technique normally used by the subject
- rehabilitation (extent, how).

2.6.5 Video filming

The test participants were video filmed when they walked in each direction on the routes. This was carried out by specialised staff (2 people).
2.7 Data analysis

2.7.1 Data quantity

The objective assessment, i.e. observation, included:

- 2 assessments per test route and test subject (one in either direction)
- 30 assessments per test subject (15 test routes, both forwards and back)
- 28 assessments per test route (14 test subjects, both forwards and back)
- A total of 420 assessments (28 assessments (forwards and back) and 15 test routes)

A total 840 assessments were carried out, as two observers made independent assessments. When all data had been collected, a reliability test was carried out on all assessments. This process also used the video recordings. The assessments by the two observers were compared for each test route and the test person forwards and back. The aim was to produce a single observation per test person and test route forwards and back. This appraisal was carried out by the two observers that had also assessed participants earlier.

Each assessment of test subject and test route, forwards and back, was therefore compared between the two assessors. If there were differences between the two observers about the way of walking then the video was consulted. Examples of differences between the assessments could be that observers had registered that a person had walked with one or both feet to the right or left of the test route. A final decision was based on video images. If there were differences in the evaluation of how difficult or easy and safe and secure it was for the test subjects to walk on the route, the following method was used:

- If the difference between assessments was one point on the scale, then the lowest or worst ranking was used.
- If the difference between the assessments was more than one point, then a new assessment was carried out using the video recording. The assessors could then decide on a final ranking.
By using this method, a single result was presented per test person and test route, both forwards and back, i.e. two assessments per test route and person.

The following data was collected based on the evaluation interviews for the route:

- 1 assessment per route and test subject (a single interview for both forwards and back)
- 15 interviews per test person (15 test routes)
- 14 interviews per test route
- a total of 210 interviews (15 test routes and 14 test participants)

The interview about personal data comprised:
- 14 interviews

Video filming included:
- a total 9 hours of film

2.7.2 Analysis

All of the accumulated data was then processed in SPSS (Statistical Package for Social Science). Frequencies and links were studied. This analysis has included:

- differences between routes for all of the studied variables
- the reason for these differences
- usability for each route.

The analysis was based on the objective assessments. Likewise, the analysis was based on a comparison of the 15 test routes, where differences and similarities were analysed and discussed. Some issues included data from both objective assessments and subjective evaluations. These were compared in the analysis, and similarities and differences were discussed. The personal data collected was mainly used to describe the test group.
3. RESULTS

3.1 Walking time

The test route was, as described in section 2.1, a total 30 m long and included a four or five metre start section, usually using concrete slabs with or without chamfered edges, a 1 metre hazard warning surface (on 11 of the routes) with various types of blister paving, and a 20 metre guidance surface with different surface materials. The walking speed for the total route was quite similar between the routes, see Figure 3.1. The average walking time was just under 40 seconds for most of the routes. Two of the test routes had an average walking time that was slower, almost 50 seconds: test route 7 (three rows of small cobblestones surrounded by concrete slabs without chamfered edges) and test route 8 (stormwater metal drain surrounded by concrete slabs without chamfered edges). Similarly, walking time was slightly longer on the test routes that included a delineator strip between pedestrian and cycle paths, i.e. test routes 14 and 15.

The figure also shows that the maximum time for the test route (i.e. the longest time taken by any single participant to walk the route) was quite similar. It is interesting to note however that the maximum time for test route 7 and test route 9 were particularly long, up to 150-160 seconds, i.e. it took at least one participant about 2.5 minutes to walk this 30 metre long route. Common for these routes is that they both include small cobblestones, test route 7 has three rows of small cobblestones as a guidance surface and test route 9 is surrounded by small cobblestones. Minimum values (i.e. the shortest time required by any single test participant to walk a route) reveal that the fastest test routes were route 3 (ribbed paving surrounded by concrete slabs without chamfered edges), test route 5 (sinu-soidal paving surrounded by concrete slabs with chamfered edges) and test route 13 (UK Cycleway Paving surrounded by concrete slabs with chamfered edges).

Figure 3.1. Walking time for each test route, objective assessment.
3.2 Long white cane technique

As described in section 2.5 Trial procedure, all participants were instructed to glide the long white cane during the trial. Most listened to this request. The results show that 12-13 of the 14 test subjects used only a gliding long white cane on all test routes irrespective of where they were on the route: on the initial four metre stretch, hazard warning surface, or the actual guidance surface. Three participants used both a gliding and sweeping long white cane at certain points of the route, Figure 3.2. The assessment also revealed that a number of test participants sometimes began by gliding the long white cane, but at times of uncertainty or if something new appeared then a few sweeping movements were used to “feel” the surface. These participants then quickly reverted to gliding movements. This mainly occurred on test route 6 (ribbed rubber paving surrounded by concrete slabs without chamfered edges).

The reach of the long white cane was judged using three levels: narrow, normal or wide. There was widespread conformity among test participants; a majority (12-13 persons) were judged to have normal cane reach, i.e. a sweeping movement that covers a surface slightly wider than the width of a body, Figure 3.3.
The long white cane reach showed little variation along the length of the route. In general, movements were slightly more sweeping when test participants were searching for the test route, narrowing on the warning surface, and then slightly wider when following the guidance route. There was a tendency to use a wider sweep mainly on test route 8 (stormwater metal drain surrounded by concrete slabs without chamfered edges), test route 9 (UK Directional Guidance Paving surrounded by small cobblestones), test route 11 (UK Hazard Warning Paving surrounded by concrete slabs without chamfered edges) and test route 15 (delineator between pedestrian and cycle path).

