TYPE OF INFRASTRUCTURES	REFERENCE	ORIGIN/CITY	TARGETED INDIVIDUALS	AIM / OBJECTIVES / HYPOTHESES	JUSTIFICATION	PARTICIPANTS	METHODOLOGY / SET UP	RESEARCH TOOLS	VARIABLES / INDICATORS STUDIED	ANALYSIS / INTERPRETATION	RESULTS	STATED LIMITS	CONCLUSION (THE BEST INFRASTRUCTURE/PRACTICE)	QUALITY
	Childs, C.R., Boampong, D.K., Rostron, H., Morgan, K., Eccleshall, T., & Tyler, N. (2009). Effective kerb heights for blind and partially sighted people: Research commissioned by The Guide Dogs for the Blind Association (Guide Dogs). *Accessibility Research Group: Civil, Environmental, and Geomatic Engineering of the University College of London*. pp. 1-30.	**London, United Kingdom**	**Vision impaired**	Guide Dogs asked UCL to investigate the minimum kerb height that blind and partially sighted people can reliably detect considering kerb height rather than alternative surfaces. To run tests to determine what kerb height could be reliably detected by blind and partially sighted people.	Several local authorities in the UK have redesigned town centres and high streets using the concept of shared space, or are in the process of doing so. Shared space aims to create shared 'social' areas for all users, reduce the dominance of motor vehicles and make streets more people-friendly. The main idea behind this is that by forcing motorists and pedestrians to use the same space, drivers will reduce speed because of the increased risk, thus making the area safer for everyone. Shared space is often delivered by means of a "shared surface design" which requires the removal of the traditional vertical upstand (kerb). The removal of the kerb takes away the vital clue used by blind and partially sighted people to help them to navigate the pedestrian environment and to identify when they have reached the edge of the footway. Optimal height of the kerb depends on the road use. Traditionally, a kerb height of 120mm to 150mm has been considered sufficient to stop vehicles mounting the footway, thus keeping the space clear for pedestrians. In traditional streetscapes safe spaces are provided by the footway, delineated by the kerb. However the traditional 120mm+ kerb makes too distinct a separation for proponents of shared space schemes. This raised the question of the possibility of finding an alternative surface as a delineator. Earlier work (GDBA, 2007) showed that the 30mm kerb suggested by Ramboll Nyvig was not sufficiently reliable for blind and partially sighted people to use as a delineator, and equally was a barrier to some people using wheelchairs.	n=36 blind and partially sighted people (23 men, 13 women). 8 participants were 18 to 40 years old, 21 participants were 41 to 64 years old, and 7 were 65 or older. 11 used a guide dog, 17 used a long cane and 8 used no aid device. All the participants recruited reported that they use the street environment independently, either limited to local familiar areas, or for exploring new unfamiliar areas. There were 36 participants in total, but not all participants completed all the trials. Only blind and partially sighted people were included in these tests as people with mobility impairments, in particular those in wheelchairs, were unlikely to overcome the kerb upstand and would need to have dropped kerbs in any design incorporating a kerb delineator.	The experiments took place at the Pedestrian Accessibility and Movement Environment Laboratory (PAMELA) at University College London. PAMELA is a laboratory used to test existing and proposed pedestrian environments under controlled conditions. The laboratory includes a computer-controlled paved platform which can be varied in terms of layout, topography and surface type. People who were positioned at set points in the laboratory and asked to walk until they were told to stop or they encountered a kerb, following the experimenter's voice to help with orientation. If the participant did not detect a kerb where there was one, the experimenter would class the trial as a fail. If a kerb was encountered, the participant was asked to give a score relating to the confidence they had that what had been encountered was a kerb. Kerbs were tested at heights from 20mm up to 120mm and in 2 profiles - bullnose and chamfer. The 'traditional kerb' height of 120mm was used as a baseline, to compare with kerb heights from 20mm up to 80mm. Two edge profiles were tested, one vertical with a chamfer, the other 15° to vertical with a 20mm bullnose. PAMELA modules were arranged with two baseline areas that would be the equivalent of the footway either side of a road. The edge length of each Baseline section was 7.2m. This allowed for three 2.4m kerb height sections on each side, thus six kerb heights along the edge of the Baseline Sections. One additional kerb height section of 3.6m long was located perpendicular to the edges of the Baseline Sections. The height changes occurred at either end of the 3.6m space between the Baseline Sections. The entire surface was covered with 400mm x 400mm chamfered edge concrete pavers. The kerb heights ranged from the traditional 120mm to 20mm (120, 80, 60, 50, 40, 30, 20). Two different edge profiles were tested to determine if the profile made a difference to the detectability of the kerb. The first profile to be tested was a straight vertical face with chamfered edge. The second profile had a straight face 15° to the vertical and a 20mm bullnose edge (Marshall's Half-Battered Kerb). The kerb heights were arranged so that a participant would have a reasonable distance to walk before they would encounter a kerb and so that the full range of kerb heights could be encountered within the layout. Each participant was led to a randomly assigned part of the platform, then asked to follow the experimenter's voice to another part of the platform, only stopping if they detected a change (e.g. a kerb). Each experiment consisted of trials where the participant encountered each of the kerb heights; stepping down and stepping up, when approached from 90° and approximately 45°. Each participant was asked the following question after each trial : 'On a scale of zero to ten, how easy was it to tell that you had detected a kerb : with zero being definitely did not detect a kerb, five being detected something but unsure whether it was a kerb and with ten being definitely did detect a kerb?' After each trial the experimenter noted whether the participant stopped having detected any kerb encountered. This was recorded as : 1) before, 2) on, 3) after, 4) fall. Each participant was asked to respond to the following question at specific times throughout their time in the laboratory : 'On a scale of zero to ten, how anxious do you feel about the experiment : with one being not anxious at all and with ten being the most anxious imaginable?'. The participants were asked their perceived anxiety at various points during the experiment process: (1) in the laboratory reception area prior to entering the laboratory area, (2) after having been led into laboratory area just prior to the first experiment trial, (3) after each experiment trial, and (4) at the end of the experiment, after being led back to the reception area.	Each test was video recorded from cameras arranged around the laboratory. The experimenter recorded the key parameters throughout the experiment.	Kerb height Approaching (stepping up or stepping down) Approaching angle (45 and 90°) Edge type Level of anxiety Level of confidence Controlled variables: footway width, distance between different kerb options	For each participant that encountered both conditions their responses to the questions regarding detect confidence and anxiety were compared. For example, the response a participant gave when they approached a kerb at 45° was compared to when they approached that same kerb height at 90°. If the detect score was higher for 45° than 90°, then this was classed as 45° being easier to detect than 90°. Conversely if the detect score was lower for 45° than 90°, then this was classed as 90° being easier to detect than 45°. If the detect score was the same for both angles, this was reported as 'No Difference'. For each comparison paired 2-tailed t-tests were performed with a *p*-value less than 0.05 considered significant. It was expected that there would be no difference in detection confidence or anxiety for any of the conditions tested. 