3.3 Finding the route

3.3.1 Lateral deviations

Finding the route was the first main task for the test participants. The results show this was not entirely without difficulties. The section before the beginning of the test route was a four or five metre long smooth surface. The shorter stretch was used if there was a hazard warning surface. This could be considered a short distance. Despite this, on all test routes at least one person lost contact at this stage and deviated more than 0.7 m laterally from the approaching test route, according to the observers, Figure 3.4. Likewise, several people were judged to have swayed on their way to the test route. It was particularly difficult to maintain a straight line on test route 9 (UK Directional Guidance Paving surrounded by small cobblestones), test route 13 (UK Cycleway Paving surrounded by concrete slabs with
chamfered edges), test route 14 (delineator strip between pedestrian and cycle paths comprising five rows of small cobblestones, with a 20 mm high arch, 500 mm wide) and test route 15 (delineator strip between pedestrian and cycle path using a UK model, i.e. white road marking line with a 150 mm base and 50 mm top). All of these four routes, 9, 13, 14, and 15, began directly with the guidance surface and did not include a warning surface, i.e. test participants were required to walk five rather than four metres. The test routes that observers judged were easiest to detect were route 12 (which began with a 1 200 x 1 200 mm area of UK Platform Edge Paving), route 1 (concrete blister slab – domed blisters – area 1 050 x 1 050 mm) and route 8 (concrete blister slab – flat-topped blisters – 1 050 x 1 050 mm).

3.3.2 Identifying hazard warning surfaces and the start of the guidance route

Identifying the test route could be signalled by test participants clearly indicating that they had found something new with either the long white cane or the feet when they stood on the hazard warning surface, or that they indicated that the test route had begun when their long white cane or feet entered the guidance route.

According to objective assessments, finding the hazard warning surface was not completely trouble-free for test participants, Figure 3.5. Test route 8 (concrete, 7 mm blister slab, surface area 1 050 x 1 050 mm) appeared to be easier to locate, as were test routes 10 and 12 (blister
UK Platform Edge Paving, surface area 1 200 x 1 200 mm). Routes where the initial warning surface was particularly difficult to identify were test route 2 (concrete blister slab – domed blisters 1 000 x 1 000 mm), route 3 (concrete blister slab, 1 050 x 1 050 mm) and route 7 (small cobblestones, surface area 1 000 x 1 000 mm). Greater lateral deviations than 0.7 m on the hazard warning surface were noted on these routes (6 people were judged to have deviated) compared with other test routes, where an average 1-2 people deviated. In a similar way, more people were judged to have deviated from the hazard warning surface on test route 15 (5 people) where the surface was UK Cycleway Paving placed transversely (surface 2 400 x 1 200 mm).

![Objective assessment Identifying the stop paving Identifying](image)

**Figure 3.5. Identifying the hazard warning surface at the beginning of the route, objective assessment.**

The assessment of identifying the test route in **Figure 3.6.** below includes an overall assessment of whether the test person identified the beginning of the test route. This could be either the beginning of the actual guidance surface or, in some assessments, the hazard warning surface. It was difficult to determine on which material, and whether it was with the long white cane or feet, that subjects noted that the test route began. The figure shows that all test routes, except route 9, were identified in principle by all test persons according to the overall assessment. According to observers, half of the test participants did not identify test route 9 (UK Directional Guidance Paving surrounded by small cobblestones). Test route 15, which was a delineator strip between a pedestrian and cycle path using a UK model (road marking line), was also more difficult to identify than the others.
The test routes that most test persons said were difficult to locate were test route 3 (ribbed paving surrounded by slabs without chamfered edges), test route 7 (three rows of small cobblestones surrounded by concrete slabs without chamfered edges), test route 9 (UK Directional Guidance Paving surrounded by small cobblestones), and test route 15 (delineator strip between pedestrian and cycle path using a UK model), Figure 3.7. Test route 9 was judged difficult to detect by 12 of the 14 test participants.

Figure 3.6. Identifying the route, objective assessment.

Figure 3.7. Assessment of routes based on how easy/difficult they were to find, subjective evaluation.

(columns in the figure do not include the value 3 on the scale of 1-5, i.e. the assessment neither easy nor difficult)
In a similar way, according to the test participants six routes were easier to detect than others: test route 1 (sinusoidal paving 350 x 350 mm surrounded by concrete slabs without chamfered edges and hazard warning surface of 5 mm domed blisters), test route 4 (sinusoidal paving 210 x 210 mm surrounded by concrete slabs without chamfered edges and warning surface with 5 mm flat-topped blisters), test route 5 (sinusoidal paving 210 x 210 mm surrounded by concrete slabs with chamfered edges and warning surface of 5 mm flat-topped blisters), test route 8 (stormwater metal drain surrounded by concrete slabs without chamfered edges and warning surface comprising 7 mm flat-topped blisters), test route 10 (concrete slabs with short ribs and warning surface comprising 5 mm flat-topped blisters) and test route 12 (UK Directional Guidance Paving surrounded by concrete slabs with chamfered edges and warning surface comprising 5 mm flat-topped blisters). Ten or more people judged these routes as easy to find.

There are clear similarities between the subjective evaluation and the objective assessment of which routes were difficult and easy to find and identify. Test route 9, where a type of ribbed slab was used as guidance surface surrounded by small cobbles, was very difficult to find and identify both according to objective assessments and subjective evaluations. This is particularly notable as this method of laying guidance surfaces is common in Sweden.
3.4 Following the route

3.4.1 Lateral deviations

The level of difficulty for test participants to follow the routes was judged in several different ways. **One method** was for observers to register if test persons deviated from the route by more than 0.7 m and, if so, how many times this occurred. Two test routes were easier to follow than others; test route 4 (sinusoidal paving 210 x 210 mm surrounded by concrete slabs without chamfered edges) and test route 13 (UK Cycleway Paving surrounded by concrete slabs with chamfered edges). Only one person deviated more than 0.7 m from route 4 and none from route 13, **Figure 3.8**.