10 was classed as the participant being confident that what had been encountered was a kerb; 6 to 9 was classed as the participant being sure that they had encountered something and were confident that it was a kerb; 5 was classed as the participant being confident that they had encountered something, but were not entirely confident that it was a kerb; 1 to 4 was classed as the participant being unsure that they had encountered something different to the surrounding paving, and were not confident that it was a kerb; 0 was classed as the participant being sure that they had not encountered anything different to the surrounding paving, and were confident that they had not encountered a kerb. For the participants who responded with a value greater than 5, they were asked whether this anxiety was related directly to the experiment (e.g. the risk of hurting themselves on the kerb) or to their perception of how they would be in a shared space having encountered this surface.	Even the traditional kerb height of 120mm cannot stop occasional instances of people walking over it before realizing they have reached a delineator in the street space : indeed, some blind and partially sighted people use that "positive" step down as their warning. This seems to occur when people step down the kerb: it was never observed to occur in these experiments when a participant stepped up the kerbs greater than 50mm high. There is an asymmetry in the 'after' score. The 'detect on' and 'fail' scores are approximately symmetrical between stepping up or stepping down, in that there are similar numbers of participants detecting the kerb once they were on top of it, or failing to detect it during the traverse. However, the number of participants who only detected the kerb after they had passed it after stepping down it was consistently higher than when stepping up for all kerb heights. Conversely, there were more detections of a kerb before reaching it when the participant was about to step up the kerb than if they were stepping down. The number of fails is highest for participants stepping up or down the 20mm kerb and this settles to zero at around the 50mm height. For the majority of trials, participants were absolutely confident that they had encountered a kerb on the trials with the 80mm (82%) and 120mm kerbs (84%). The levels of confidence drop when the kerb height is 60mm or less (participants scored '10' for 74% of trials over 60mm, 64% of trials over 50mm, 63% of trials of over 40mm, 54% of trials over 30mm and 30% of trials over 20mm). In general, the confidence that a kerb was detected tended to be higher when the participant approached the kerb from the lower side. These numbers indicate the high level of confidence that participants had encountered a kerb when it was 120mm high. No participant failed to detect the 120mm, 80mm, or 60mm kerb on any trial, from any angle tested, or for either of the edge profiles. There were no failures when going up this kerb. The first failure to detect when stepping up a kerb was for the 40mm height. Four guide dog owners, six long cane users and three people who didn't use any aid, failed to detect the 20mm kerb. For the majority of the participants (61% of the participant tests) there was no change over time, with all these participants showing low levels of perceived anxiety throughout. For all the trials where the perceived anxiety varied throughout the experiment, there was no apparent trend for higher anxiety scores with either lower or higher kerbs. From participant feedback during the experiments, there were some comments where people stated that they were more anxious over the lower kerb heights in the sense that they would be less confident that they were actual kerbs when encountered in an environment that meant they could be walking out into a space with vehicles. There was no statistical difference in detection ($p = 0.39$, paired 2-tailed t-test) or anxiety ($p = 0.66$, paired 2-tailed t-test) scores given when the participants approached the kerb straight on, compared to approaching it from an oblique angle. There was a statistical difference in both detection and perceived anxiety scores ($p < 0.01$, paired 2-tailed t-test) comparing when the participants stepped up or down the kerb. There is a large number showing no difference in detection (353 trials) or perceived anxiety (402 trials). More people reported a higher detection confidence score when they stepped up (160 trials) than when they stepped down the kerb (61 trials). In addition, more participants reported a lower perceived anxiety score when stepping up the kerb (122 trials) than when stepping down. There was a statistically significant difference ($p = 0.02$, paired 2-tailed t-test) between the detection scores on test day 1 (chamfered edge) and test day 2 (bullnose edge). However, there are only slightly more occasions (128 rather than 112) when the bullnose edge was scored higher on the detect scale than the chamfered edge. Similarly, there was a statistically significant difference ($p << 0.01$, paired 2-tailed t-test) between the perceived anxiety scores on test day 1 (chamfered edge) and test day 2 (bullnose edge). There were more occasions (169 compared to 41) where the chamfered edge was scored lower than the bullnose edge (for the same kerb height and direction) in terms of perceived anxiety. There is a large number showing no difference in detection or perceived anxiety.	These experiments were designed to determine whether different kerb heights could be detected. They were not tested to see if they could be followed for any distance. All the participants knew they were in a safe, relatively quiet space with no vehicles. After the first few trials they were also aware that there were no obstacles in the space such as lamp posts (which could also be used as indicators of position). The distance was functionally short (3.6m maximum at 90°, approximately 5m maximum at 45°), and as such it was a realistic distance from the building line to the kerb, but in reality, walking down a street someone may walk for tens of metres before encountering a kerb. Issues relating to other groups, such as people with learning disabilities, would need to be considered in other future research.	Kerb heights of 60mm and above were detectable when stepping up and stepping down and induced the greatest confidence in what they were and what they signified. Kerb heights less than 40mm appear to be less consistent in detection rates and thus consideration should be given to avoiding them if possible. Epidemiological tests would be required to determine if 50mm kerbs would be a problem in the wider population of people who are blind or partially sighted. There was no statistically significant difference in the rate of detection whether the participant approached the kerb from straight on or from an oblique angle. It is unlikely that the kerb edge profile makes a significant difference as long as the kerb face is approximately vertical.	40
	Cooper, R. A., Wolf, E., Fitzgerald, S.G., Kelleher, A., Ammer, W., Boninger, M.L., & Cooper, R. (2004). Evaluation of selected sidewalk pavement surfaces for vibration experienced by users of manual and powered wheelchairs. *Journal of Spinal Cord Medicine*. 27: 468-475.	**Pittsburgh, Pennsylvania, United States**	**Mobility impaired, wheelchair users**	Conduct an evaluation of the vibration exposure during electric-powered wheelchair driving and mechanical energy requirements for manual wheechair propulsion over selected sidewalk surfaces. Determine the criteria for a wheelchair-pedestrian access route that does not require excessive propulsive work or expose wheelchair users to potentially harmful vibrations.	While propelling a wheelchair, users encounter obstacles such as bumps, curb descents, and uneven driving surfaces. These obstacles cause vibrations on the wheelchair. Extended exposure can cause lower back pain, disk degeneration, and other harmful effects to the body. To date, little research has been conducted to assess this issue.	n = 10 unimpaired individuals (5 men, 5 women, mean age: 32.5 years (23-55 years), mean mass 71.1kg (47-104kg), height 170cm (157-187cm). **Exclusion criteria:** shoulder pain (preventing manual wheelchair propulsion), history of cardiopulmonary disease.	**Experimental design. Methodology: Electric wheelchair:** Subjects were asked to drive 3 times over the 6 surfaces at 2 speeds (360 trials). **Manual wheelchair:** Subjects were asked to propel 3 times over the 6 surfaces at one speed (180 trials). **Set up: 6** types of sidewalks (all of them 4-ft wide, 25-ft long, 1.3° slope, and no cross slope). **1:** poured concrete with a brush finish to represent the norm ; **2:** concrete pavement constructed of blocks with squared edges (90° herringbone pattern); **3:** concrete pavement with 2-mm beveled edges (90° herringbone pattern); **4:** concrete pavement with 8-mm beveled edges (90° herringbone pattern); **5:** fired clay bricks with 4-mm beveled edges (45° herringbone pattern); **6:** fired clay bricks with squared edges (45° herringbone pattern). All the surfaces were tested outside (19°C average) while dry. **Wheelchairs used: Electric wheelchair**: rigid frame with 203mm front casters and 254-mm-diameter rear wheels, seat width of 406mm, seat depth of 415mm, backrest height of 435mm, mass of 89kg. **Manual wheelchair:** rigid frame design with 127-mm-diameter polyurethane tires and standard 610-mm-diameter rear wheels, seat width of 406 mm, seat depth of 458mm, backrest height of 410mm, mass of 15.5kg.	SmartWheels (mechanical work) and accelerometers	Surface Peak acceleration Power acceleration per octave Frequency at which peak acceleration occurs Mechanical work to propel over surfaces (manual wheelchair)	Data reduction consisted of converting each of the 3 axes of the accelerometers into a resultant acceleration vector for both the seat and the footrest. A statistical analysis was performed in order to redress the acceleration (vibration) information issued by the seat and foot sensors. The power of acceleration (seat and feet) expressed in Hz was aggregated by octaves to ease comparisons. An analysis of variance was performed. Vibration data were also compared with ISO 2631 standard of exposure time, which measures how long it would take before injury occurs based on vibration level.	**Electric wheelchair:** At 1m/s, significant differences were found in the **peak acceleration** between the sidewalk surfaces. The peak acceleration for surfaces 2, 5, and 6 where lower than the standard (1) sidewalk surface, with surface 4 being significantly higher. Similar results were seen for 2 m/s, surface 4 having higher peak amplitude. The standard sidewalk recorded significantly higher **vibration values per octave** than other surfaces for the octaves examined. For several of the octaves, surface 4 recorded the lowest vibration at 2m/s (differences not statistically significant). The electric-powered wheelchair tended to record **seat vibrations** higher than the manual wheelchair. Comparison with **ISO 2631** shows that at 1m/s surfaces 4 and 5 did not exceed the 78h exposure limit boundary. Data at 2m/s: all surfaces, including the poured concrete sidewalk, induced whole-body vibrations that exceed the limit after 3-hours of exposure. **Manual wheelchair:** Surfaces 2, 3, 5, and 6 have lower **peak vibrations** and surface 4 has the highest peak vibration, even more than surface 1. For the octaves between 2 and 12.5Hz, the **vibration power** for all surfaces was equal to or significantly lower than the standard sidewalk, with the exception of surface 4. Surface 4 had higher vibrations in all octaves in comparison to the standard sidewalk. For all surfaces, no significant differences were found for the **work to propel** over the different kinds of sidewalks. Surfaces 1, 2, and 6 tended to transmit **peak accelerations** lower than the natural frequency range of humans. The values for work required to propel over the surfaces tested were not statically different.	1) The placement of the seat accelerometer on the seat frame underneath the cushion (not desirable to have a contact with the subject). 2)The addition of the SmartWheel to the manual wheelchair. The added mass of the wheels could affect the resultant vibrations. 3) Other studies need to examine a broader range of surfaces, including the aging ones due to exposure to weather. 4) It would be desirable to conduct similar studies with impaired subjects in the sample.	Finding peak frequencies between 2 and 11Hz, this study found that the greatest risk for injury due to shock and vibration occurs near the natural frequency of seated humans (between 4 and 12Hz). It is desirable to either reduce the amplitude of power of the shock and vibration or to shift in the frequency so that it is outside this range. In this study, peak frequencies occurred between 2 and 11Hz. When treating the poured concrete sidewalk as the normative standard, surfaces 2, 3, 5, and 6 compared most favorably in terms of shock and vibration exposure, whereas surface 4 produced mixed results.	47
			To establish if the selected surfaces were useful to visually impaired people in a real pedestrian environment, and what were the most appropriate layouts for each type of surface.	n=51 visually handicapped people (53% men, 47% women) (age range from 16 to 89 years - 1/3 of subjects were aged 56 to 65)). When asked if they had any other disability, 10 people (20%) said that they had diabetes.	**Part 1.** A series of consultative meetings with representatives from Wolverhampton Metropolitan Borough Council, CENTRO West Midlands, (the former West Midlands PTE), British Rail, TRRL, Department of Transport and manufacturers of surfaces, to view various sites and to discuss proposed layouts of the different surfaces. **Part 2.** A series of experiments, designed to assess how useful the various surfaces and associated layouts were to a sample of visually impaired people. A group of ambulant disabled people and wheelchair users also tested the installations to find out whether they caused any mobility problems.	Before participating in the actual experiment, subjects were asked to complete a questionnaire giving details of their personal characteristics, such as level of msion, type .of mobility aid used and whether they had any other disabilities, in particular diabetes. Similarly, prior to the actual experiments, subjects were asked a series of questions designed to establish whether they had any problems when walking through pedestrianized areas, locating bus stops, identifying road crossings where dropped kerbs have been installed, locating steps and negotiating railway stations.	Depth of the tactile surface	The stronger the contrast or brighter the colour of tactile surfaces the more likely the installations prove useful for people with residual vision. 20% of the sample had diabetes, which is of particular concern to the research as this illness can result in reduced sensitivity in the feet. Little attention has been paid to assessing levels of residual vision of people with diabetic retinopathy. The finding that nearly a third (15 people) of the sample had been hurt in accidents involving steps emphasizes the need to install tactile markings to indicate steps and the importance of step nose markings to show the step edges. 24% of the sample (12 people) reported being involved in accidents at pavement works. This suggests that further research is required to examine the problem and to ascertain the feasibility of providing a portable tactile surface to warn of pavement works. However, it is difficult to envisage a portable tactile warning that is also vandal proof. The finding that just under a third (27%) of subjects had experienced accidents involving cycles either on footpaths or shared cycleways, suggests that further research in this area is required.	Further research is required to examine the problem and to ascertain the feasibility of providing a portable tactile surface to warn of pavement works. However, it is difficult to envisage a portable tactile warning that is also vandal proof.	A disturbing finding is that a high proportion of the study sample had been hurt in various pedestrian accidents. This finding adds to the argument that tactile surfaces are both useful for visually handicapped people and may well increase the safety of blind pedestrians.	