![Objective assessment](image)

**Figure 3.8. Lateral deviations (> 0.7 m), objective assessment.**

The routes where most people deviated by more than 0.7 m were test route 7 (three rows of small cobblestones surrounded by concrete slabs without chamfered edges), test route 8 (stormwater metal drain surrounded by concrete slabs without chamfered edges), and test route 9 (UK Directional Guidance Paving surrounded by small cobblestones). More than half of the test persons deviated on these three routes. On all of these routes, 4-5 persons deviated from the guidance surface 2-4 times.
3.4.2 Losing contact / need for assistance

Another way to judge how easy or difficult it was to follow the route was to register if the test person lost contact with the test route and how many times this happened. The assessments are almost completely in agreement with the measurement of if and how often the test persons deviated more than 0.7 m from the different routes as noted above. It was therefore mainly test routes 7, 8, and 9 (and to some extent test routes 3 and 14) where test participants lost contact with the guidance surface. The number of times contact was lost with each route is shown in Figure 3.9. The results clearly show that if a participant deviated more than 0.7 m from a guidance surface there was a very great risk that the person also lost contact with the route.

![Objective assessment](image)

**Figure 3.9.** The number of test persons that deviated from each respective route, objective assessment.

A third method to assess how easy or difficult it was to follow a route was to register if and how often test persons needed help to find their way back to the guidance surface once they had lost contact. This assessment reinforces the two earlier assessments reported, i.e. the four routes where deviation was great, test routes 7, 8, 9, (and to some extent test route 3), were routes where a large number of test persons also needed help to find their way back to the guidance surface, Figure 3.10.
Test route 7 (three rows of small cobblestones surrounded by concrete slabs without chamfered edges) and test route 9 (UK Directional Guidance Paving surrounded by small cobblestones) were once again the routes where people required most help in refinding the guidance surface. Half of the participants were not able to complete route 7 unassisted. The number of times people needed help corresponds with the number of times people lost contact with the route, see Figure 3.9 above.

The most difficult test routes, according to a subjective assessment in the interviews, were test route 3 (ribbed paving 350 x 350 mm surrounded by concrete slabs without chamfered edges), test route 6 (rubber ribbed paving surrounded by concrete slabs without chamfered edges), test route 7 (three rows of small cobblestones surrounded by concrete slabs without chamfered edges), test route 8 (stormwater metal drain surrounded by concrete slabs without chamfered edges), test route 9 (UK Directional Guidance Paving surrounded by small cobblestones) and test route 10 (concrete slabs with short ribs), Figure 3.11. Four of these test routes were judged as difficult to follow by a majority of the 14 trial participants.
In a similar way, according to the test participants four routes were easier to follow than others: test route 1 (sinusoidal paving 350 x 350 mm surrounded by concrete slabs without chamfered edges), test route 2 (sinusoidal paving 350 x 350 mm surrounded by concrete slabs with chamfered edges), test route 4 (sinusoidal paving 210 x 210 mm surrounded by concrete slabs without chamfered edges), test route 11 (UK Hazard Warning Paving surrounded by concrete slabs without chamfered edges) and test route 12 (UK Directional Guidance Paving surrounded by concrete slabs with chamfered edges). Ten or more people judged these routes as easy to follow.

There are clear similarities between the subjective evaluation and the object assessment of which routes were difficult and easy to follow, Figure 3.12. According to the objective assessment, three routes were found to be particularly difficult to follow. These were test route 7 (three rows of cobblestones surrounded by concrete slabs without chamfered edges), test route 8 (stormwater metal drain surrounded by concrete slabs without chamfered edges), and test route 9 (UK Directional Guidance Paving surrounded by small cobblestones).
Four of these test routes were particularly easy for most participants to follow. These were test route 4 (sinusoidal paving 210 x 210 mm surrounded by concrete slabs without chamfered edges), test route 5 (sinusoidal paving 210 x 210 mm surrounded by concrete slabs with chamfered edges), test route 11 (UK Hazard Warning Paving surrounded by concrete slabs without chamfered edges), test route 12 (UK Directional Guidance Paving surrounded by concrete slabs with chamfered edges), and test route 13 (UK Cycleway Paving surrounded by concrete slabs with chamfered edges).

Both the objective assessment and the subjective evaluation indicated therefore that test routes containing small cobblestones, either as part of the guidance surface or as surrounding material, were difficult to follow. Materials that were easiest to follow appear to be guidance surface materials that have soft edges and provide a slight sinusoidal wave effect that can be discerned by the long white cane. The long white cane must not stick on the guidance surface or the surrounding material.
3.5 Walking on the route

3.5.1 Foot placement

All test participants walked with both feet on all of the test routes apart from three: test route 8 (stormwater metal drain surrounded by concrete slabs without chamfered edges), and test routes 14 and 15, i.e. the two routes with delineator strips between pedestrian and cycle paths and where participants were to walk alongside the route. All of these routes were too narrow to follow with both feet.

The placement of feet on the route was also an indication of how easy or difficult it was to follow the route. This was mainly observed if the person walked both on the test route and on either side of the route with one or both feet. Test participants swayed significantly on two test routes and sometimes had both feet on one side of the guidance surface and sometimes on the opposite side, Figure 3.13. These were test route 7 (three rows of small cobblestones surrounded by concrete slabs without chamfered edges) and test route 8 (stormwater metal drain surrounded by concrete slabs without chamfered edges). These two test routes were narrow, which to some extent explains the walking behaviour. The figure shows that a few test participants walked to one side of the guidance surface on all routes.