			At St Peter's Square: To ascertain whether the tactile surface could be detected and if the layout enabled visually impaired people to follow the guidance path across a public square.		St. Peter's Square. The guidance path was 800mm wide and consisted of 2 rows of concrete paving slabs each measuring 400mm x 400mm. Each paving slab had a bar face pattern with an upstand of 3mm as opposed to the recommended height of 5.5mm. The bar pattern was used to provide directional information at turning points on the path. At the junction in the path layout, two paving slabs were laid transversely to indicate the directional change. ***At Saint Peter's square, subjects were given a detailed verbal description of the guidance path dependent on the route to which they had been allocated. In order to successfully complete the experiment, subjects had to follow the guidance path along the allocated route and return to their starting position. At the end of the experiment, subjects were asked a series of questions about the surface and la out of the path.	Questions were asked about whether they could see it, and whether the layout was useful. Subjects were also invited to make suggestions on how the usefulness of the installation might be improved.			The research has shown that the layouts or routes of guidance paths, through pedestrianized areas, must be simple and direct. Right angle turns and T junctions must, where possible, be avoided. A path 80cm wide is useful for visually handicapped people. Most ambulant disabled people and wheelchair users did not encounter mobility difficulties when walking or wheeling along the experimental guidance path. However, the pattern profile of this surface was 2mm lower than is recommended. It is, therefore, advisable that ambulant disabled people and people in wheelchairs test a guidance path comprised of the recommended tactile slabs (with 5mm high directional bars).The results of the guidance path experiment suggest two main points: firstly, that the layout of these installation should be simple, direct and with few turns, junctions or corners. If the pathway is designed to guide people to specific entrances or facilities, it should lead the users into the entrance or to the facility. Secondly, that installing authorities should ensure that the tactile pattern meets the recommended specifications. The bars on the paving used in the experiment were 2mm below the recommended 5mm pattern upstand.	
			At Darlington Street: To establish whether visually impaired subjects could detect the tactile surface laid to indicate a bus stop and how useful they found the layout.	Of the 51 subjects, 17 (33%) said they were totally blind. The 34 people who had some residual vision were asked to describe what they could see. The majority (62%) could see colour, contrast and shape, however a substantial proportion (41%) had sight in one eye only. Most of the people with residual vision (75%) said that their sight was useful when they were out walking.	Darlington Street Bus Stop. A latex surface was used to indicate the location of a bus stop. The material is a mixture of shredded rubber and adhesive, and is soft and malleable when initially installed. Before the latex material has 'hardened', which can take 8 to 12 hours depending on weather conditions, lines or ridges can be drawn across the surface to enhance its tactile qualities. The surface measured 2m x 2.35m, stretching completely across the pavement area. The latex was 29mm thick and the edges were bull-nosed whereas the recommended specification is that the surface be 18mm thick with sloping edges. When newly installed the latex was coloured bright orange. However, heavy pedestrian traffic quickly changed the colour 3nd the surface was brown during the experimental trials. *** Subjects were positioned approximately 30m from the bus stop and asked to walk alone, in their normal manner, and to stop if they located a tactile surface. Whilst standing on the surface, subjects were asked to find the bus stop pole. At the end of the experiment, subjects were asked a series of questions about the surface whilst standing on it.	Questions were asked whether they could feel the surface and if so, could they describe the pattern, if it was useful, if it felt softer than the ordinary pavement, whether they could see it, and whether the layout was useful. Again subjects were invited to make suggestions that would improve the usefulness of the installation.		Over half of the subjects (56%) said that they had a problem identifying bus stops, mainly because there were too many similar poles and posts in the street environment. Nearly all of the subjects (98%) detected the tactile surface. 42 people located the bus stop pole, and therefore successfully completed the experiment. The 6 people who could not find the bus stop pole had no distinguishing characteristics.The majority of subjects (79%) said that the tactile surface felt softer than the ordinary pavement; 3 of the 10 people who said the surface was harder or the same as the pavement had diabetes. 27 of the 33 people with residual vision could see the surface. Contrast was the most distinct feature of the surface, visible to a substantial proportion (76%) of partially sighted subjects. Of the 6 people who could not see the surface, 4 had tunnel vision and only half could see colour. Most people said that they thought both the layout and surface were useful (81% and 98% respectively), however, 5 subjects thought that the edge of the surface was too high. The information surface caused most problems (7%): 5 people using wheelchairs, 1 person using a frame and 1 person who used a stick said that the edge of the surface was too high. The findings of the experiment involving the information surface installed to indicate a bus stop suggest that both the layout and surface are useful for visually handicapped pedestrians. However, 5 people com lained that the with bull nosed edges and not the recommended specification of 18mm depth, with sloping edges. This illustrates the problem faced by authorities of ensuring that manufacturers install tactile surfaces to the recommended specifications. Given that it could be difficult to ensure that this particular surface meets the required specifications, it may be more appropriate that the material is inlaid and the edges made level with the surrounding pavement.		The findings of the experiment involving the information surface installed to indicate a bus stop suggest that both the layout and surface are useful for visually handicapped pedestrians. However, five people complained that the edges of this installation were too high. The surface was 29 mm in depth, with bull nosed edges and not the recommended specification of 18 mm depth, with sloping edges. Although this study has shown that the information surface installed at a bus stop is extremely useful for visually handicapped people, the height of the installation created problems for wheelchair users. It is, therefore, recommended that this surface be installed flush with the surrounding area, and tested to ensure that its high detection rate remains.	