![Figure 3.13. Foot placement on / to one side of the route, objective assessment.](image-url)
3.5.2 Sticking with the long white cane

A light, gliding movement with the long white cane without sudden halts is one important factor for a comfortable and safe navigation of the route. The objective assessment showed that the long white cane stuck on most routes and for a majority of test participants, often sticking more than once, Figure 3.14. The long white cane stuck either in the guidance surface or in the surrounding material.

![Objective assessment diagram](image)

**Figure 3.14. Long white cane sticking in the guidance surface, objective assessment.**

The five test routes where a majority of test participants did not stick with the long white cane were test route 3 (ribbed paving 350 x 350 mm surrounded by concrete slabs without chamfered edges), test route 4 (sinusoidal paving 210 x 210 mm surrounded by concrete slabs without chamfered edges), to some extent test route 5 (sinusoidal paving 210 x 210 mm surrounded by concrete slabs with chamfered edges), test route 13 (UK Cycleway Paving surrounded by concrete slabs with chamfered edges), and test route 15 (delineator between pedestrian and cycle path using the UK model, i.e. white road marking line with a 150 mm base and 50 mm top). Test routes where the long white cane stuck for all participants were test routes 7, 8, and 9, i.e. the routes which included small cobblestones either in the guidance surface or as surrounding material, and where the guidance surface was a narrow stormwater metal drain.

In a similar way, an objective assessment was made of whether the long white cane stuck in the warning surface on the test route, see **Figure 3.15.** The results reflected a similar pattern to the results for the guidance surface; a majority of long white canes stuck. The exceptions were hazard warning surfaces on test routes 1, 2, and 3. These warning surfaces have domes of various forms, heights and diameters. The reason
white canes did not stick in the test routes 1 and 2 was probably that the blisters were rounded, without sharp edges. On test route 3, the domes were so low that the structure could not be detected with the long white cane.

3.5.3 Stopping on the route

The objective assessment also registered if the test person stopped while walking on the test route, Figure 3.16. One reason that test participants stopped on the route could be that the long white cane had stuck in the guidance surface or in the surrounding material, or that participants became unsure and stopped to change direction.
The figure shows that at least some participants needed to stop when walking on all test routes. On test route 7 (three rows of small cobblestones surrounded by concrete slabs without chamfered edges) a majority of test participants stopped, 8 of 14 people. Some people stopped up to four times on this route. A relatively large number of test participants needed to stop on both test routes that included a central delineator strip between pedestrian and cycle paths and on test route 8 (stormwater metal drain surrounded by concrete slabs without chamfered edges).

3.6 Identifying the end of the route

The test routes ended in the same way as they had begun, i.e. most of the test routes ended with a warning surface, often with blister paving, between 800 x 800 mm and 1 200 x 1 200 mm. This was followed by a 4 metre surrounding surface, often using concrete slabs. Blister paving is widely used in pedestrian environments today to warn of various types of dangers. A common use is as a warning on a pedestrian surface near a road with a pedestrian crossing.

The tests showed that blister paving had a limited effect as warning slabs. The objective assessment revealed that on all routes only a minority of participants noticed the hazard warning surface at all, Figure 3.17. However, on test route 15 a majority of participants noticed that the route changed material to a hazard warning surface. This route was a marked delineator strip between pedestrian and cycle paths using a UK model, i.e. white road marking line. The warning surface comprised UK Cycleway Paving covering an area 2 400 x 1 200 mm.

![Figure 3.17. Identifying the warning surface at the end of the guidance route, objective assessment.](image-url)
In a similar way, an objective assessment was made of whether test participants noticed when the test route ended. This was an important test, as routes with warning surfaces often warn pedestrians of a road with a crossing. In practice, this means the person enters the road almost immediately after the hazard warning surface. The objective assessment showed that none of the test routes were optimal, in the sense that all participants stopped within one metre of the end of the warning surface, Figure 3.18.

![Figure 3.18. Identifying the end of the test route, objective evaluation.](image)

On six of the routes at least half of the test persons stopped within one metre of the end of the route. The greatest difficulty identifying the end of the route and the hazard warning was experienced on test route 7 (three rows of cobblestones (and stop surface in small cobblestones) surrounded by concrete slabs without chamfered edges) and on test route 9 (UK Directional Guidance Paving surrounded by small cobblestones) where none of the participants noticed that the route had ended but continued walking forwards. It was also difficult for test persons to identify the end of test route 10 (concrete slabs with short ribs and a warning surface comprising blister slabs UK Platform Edge Paving in concrete surrounded by concrete slabs without chamfered edges).
3.7 Easy or difficult to walk on the route

3.7.1 Easy, comfortable, safe

Test participants were each asked to evaluate how easy, comfortable, and safe they felt walking on each test route, **Figure 3.19**.

![Graph showing the ease and comfort of walking on the route](image1)

![Graph showing the ease and comfort of walking on the actual guidance path](image2)
The interviews revealed that certain test routes were significantly better than others irrespective of how the test participants were asked to evaluate the routes (easy, pleasant, safe). These routes were test route 1 (sinusoidal paving 350 x 350 mm surrounded by concrete slabs without chamfered edges), test route 2 (sinusoidal paving 350 x 350 mm surrounded by concrete slabs with chamfered edges), test route 4 (sinusoidal paving 210 x 210 mm surrounded by concrete slabs without chamfered edges), test route 5 (sinusoidal paving 210 x 210 mm surrounded by concrete slabs with chamfered edges), test route 11 (UK Hazard Warning Paving surrounded by concrete slabs without chamfered edges) and test route 13 (UK Cycleway Paving surrounded by concrete slabs with chamfered edges). For each of these test routes more test participants judged the route on the positive side of the scale than on the negative. Test route 6 (rubber ribbed paving surrounded by concrete slabs without chamfered edges) and test route 12 (UK Directional Guidance Paving surrounded by concrete slabs with chamfered edges) were also to some extent given a positive evaluation.