			At the Chapel Ash steps: To ascertain whether the tactile surface could be detected and what layout was most useful for visually impaired people. Of particular concern was establishing the most suitable width of tactile surface and how far from the beginning of steps it should be installed.		Chapel Ash-Warning of Steps Site. Two different widths of tactile surface were laid: one row of concrete tactile paving slabs, each measuring 400mm x 400mm was laid at the top and bottom of the steps on one side of the building and 2 rows were laid at the top and bottom of the steps on the other side. The pattern on the tactile paving resembled 'corduroy', with each rounded ridge having an upstand of 6mm. Although the light grey colour of the tactile paving contrasted sharply with the dark brown brick pavers, the contrast was not as marked where the surrounding pavers were buff coloured. *** Subjects were positioned directly opposite the tactile surface. Subjects then were asked to proceed forward and to stop if they felt or located a tactile surface. Subjects were then asked to make their way either up or down the steps, dependent upon the route allocated.	Questions were asked about whether they could feel the surface and if so, to describe the pattern, if it was useful, whether they could see it, and whether the layout was good. Subjects were also invited to make suggestions that would improve the usefulness of the installation.	Length of the tactile surface	Most people (79%) said that they had problems using steps. A far larger proportion of people with residual vision encountered difficulties with steps than totally blind subjects (94% and 47%, respectively). The majority (65%) of the 37 people had difficulty in locating or being aware of unexpected steps. A high proportion of subjects (60%) also said that the edges of steps appeared to merge or blur and, therefore, became indistinct. Nearly all the subjects were able to detect the tactile surface regardless of whether it was 40cm or 80cm wide. 3 people with residual vision; 1 of whom had diabetes, failed to locate the 40cm surface but were able to detect the 80cm wide installation. 2 of the subjects who had difficulty detecting the 40cm wide surface also had problems negotiating the steps; 1 of them had diabetes. With the exception of the woman who was unable to detect either width of surface, all the subjects said that they could feel the pattern and most (67%) correctly described it as consisting of horizontal lines. 23 people with residual vision said they could see the surface, and contrast was the most frequently mentioned visible feature. The majority of people who said they could see the colour of the surface (90%) correctly described it as 'grey'. Most subjects (82%) said that the surface used to indicate steps did not present them with any problems. 47 subjects said the surface was useful, and 40 people thought the layout was good. However, 21 subjects (45%) said that the wider 80cm layout was more useful than the narrower version. Also, 9 people emphasized that the white lines marking the edges of steps provided very useful guidance. The findings of the experiments involving surfaces to indicate steps suggest that this surface, both in rubber or concrete, is useful for visually impaired people. Although, a high percentage of subjects (44%) preferred the wider 800mm layout of the surface, most participants (43 people) did detect the narrower 400mm version. Bearing in mind the needs of other footway users, a 400mm wide installation of the surface is most appropriate.	A third (27%) of subjects had experienced accidents involving cycles either on footpaths or shared cycleways, suggests that further research in this area is required.	The findings of the experiments involving surfaces to indicate steps suggest that this surface, both in rubber or concrete, is useful for visually impaired people. Although, a high percentage of subjects (44%) preferred the wider 800mm layout of the surface, most participants (43 people) did detect the narrower 400mm version. Bearing in mind the needs of other footway users, a 400mm wide installation of the surface is most appropriate.	

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Sidewalk	**Gallon**, C. (1992). Tactile surfaces in the pedestrian environment: experiments in Wolverhampton. *Transport and Road Research Laboratory, Contractor Report 317*. 1-47.	**Wolverhampton, United Kingdom**	**Visually impaired and mobility impaired**	**The uncontrolled road crossing:** To find out whether the tactile surface could be detected and if the layout was useful for visually impaired pedestrians. To establish whether blind people encountered any problems when negotiating a non-parallel crossing.	Tactile surfaces are special footway surfaces designed to provide visually impaired pedestrians with information regarding their immediate environment. In November 1988, the Centre for Transport Studies (CTS), under contract to the Transport and Road Research Laboratory, conducted research to determine how many different tactile surfaces could be detected and distinguished by visually impaired people. The output from this research was the recommendation of a number of different tactile surfaces, each with a different message for the pedestrian (warning, guidance or information), each distinguishable by all or virtually all visually handicapped people and none causing problems to other pedestrians.	There was a fairly even distribution between the type of mobility aid people used. Only 6 people did not use any form of aid. All the people who used guide dogs had been trained. Only 40% of the remaining subjects had received mobility training.	Chapel Ash-Road Crossing Site. The tactile pattern was moulded on the surface of concrete paving and each slab measured 400mm x 400mm. The variation of profile height (1mm - 4mm) was attributed to the effects of coating the slabs with 'Day-Glow Yellow' paint, applied to enhance the visual quality of the surface. On one side of the road the dropped kerb was rectangular wide brick pavers; all this area was coloured yellow. On the opposite side of the road, a dropped kerb had been installed on a curve that faced into the middle of the junction. The central reservation was level with the highway and three rows of tactile paving, measuring 1.2 m in total width were installed. The tactile area was edged with brick paviers measuring 100 mm in width, and the whole area was painted yellow. *** Subjects were positioned approximately 10m from the tactile surface and asked to walk to the edge of the road and stop. They were asked if they had detected a tactile surface. A series of questions regarding the surface and layout were asked. Subjects were instructed to cross the road only when a researcher said proceed. Whilst crossing the road, a researcher walked on each side of the subject; if the person began to veer away from the central reservation he/she was guided in the right direction. Once on the central reservation, subjects were asked 'where are you now?' When it was safe to cross to the other side of the highway, subjects were told to proceed.			Video recordings were made of pedestrian movement across St Peter's Square to assess whether the tactile guidance path influenced people's walking behaviour in any way. The recordings were made on Friday, 23 February and Monday, 19 March from 11.30 to 13.45. The analysis of the video recordings involved detailed monitoring of pedestrians walking across the square every tenth minute. Pedestrian behaviour was classified in three ways: people who walked along the guidance path across the square; people who walked along the path partially across the square and those who did not walk along the path at all.	20 people said they experienced difficulties when crossing roads, and the most frequently mentioned problem was recognizing a highway when a dropped kerb had been installed. 28 people detected the tactile surface and stopped at the edge of the road. 5 subjects who did not locate the surface stopped of their own accord because they were lost, and 3 people were restrained by researchers to prevent them walking into the road. A higher proportion of people with residual vision detected the surface compared with totally blind subjects. 2 of the subjects with residual vision who failed to detect the surface had diabetes. Most partially sighted subjects (83%) could see the surface, and colour was the most frequently mentioned visible feature. 12 of the subjects who said they could see colour correctly described it as yellow. When standing on the surface, most subjects (97%) said they could feel the pattern, and the majority of these (69%) correctly described the pattern as consisting of blisters. Most subjects (83%) said that the tactile surface was useful. However, 5 people thought the pattern was too indistinct. Less than half the sample (48%) said that the particular layout was useful, and 18 people made suggestions for improving the layout. 14 subjects said the area of the tactile markings should be enlarged, and four people complained that the When asked what type of road crossing they were at a substantial proportion of subjects (36%) said they did not know. Also, 3 partially sighted people thought they were at a pedestrian crossing and 3 subjects believed they were at a pelican crossing. Most subjects (81%) knew when they had reached the central reservation. However, 4 people said they were at the other side of the road, and 2 totally blind people had no idea where they were. Only half the subjects had experienced no problems completing the experiment. A third of the subjects who did experience problems had used the edge of the surface to orientate themselves, and consequently walked in a straight line into the traffic junction. 4 of these 6 people were totally blind, 1 person used a guide dog and the remainder used long canes. During the experiment, 5 people were unaware that they were crossing the central reservation and had to be restrained. All of these people were guide dog owners, 2 had diabetes and 1 person had some residual vision. 2 people had particular problems with their guide dogs; one dog refused to stand on the tactile surface at the onset of the experiment, and the other refused to take its owner onto the central reservation.		Fewer people detected the rubber version of the warning of steps surface installed at Coseley Station than the concrete slabs at Chapel Ash. The main reason for this difference is that at Coseley the 300mm x 300mm rubber tiles were installed only 3mm from the bottom of the steps and people tended to step completely over the surface. At Chapel Ash 400mm x 400mm slabs were installed 110mm from the bottom of one set of steps, and the additional 100mm of surface width appears to have ensured subjects did not step over it. The most frequently detected surface at Chapel Ash was installed 400mm from the top edge of the steps: this distance allowed people enough time to locate the first step after detecting the warning surface.	36