Figure 3.19. How easy/difficult, pleasant/unpleasant, safe/unsafe is it to walk on the guidance surface, subjective evaluation.
(cOLUMNS IN THE FIGURE DO NOT INCLUDE THE VALUE 3 ON THE SCALE OF 1-5, I.E. THE ASSESSMENT NEITHER EASY NOR DIFFICULT, NEITHER PLEASANT OR UNPLEASANT AND NEITHER SAFE OR UNSAFE)
3.7.2 Secure

There was also an assessment of how secure the route was, in part by the test participants themselves (subjective evaluation), in part by the observers (objective assessment). Firstly it can be noted that the routes which a majority of test participants experienced as secure were test routes 1 (sinusoidal paving 350 x 350 mm surrounded by concrete slabs without chamfered edges), test route 4 (sinusoidal paving 210 x 210 mm surrounded by concrete slabs without chamfered edges), test route 5 (sinusoidal paving 210 x 210 mm surrounded by concrete slabs with chamfered edges) and test route 11 (UK Hazard Warning Paving surrounded by concrete slabs without chamfered edges). Test route 12 (UK Directional Guidance Paving surrounded by concrete slabs with chamfered edges) was also experienced by test participants as being highly secure, Figure 3.20.

Four routes were experienced as particularly insecure by participants. test route 3 (ribbed paving 350 x 350 mm surrounded by concrete slabs without chamfered edges), test route 7 (three rows of small cobblestones surrounded by concrete slabs without chamfered edges), test route 8 (stormwater metal drain surrounded by concrete slabs without chamfered edges), and test route 9 (UK Directional Guidance Paving surrounded by small cobblestones). The two routes that marked a delineator strip between pedestrian and cycle paths, i.e. test routes 14 and 15, were also viewed as insecure routes.

![Figure 3.20. How secure is the guidance surface to walk on, subjective evaluation.](columns in the figure do not include the value 3 on the scale of 1-5, i.e. the assessment neither secure nor insecure)
The objective assessment by observers is consistent to some extent with evaluations by the test participants, **Figure 3.21.** Only three routes were judged as reasonably secure for at least half of the test participants, namely test route 4 (sinusoidal paving 210 x 210 mm surrounded by concrete slabs without chamfered edges), test route 5 (sinusoidal paving 210 x 210 mm surrounded by concrete slabs with chamfered edges) and test route 12 (UK Directional Guidance surrounded by chamfered edges). Note however that only seven and eight people respectively (of 14) judged these test routes as secure.

Observers and test participants almost completely agreed on which test routes were particularly insecure, which were test route 7 (three rows of small cobblestones surrounded by concrete slabs without chamfered edges) and test route 9 (UK Directional Guidance Paving surrounded by small cobblestones) and to some extent test route 8 (stormwater metal drain surrounded by concrete slabs without chamfered edges). All three routes contained small cobblestones either on the route or as surrounding material.

![Figure 3.21](https://example.com/figure321.png)

**Figure 3.21.** How secure is the guidance surface to walk on, **objective assessment.**
3.8 Sensing the difference between materials on the trial route

During the interviews, test participants were also asked if they had found any difference between the guidance surface and surrounding material, or between different materials used on the test route. Test participants were asked to evaluate how easy or difficult it was to notice the differences. The interviews showed that it was relatively easy to feel the difference between the surrounding material and the route on most of the routes, Figure 3.22.

![Figure 3.22. Noticing the difference between route and surrounding surfaces, subjective evaluation.](image)

(columns in the figure do not include the value 3 on the scale of 1-5, i.e. the assessment neither easy nor difficult)

The test routes where the difference was easiest to feel were, according to the participants, once again routes 1, 2, 4, 11, and test route 12, followed by test route 5 (sinusoidal paving 210 x 210 mm surrounded by concrete slabs with chamfered edges), test route 10 (concrete slabs with short ribs surrounded by concrete slabs without chamfered edges), and test route 14 (delineator between pedestrian and cycle paths comprising five rows of small cobblestones, with a 20 mm high arch, 500 mm wide). The results show significant concurrence between the evaluations by test participants of route security.

To notice the differences between the various materials used on test routes, i.e. the difference between the route surface and the warning surface, was more difficult, Figure 3.23.
A majority of test participants found it difficult to notice any difference between the surface structures or did not notice any difference at all for all of the test routes except four. The exceptions were test route 4 (guidance surface sinusoidal paving 210 x 210 mm and a hazard warning surface on 5 mm flat-topped blisters), test route 8 (guidance surface stormwater metal drain and warning surface comprising 7 mm flat-topped blisters), test route 12 (UK Directional Guidance Paving and warning surface comprising 5 mm flat-topped blisters), and test route 15 (delineator strip between pedestrian and cycle path using the UK model, i.e. white road marking line and warning surface UK Cycleway Paving 3 mm high). The result of this subjective evaluation is consistent with the objective assessment by observers of test participants identifying the hazard warning surface at the end of the route, see Figure 3.17 above.