				Coseley Railway Station: To ascertain whether visually impaired people could detect a train platform edge warning surface. To find out whether the warning surface was wide enough and how far from the platform edge the surface should be installed. To assess a rubber version of the warning of steps surface.			Coseley Railway Station. The station platforms were marked with a yellow painted line (the turbulence line) beyond which it was not advisable to stand because of fast through trains. On the platform that was only accessible by steps, designated platform A, a single row of rubber tiles was laid 910 mm from the edge onto a concrete surface. On platform B, the tiles were laid 610 mm from the edge on granite pavers. The rubber tiles measured 300 mm x 300 mm and had a pattern profile of 5 mm. *** Subjects were allocated to either platform A or platform B and positioned either at the top of the steps (platform A access) or the top of the slope (platform B access). They were asked to proceed to the railway platform and to stop when it was reached. At this stage, all subjects were asked, 'where are you now?'. Those subjects allocated to platform A were asked whether they had detected a tactile surface at the bottom of the steps. Those who had not were guided to the surface and each subject was asked a series of questions about it. Subjects were then told that a tactile surface had been laid to warn that they were close to the edge of the railway platform, and that we were testing whether this worked. Each subject was positioned approximately 10m from the platform edge and told 'you are facing the platform edge, located before the edge there is a tactile surface, please proceed forward when I tell you to, and stop when you feel the tactile surface and move back. If I tell you to stop, you must stop immediately.' The researcher positioned him or herself on the tactile surface to one side of the subject's direct path and asked the subject to proceed. Any subject who failed to detect the tactile surface was stopped immediately by researchers. Subjects were positioned away from the platform edge whilst they answered a series of questions about the surface and layout.		Width of the tactile surface		Most subjects (82%) knew when they had reached the station platform. However 7 people, 2 of whom were totally blind, did not know where they were. 5 of these subjects travelled unaccompanied and 2 of them travelled by rail alone. Over half the subjects who were allocated to site A (62%), detected the rubber corduroy tiles installed at the bottom of the steps to the platform. All 21 people were asked if they could feel the tactile pattern, and most (81%) said yes. A substantial proportion of subjects (71%) said that this surface was useful. Nearly all the subjects (92%) detected the tactile surface warning of the platform edge. The 2 people who located the surface before stepping on it were both long cane users. All the subjects said they could feel the pattern of the surface, and most (82%) correctly described it as composing bumps or dots. However, only half the subjects said the surface felt softer than the ordinary platform material. Most of the 27 subjects with residual vision (82%) said they could see the contrast between the surface and platform. 35 people (92%) said that the surface was useful. However, a high percentage of subjects (63%) said that the layout should be wider. Nearly all the subjects who tested the railway platform edge said that it did not resent them with a problem. Fewer people detected the rubber version of the warning of steps surface installed at Coseley Station than the concrete slabs at Chapel Ash. The main reason for this difference is that at Coseley the 300mm x 300mm rubber tiles were installed only 3 mm from the bottom of the steps and people tended to step completely over the surface. At Chapel Ash 400mm x 400mrn slabs were installed 110mm from the bottom of one set of steps, and the additional 100mm of surface width appears to have ensured subjects did not step over it. The most frequently detected surface at Chapel Ash was installed 400mrn from the top edge of the steps: this distance allowed people enough time to locate the first step after detecting the warning surface.		The research does suggest that the surface warning of railway platform edges is very useful for visually handicapped people. However, the width of the surface should be greater than 300 mm and also, the tiles should be laid more than 910 mm from the edge.	
						The majority of subjects (88%) said that they travelled alone. However, when asked how they would approach a new route, just over half of guide. 49 subjects were asked whether they had ever been in accidents involving plate glass windows, pavement works, steps, crossing roads, railway platform edges or had been hit by a cycle on a footpath or shared cycleway. High proportions of people said that they had been hurt in these kinds of accidents.					A high percentage of the sample (42%) said that they were concerned about not locating roads because of dropped kerbs installed at crossings points. Although most subjects (82%) said the warning surface at dropped kerbs was useful, the results suggest that the pattern was too indistinct and the layout was not helpful. It is not surprising that people found that the tactile markings were indistinct, since the recommended height of the blisters is 5mrn and those tested were only 1mm to 3mm high. This illustrates again the importance of manufacturers providing materials to recommended specifications and authorities ensuring that tactile markings meet the required standards prior to installation. Although 39% of the subjects (14 people) said that the layout of the surface would be improved if enlarged, this may not be necessary if the blisters are 5mm high. In other words, the effectiveness of layout size was probably undermined because of the poor tactile quality of the installation. Nevertheless, it may well be prudent to undertake further trials with this (correctly manufactured) surface to find out the most appropriate width for dropped kerbs at road crossings. The findings suggest that visually handicapped people use the edges of tactile paving to orientate themselves in order to cross the road in a straight line. Consequently, if the edge of the blistered paving points into the centre of a junction, there is a risk that some visually handicapped people, in particular totally blind long cane users, will walk into the middle of the junction and not reach the other side of the road. The risk of this occurring is increased when the crossing is non-parallel. More research is required to establish whether alternative forms of tactile layouts, most especially ones which do not follow the apex of drop kerbs installed at curved crossing points, may be more appropriate. Also, attention should be given to assessing the usefulness of guidance strips to provide orientation across the highway. Of the 36 subjects, 19% (7 people) did not know what sort of road crossing they were at. Similarly, 3 people said they were on the edge of a pedestrian crossing and one person at a pelican. These results clearly support the Department of Transport's decision to investigate the use of a 'ticking' mechanism to provide blind people with audio indication of pelican crossings, and a tactile 'z' marking on the pole at belisha-beacons, to distinguish pedestrian crossings. It is of concern that 6 subjects were unaware that they were standing on a central reservation. Clearly, it is not always possible to install 'sheep pen' style barriers at central reservations, but the finding does call into question the practice of installing blistered paving completely covering the central reservation area. The reduced pattern height of the blistered paving may well have contributed to 5 guide dog owners' failure to stop on the central reservation. However, the reservation was only 1.2m wide, and researchers observed that large dogs could not safely stand or sit in the limited space. Finally, the research does suggest that the surface warning of railway platform edges is very useful for visually handicapped people. However, the width of the surface should be greater than 300mm and also, the tiles should be laid more than 910mm from the edge.	Further experimental work with visually handicapped people to evaluate the effectiveness of a guidance path of the appropriate tactile dimensions should be conducted to determine the full effect of such installations.	Although this study has shown that the information surface installed at a bus stop is extremely useful for visually handicapped people, the height of the installation created problems for wheelchair users. It is, therefore, recommended that this surface be installed flush with the surrounding area, and tested to ensure that its high detection rate, found in previous research, remains.	
											A total of 59 people completed questionnaires about the guidance path at St Peter's Square. 16 people (27%) already knew that the surface was intended to provide guidance for visually handicapped people. With the exception of one person who thought that the surface should have a handrail, everyone said that they thought the idea of a tactile guidance path was good or very good (58% and 41%, respectively). Although several people said that the layout could be improved, most comments were positive.		The study has shown that the surface to indicate steps is useful for visually handicapped people and does not present a problem to ambulant disabled individuals. In the interests of other footpath users, it is recommended that the installed surface be 400mm wide. This will allow wheelchair users to avoid encountering the surface and ensure ambulant disabled people walk a minimum distance upon it. The surface should be installed 400mrn from the first step, allowing visually handicapped people a reasonable amount of time to detect the edge of the step. Finally, the layout of the surface should be wider than the actual steps to allow those approaching at an angle to detect the surface.	
							Part 3. A study to establish the public's view of the of pedestrian traffic across St Peter's Square, where a guidance path had been laid, to assess whether the installation influenced people's walking behaviour. To find out the general public's opinion of the tactile surfaces, a survey was conducted from 17th to 21st September at all the sites. One in five people in the area of each of the tactile surfaces were stopped and asked their views regarding the surfaces.	Questionnaires	Color of the tactile surface		50 people responded to the survey at the bus stop (information surface) located in Darlington Street. A total of 14 people (28%) knew that the surface was designed to indicate the location of a bus stop to blind people. Following the explanation of what the surface was intended for 48 people said that the idea was good or very good (54% and 40%, respectively). One person said the idea was very bad because the surface was not brightly coloured. Although most of the public made positive comments about the tactile material, 9 people were concerned about the height of the surface and whether this might cause people to trip.		The edge of blistered paving is used by some blind people to provide orientation when crossing the highway. If this surface is installed to indicate a dropped kerb that points into the middle of a junction, there is a risk that visually handicapped people who use the edge for orientation will walk into the middle of the junction. This risk is increased when the crossing is panparallel and also if a curved corner has been completely dropped. More research is required to establish whether alternative forms of tactile sixface layout can overcome this problem. Consideration should be given to evaluate the usefulness of guidance strips laid on the highway at non-parallel crossing points.	
											At the site where the surface to warn of steps was located, a total of 51 people corn completed questionnaires. 10 people (20%) already knew that the surface was to warn visually handicapped people that they were near a flight of steps. When the intention of the surface was explained to them, six people were indifferent to the concept, and the remainder said that the idea was good or very good (35% and 53%, respectively). Most of the comments people made about the surface were positive, however, 3 people said that the pattern could cause people to trip.	The information surface was laid completely across the rather narrow footpath, and experimental subjects had no option but to walk over it. Clearly in some circumstances it is-feasible for the layout to completely cover the footpath. In order to provide authorities with the most appropriate layout for installing the information surface on wider footpaths, further research regarding this surface must involve an evaluation of its installation on a wider footpath, or pedestrian areas.	The study has shown that the tactile surface installed on Coseley Station platform was very effective in warning visually handicapped people that they were near to the edge. However, the general view was that the surface should be wider and further away from the edge. It is therefore, recommended that this surface should be a minimum of 400 mm wide. As mentioned earlier, a yellow line was painted on the platform at the station, to indicate that waiting passengers should not stand beyond it because of turbulence created by fast through trains. During the research, debate occurred as to whether the warning surface should be laid adjacent to this line or remain near to the platform edge. However, not all station platforms have turbulence indicators, and consequently this could result in layout of the warning surface being inconsistent. A blind person would not know whether the surface was indicating a turbulence line or a platform edge.	
									Detectability of the tactile surface		A total of 49 people participated in the survey regarding the use of tactile surfaces to indicate road crossings. 14 people (29%) said that the surface was to assist visually handicapped people. When advised what the purpose of the surface was, 48 people said that the concept was good or very good (51% and 47%, respectively). One person said that the idea of a tactile surface at a road crossing was bad because he though visually handicapped people would not understand its meaning. Generally, all the comments made were positive and 13 people specifically mentioned the improved road safety aspects of such installations.		The study has shown that tactile surfaces do provide blind people with important environmental clues even when the full impact has been lost because of incorrect layout. Further, the importance of training in order that visually handicapped people can fully utilize the tactile surfaces and also learn to distinguish the different meanings, must be emphasized.	
							The experimental work undertaken in June was conducted in dry and sunny conditions, whereas the weather was cold and wet during the September trials. Despite the variation in the weather conditions, no differences were found between the results of experiments held in June and those which took place in September.				56 people were interviewed on the platform at Coseley Railway station. 10 people (18%) knew that the surface was to warn visually. handicapped people that they were approaching the platform edge. When advised of the surface's purpose, 55 people said that the idea was good or very good (68% and 30%, respectively). Only one thought that the concept was bad because he thought there was a risk of tripping on the edge of the surface onto the track. Most of the comments made about the surface were positive, however, 6 people said that it should be coloured yellow.			