3.9 Route usability

The final question to test participants was whether they believed the test routes were usable or not. This question was on a scale of 1-10, where 1 represented “not usable at all” and 10 “very usable”, Figure 3.24. Routes that received a 6 or above, i.e. the positive half of the scale, were test route 4 (sinusoidal paving 210 x 210 mm surrounded by concrete slabs without chamfered edges), test route 11 (UK Hazard Warning Paving surrounded by concrete slabs without chamfered edges), and test route 12 (UK Directional Paving surrounded by concrete slabs with chamfered edges). Four test routes received a 5: test route 1 (sinusoidal paving 350 x 350 mm surrounded by concrete slabs without chamfered edges), test route 2 (sinusoidal paving 350 x 350 mm surrounded by concrete slabs with chamfered edges), test route 5 (sinusoidal paving 210 x 210 mm surrounded by concrete slabs with chamfered edges), and test route 13 (UK Cycleway Paving surrounded by concrete slabs with chamfered edges).
The three routes that received a positive evaluation from a majority of participants also received positive rankings for almost all other factors assessed by the test participants. The three test routes were also judged to be easy to follow according to observer assessments. In part, lateral deviations were less than 0.7 m, in part test participants did not lose contact with the route. It was also easy for test persons to identify the beginning of these routes and relatively easy to identify when they ended. However, observers assessed only one test route as relatively secure for test participants, namely test route 4 (sinusoidal paving 210 x 210 mm surrounded by concrete slabs without chamfered edges). To some extent, test route 12 (UK Directional Paving surrounded by concrete slabs with chamfered edges) was also judged as relatively secure.
4. CONCLUSIONS AND RECOMMENDATIONS

4.1 Results summary

1. Guidance surfaces: The sinusoidal paving slabs used on test routes 1, 2, 4, and 5, and the UK warning slabs on test route 11 and UK guidance surface on test route 12 were judged to be usable guidance routes. All of these were considered as positive to “find, follow and walk on” and were on the upper half of the scale for “usability”.

2. Guidance surfaces with non-chamfered edges seem to offer a smoother walking pattern. Guidance surfaces on test routes 1 and 2 had chamfered edges longitudinally, which meant test participants experienced difficulties with the long white cane sticking in the joint when they walked along these surfaces. Guidance surfaces for routes 4 and 5 had non-chamfered edges, which resulted in a much smoother walking pattern.

3. Surrounding materials are very important. Smoother surroundings make it easier to “feel the difference compared with the route” and also to “follow the route”. The UK guidance surface was included on two test routes – test routes 9 and 12. Test route 9 was surrounded with small cobblestones while the surrounding surface for test route 12 was concrete slabs with chamfered edges. Test route 9 was unusable, while test route 12 was among routes that were judged as usable.

4. If warning surfaces are to be identified then they should be designed so that canes stick in them. However, the structure should not be so high that there is a risk that other people trip. The blister paving on test routes 4, 5, 6, 8, 10, and 12 seemed to be easier to find than those on test routes 1, 2, and 3 as white canes became stuck in the earlier slabs.

5. At the beginning of the route – when users moved from the smooth concrete slabs – more people noticed the blister slab than at the end of the route. The structural difference between the surfaces was much greater where the blister paving was first noticed.

6. The two test routes where it was difficult to find the route at all using the surface guidance structure were routes 3 and 9. The low rib height on test route 3 meant users could not identify any difference in height between the ribs and the slab base. For test route 9, the difficulties were a result of the long white cane jumping on the surrounding material which meant users could not achieve the calm, sinusoidal wave movements, that the same guidance surface offered on test route 12.
7. Concentration was disturbed as soon as the long white cane jumped or stuck in the guidance surface or surrounding material, and it became difficult to register the difference between guidance surface and surrounding material. This was irrespective of where the unevenness occurred.

8. Test routes 1, 4, 5, 11, and 12 were considered “secure”. Test routes 1, 2, 4, 5, 11, 12, and 13 were judged as “usable”. Test routes 1, 2, 4, 5, and 11 were regarded as “safe”. If the long white cane stuck for some reason the user came to a halt, lost direction, had difficulty finding his or her bearings again and needed help.

9. Test routes 3, 7, 8, 9, and 10 all had low and differing subjective and objective values. The routes were difficult to follow, users became stuck, swayed and walked on first one and then the other side of the route.

10. An 80 cm wide guidance surface was too wide (test routes 11, 12, and 13). Test participants commented on the width by saying that they felt insecure as they could not feel the outer edges of the test route. The narrow routes – 13-35 cm – seemed to be too narrow to walk on. Only the long white cane could be used to follow these and this was clearly difficult.

4.2 Comments

The study has both confirmed and rejected results from earlier trials listed in the reference literature or results from other sources. Firstly, we can note that blind persons had great difficulty in feeling the difference between guidance surfaces and warning surfaces currently used in the physical environment. This study showed that when guidance routes are built that end with a warning surface of blister paving, completely blind people are not made sufficiently aware of the danger. The reason for this is that the differences in indications in the hand from the long white cane were not sufficiently different when moving from a guidance surface with ribbed or sinusoidal paving to a warning surface with blister paving.

A majority of test participants in this study did not notice the transition from guidance surface to warning surface until several metres after the end of the warning surface. In practice this meant the person would be several metres onto the road if there was no edge to indicate the transition from pedestrian walkway to road. Test participants found it slightly easier to identify the hazard warning surface if the transition
was from a smooth surface, which was the case at the beginning of each test route in the trial. The results also showed that many more people identified the beginning of the test route than its end. Blister paving with flat-topped blisters were slightly easier to identify than slabs with rounded domes.

One of the test routes included a design that is common in Sweden today: ribbed paving and blister paving flat-topped blisters, both structures are 2.5 mm high. Tests with visually impaired people in the late 1980s found this combination usable. This opinion has been modified in more recent years. In real environments that use this type of guidance route, blind persons have experienced great difficulty in identifying and finding the route. This combination was included in the trials and the difficulties were verified. We noted that if the route was identified it was not because of the difference in structure but because of differences in sound, which test participants also commented on. These differences in sound were dependent on whether the slabs were dry or wet pressed, irrespective of type of slab.

The use of sound for identification and guidance is however not usable in a real traffic environment. The fact that several test participants could hear a difference in sound during the trials was because the tests were carried out in a sheltered environment, without other distracting sounds or other distractions, such as other road users. Test participants pointed this out in interviews. That the combination of 2.5 mm high ribbed and blister paving was originally thought to be usable, and has as a result been widely used, was probably because these tests in the 1980s were also carried out in an environment free from interference.

Another important observation during the tests was how the long white cane moved across the ground. We noted that ground that provided a soft and even sinusoidal wave movement in the long white cane and its extension the hand, were assessed and evaluated as most usable and easy to follow. Of the test routes used in this study, both the sinusoidal slabs and certain ribbed slabs produced this movement. Other surface structures that were not tested in this trial, both sunken and raised, offer the same qualities, i.e. the long white cane can dip without sticking. In this respect, it is important not only with the width of the raised or sunken area but also the relationship between the widths of the raised and sunken parts of the structures.
Another important observation during the trials was that even slight chamfers on slab edges resulted in the long white cane sticking, irrespective of whether the chamfer was on the guidance surface or on surrounding material. This led to repeated stoppages for test participants, which impacted both the walking rhythm and the opportunity to orientate themselves on the guidance surface. Constant stoppages can cause completely blind persons to easily lose the direction of the guidance surface, requiring them to search the surface to regain their bearings. This was experienced by several test participants as a narrowing of the guidance route at certain points or that the test route turned. The surface structures that provided the positive quality of sinusoidal movements with the long white cane were not as useable if the slabs had chamfered edges compared with non-chamfered. This was because the long white cane stuck in the chamfer. The same was true if the surrounding slabs had chamfered or non-chamfered edges. Another observation was that guidance surfaces with ribs also resulted in sudden stoppages when the ribs were not completely edge to edge at the joint between paving slabs.

In this context, the problem of small cobblestones is also worth discussing. On two of the test routes small cobblestones were used as part of the guidance route and on one as part of the surrounding material. Small cobblestones in the guidance surface led to continuous stoppages because of sticking white canes, which in turn meant test participants often lost contact with the guidance route. A surface structure with small cobblestones always entails frequent joints, which makes this material unsuitable for use as a guidance surface. The tests also showed that even small cobblestones as surrounding material resulted in sticking in the joints and that the difference in structure compared with more suitable guidance routes (that provide sinusoidal movement) was so small that blind persons had great difficulty in locating the guidance route at all.

The problem with the sticking long white cane and the resulting problems for blind persons in following the guidance route also embraces other dimensions in addition to a stuttering walk, constant stoppages and difficulties in orientation. It also influences security, both the experienced security and the real. The strain on individuals is great; users must concentrate all the time, which requires a substantial effort. This affects the level of attentiveness on other important factors in traffic, which test participants noted immediately and expressed as insecurity, and observers noted during the tests.

One important question that was often discussed is how wide a guidance route should be. The test surfaces that were part of the trial were designed using different widths (130 - 800 mm), though the same guidance route was not tested with more than one width. Previous trials in Sweden have found that the width should be slightly
more than shoulder width. In practice this has often meant two rows of slabs (about 700 mm). The reason for this particular width is that people should be able to use the long white cane to identify potential dangers in front of their own body.

Results of the trials show that both test participants and observers found the narrow guidance surfaces (130 – 350 mm) difficult to follow. Test persons often lost contact and needed help to find their way back to the guidance surface again. The widest routes (800 mm) were regarded as too wide. Test participants were unsure of whether they were still on the guidance surface or not, as they did not always maintain contact with the surrounding surface when they walked on the guidance route. This trial offers no direct answer to the issue of a suitable width, but we could observe from the trial that guidance routes that were too narrow (small cobblestones and stormwater drains, with or without small cobblestones) were not suitable either. Narrow routes that offered sinusoidal movements with the long white cane have not been tested. It is possible that this type of guidance route could provide enough information at a width of about 350 mm, but further tests must naturally be carried out. One reason for doubt, is that at a width of 350 mm users cannot walk with both feet on the guidance route.

The trial also included two test surfaces for tactile separation of pedestrian and cycle paths. Test participants were required to walk on the pedestrian path and identify this central delineator strip from the side. We noted that neither of the structures, neither the arched surface with small cobblestones which was about 500 mm wide nor the 10 mm high road marking line, was sufficient for a blind person to safely navigate the route. By this, we mean that pedestrians should be able to use the pedestrian walkway without accidentally walking onto the cycle path or catching a bicycle wheel with the long white cane.

As mentioned in section 2.4, four physically disabled persons also tested the various guidance and warning surfaces. The aim with this was to see if the tested structures were an obstacle or caused difficulties to walk on or drive over for these groups. We noted that for persons with walking aids on wheels (walking frame or wheelchair) the guidance surfaces which were useable for blind persons were generally inconvenient for these groups. The reason for this was that on these surfaces front and back wheels roll on different tracks, which results in shaky and unsteady rolling with a walking frame or wheelchair. It is therefore important that the smooth part of the pavement alongside a guidance route is wide enough to accommodate a person using this type of walking aid. The width of the guidance paths tested in this trial (up to 800 mm) presented no problems for users that walked straight across them.
4.3 Continued research

The trial has clearly illustrated the need for research about visually impaired people and guidance routes. In this study, we have particularly focused on opportunities for blind persons to identify different surface structures using a long white cane. Many new questions have arisen during the trial. These include basic questions about when artificial guidance routes should be used, how they should be designed at roundabouts or raised pedestrian passageways, and which combinations of materials provide the information required. Even if this project has not studied luminance contrast, there is a great need for systematic research in this field, such as the size of surfaces in relation to the differences in luminance on the contrasting surfaces.

With regard to tactility, it is important that experiences from this project are utilized. The combinations of guidance surfaces that were found to be most usable in this project should be tested in a real traffic environment. This is important as some of the findings of this trial in a controlled environment indicate that there are many disturbing factors in the traffic environment that impact a blind person’s concentration and opportunities to detect and follow a guidance route. A project of this nature should use a clear route from a starting point to a target point, including both natural and artificial guidance surfaces, and also points offering choices and warnings. This trial should also include a solution for crossing a cycle and road carriageway. Another item for further study is the problem of winter conditions. In part, this concerns the opportunity to use guidance routes when there is snow and ice. In part, this also concerns the operation and maintenance of guidance and warning surfaces and how this impacts the materials.

For continuing research, it is important to incorporate a European perspective as standardisation work is already underway.
References


Taktilla ledstråk och taktilla markeringar : utvärdering (2002) Stockholm, Resandegruppen, Synskadades riksförbund

Guidance route project. Assessment questionnaire

Name: ___________________________
Date: ___________________________
Day of week: ______________________
Time of day: ______________________
Weather: __________________________
Guidance route number forwards ☐ back ☐ Number in sequence: _______
Which hand is holding the long white cane right ☐ left ☐
Time taken to walk route (30 m): __________________________

Assessment
"Finding the route" – 4 metres
- lateral deviation (0.7 m) yes ☐ swaying ☐ no ☐
- long white cane technique sweeping ☐ gliding ☐ both ☐
- width of sweep arc narrow ☐ normal ☐ wide ☐
  (body width)

Identifying the stop paving: YES ☐ NO ☐
- long white cane technique sweeping ☐ gliding ☐ both ☐
- sticks yes ☐ no ☐
- deviates from the route (0.7 m) yes ☐ sways ☐ no ☐
- width of cane arc narrow ☐ normal ☐ wide ☐

Identifying the route: YES ☐ NO ☐
Following the route:
- long white cane technique sweeping ☐ gliding ☐ both ☐ other ☐
  yes ☐ no ☐
- lateral deviation (0.7 m) yes ☐ no ☐
  if yes, how many times _____
- where does the subject walk on the route to the left ☐ to the right ☐ one of these ☐ both ☐
- follows the route with both feet yes ☐ no ☐
- stops yes ☐ no ☐
  if yes, how many times _____
- loses contact with the route yes ☐ no ☐
  if yes, how many times _____
- needs help yes ☐ no ☐
  if yes, how many times _____
- width of cane arc narrow ☐ normal ☐ wide ☐

Identifying the stop paving: YES ☐ foot ☐ cane ☐ NO ☐
Identifying the end of the route: YES ☐ foot ☐ cane ☐ NO ☐
Objective assessment after each guidance route:

- finding the route?
  1. Very easy  
  2. Quite easy  
  3. Neither easy nor difficult  
  4. Quite difficult  
  5. Very difficult  

- following the route?
  1. Very easy  
  2. Quite easy  
  3. Neither easy nor difficult  
  4. Quite difficult  
  5. Very difficult  

- walking on the route?
  1. Very secure  
  2. Quite secure  
  3. Neither secure nor insecure  
  4. Quite insecure  
  5. Very insecure  

Annex 2

**Interview** (after each route)  
**Interviewer:** __________

Name: _________________________  
Date: _________________________  
Time of day: _____________________  
Day of week: _____________________  
Weather: _________________________  
Guidance route number: __________  Number in sequence: __________

**Subjective assessment:**
- how easy was it to find?
  1. Very easy  
  2. Quite easy  
  3. Neither easy nor difficult  
  4. Quite difficult  
  5. Very difficult

- how easy was the route to follow?
  1. Very easy  
  2. Quite easy  
  3. Neither easy nor difficult  
  4. Quite difficult  
  5. Very difficult

- how easy was the route to walk on (the combination)?
  1. Very easy  
  2. Quite easy  
  3. Neither easy nor difficult  
  4. Quite difficult  
  5. Very difficult

- how did it feel to walk on the guidance paving?
  a) 1. Very pleasant  
     2. Quite pleasant  
     3. Neither pleasant nor unpleasant  
     4. Quite unpleasant  
     5. Very unpleasant
b) 1. Very safe  
   2. Quite safe  
   3. Neither safe nor unsafe  
   4. Quite unsafe  
   5. Very unsafe  

or alternatively

1. Very secure  
2. Quite secure  
3. Neither secure nor insecure  
4. Quite insecure  
5. Very insecure  

- how clearly did you **notice the difference** between the guidance route surface and the surrounding material?
  1. Very easy  
  2. Quite easy  
  3. Neither easy nor difficult  
  4. Quite difficult  
  5. Very difficult  

- did you **notice differences** in the guidance route materials?  
  yes ☐ no ☐

  if yes, how did the blister paving feel?
  1. Very clear  
  2. Quite clear  
  3. Neither clear nor unclear  
  4. Quite unclear  
  5. Very unclear  

- **how usable did you find this route on a scale of 1-10?**  
  (1 = not usable at all, 10 = very usable)

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- General comments __________________________________________________________

______________________________
Interview (during the break)  

Name: ________________________________  

Day of week: ____________________________  

Time of day: ____________________________  

Weather: _______________________________  

Information about the subject:  

- age ______________________________  

- gender ____________________________  

- hearing ____________________________  

- type of physical disability  

- diabetic ____________________________  

- sensitivity in feet ____________________  

- shoe size ____________________________  

- type of shoes ________________________  

- how long has the subject been completely blind ____________________  

- experience outdoors ____________________  

- rehabilitation outdoors ________________  

- usual cane technique used outdoors  

- has the subject grown up in another country with other customs  

______________________________