						n=16 ambulant disabled people and 9 people in wheelchairs participated in experimental trials but not all at the same time nor at the same sites. During June 1990, the participants took part in trials at the sites where the guidance path, information and warning of steps surfaces had been installed. In September and December 1990, 12 ambulant disabled people and two wheelchair users tested the surface designed to warn of the railway platform edge. The highest percentage of subjects (40%) said that they had weak legs and/or problems in lifting their feet. 4 people said that sometimes they had to use a wheelchair because walking became too difficult for them. Only 5 people did not use an aid at all. Most of the ambulant disabled people (69%) said that they experienced problems when negotiating steps. 'The majority of both ambulant disabled subjects and people in wheelchairs (80%) said that dropped kerb installations assisted their mobility, and 23 people (92%) said that uneven pavements were a problem.	The Department of Transport's 'blistered' paving recommended to indicate dropped kerbs at road crossings was not included in these experimental trials because this surface had been previously evaluated by ambulant disabled people and people in wheelchairs. However, all the tactile surfaces and associated layouts were tested by ambulant disabled people and people in wheelchairs to assess whether these installations created mobility problems for these groups.				Most people (82%) said that the guidance path did not present them with a mobility problem. 2 people in wheelchairs said that the path made the chair vibrate, and 1 person who used a frame said that he felt unsteady on the surface. 6 subjects, 5 of whom used wheelchairs and one a stick, were more concerned about the drainage gullies that are laid at intervals right across St Peters Square. The information surface caused most problems (7%): 5 people using wheelchairs, 1 person using a frame and 1 person who used a stick said that the edge of the surface was too high. All of the 5 people in wheelchairs experienced difficulties in wheeling onto the surface, particularly in an uphill direction. Most subjects (82%) said that the surface used to indicate steps did not present them with any problems. However, 2 people using wheelchairs said that steering on the surface was difficult, and 1 person who used a walking frame said he felt unsteady. Although 2 ambulant disabled subjects said that the surface did not create any mobility problems, 1 mentioned that it hurt her feet slightly and the other said she preferred the narrower layout. Nearly all the subjects who tested the railway platform edge said that it did not resent them with a problem. The only subject who mentioned that the surface created a mobility problem said that the actual pattern did not worry her but she was concerned about tripping over the edge of the tile, which was 2mm high.		The findings indicate that the guidance path surface is generally acceptable to people with mobility handicaps. However, it must be remembered that the surface profile was only 3mm high, and not the recommended 5mm. Nevertheless, as this tactile marking is for use in pedestrianized areas, people without visual handicaps do not need to walk or wheel on it except when and if they have to cross the surface. People in wheelchairs had particular difficulties going uphill over the information surface installed at the bus stop. This 29mm deep surface had been installed with 'bull nosed' edges instead of the recommended gradual sloping edges and depth of 18mm. Installing this material to exact specifications could be difficult; it might be more appropriate if this surface was inlaid and flush with the surrounding pavement. Most people were found to have no problems when walking or wheeling on the surface used to indicate steps. However, 2 people in wheelchairs did experience steering difficulties. 2 ambulant disabled people who had said the surface did not present them with problems, said that they preferred the 400mm wide surface. It may, therefore, be appropriate to install the narrower version (400mm wide) of this surface, allowing at least part of the ordinary pavement to be hazard free for wheelchair users and reducing the surface walking distance to be covered by ambulant disabled people who may feel unsteady. The findings show that the railway platform edge surface does not present problems for ambulant disabled people.	
	Ishida, T., Takemoto, H., Ishida, S., Kameyama, S., Himeno, K., & Kashima, S. (2006). Evaluation of sidewalk unevenness based on wheelchair traveling resistance. *Transportation Research record: Journal of the Transportation Research Board.* 1956, 68-75.	**Hokkaido, Japan**	**Mobility impaired**	To establish a method for evaluating sidewalk unevenness according to wheelchair travel resistance. Unevenness means ripples with relatively short wavelengths, such as the unevenness because of the intersection of a sidewalk and a driveway.	Sidewalks have tended to be treated as an afterthought, and their design and construction do no always consider pedestrian convenience. Quantitative standards for cracking ratio, surface unevenness, rut depth, and skid resistance are available for roadway pavements; only qualitative descriptions are available for sidewalks. Clear standards for pedestrian safety and convenience have not been established. The Ministry of Land, Infrastructure, and Transportation established the Standard for Level differences and Gradients on Sidewalks to promote the development of sidewalks that afford barrier-free mobility. The standard has 3 principal rules: 1) sidewalks should have a continuous level surface with an effective width of at least 2m, 2) sidewalks should have a standard gradient of less than 5% and a standard cross slope of less than 1%, 3) the standard difference in the level at the boundary between the roadway and the sidewalk should be no more than 2 cm, and other portions where pedestrians walk should have no differences in levels. Even on sidewalks that fulfill this criteria for level differences and gradients, however, wheelchair users may find it difficult to travel if the sidewalk is substantially uneven. Because manual wheelchairs are powered by the upper body of the user, the wheelchair travel resistance caused by sidewalk unevenness is an important discomfort factor for wheelchair users, just as the discomforts caused by steep gradients and cross slopes are.	To secure subjects of sufficient number and of sufficient diversity by gender, age, and physical ability, the traveling test and the questionnaire survey were administered during an annual festival at the Hokkaido Institute of Technology attended by many students and local residents.	Two surveys were performed. In **Survey 1**, the longitudinal profiles of sidewalks in service were measured and torque data for a traveling wheelchair were analyzed with the goal of developing a method for evaluating sidewalk unevenness. In **Survey 2**, a questionnaire survey was administered to wheelchair users to determine the subjective discomfort that they experienced when they were traveling on an uneven test track. The relationship between the sidewalk unevenness index obtained from Survey 1 and subjective discomfort was analyzed.	Before the traveling rest, the maximum manual power output that the subject could cause to act on the wheelchair was measured with a digital force gauge installed on a frame (at a height of 300mm) beneath the seat of the wheelchair used in the survey (The 2 front wheels were replaced by a single wheel that could rotate but that could not be steered. The left and right rear wheels were connected by an axle and were powered with electricity from a battery loaded on the wheelchair so that they could rotate). A torque meter was installed on the rear axle. The speed was set at 0,167 m/s, which is near the minimum measurable speed of this device.	Power (force)	F-test and a t-test	The average manual power output differed greatly by gender. Even so, there were men whose maximum manual power output was among the lower values.	It took time to adjust the gradient and install bumps on the test track surfaces, and keeping the subject waiting while such adjustments were made would inconvenience the survey subject and make it difficult to ask for the cooperation of many people.	In Survey 1A, the gradient and wheelchair traveling torque were measured on 11 sections of sidewalks with gradients of 0 to 10% and even surfaces. The average effective traveling torque obtained from the wheelchair traveling torque correlated closely with the gradient.	38
						n = 576 (58% men, 42% women). Most of the subjects were age 39 or under, regardless of gender, but about 30% of the subjects were over the age of 40 years.	A 5-m long test track was made, and the height of the track was adjustable by the use of flexing joints. The track can give a slope with a constant gradient. The bottom of the test track is a steel frame. With a few sheets of plywood placed on the bottom, the surface unevenness and unevenness intervals of the track can be varied.		Length of the sidewalk		There were no significant differences in the mean discomfort ratings between the high and the low maximum manual power output groups for tracks other than that with Pattern 3-2 (distance=1500mm, height of unevenness=90, 2 bumps). Therefore, the 11 patterns of the uneven tracks other than that with Pattern 3-2 and tracks with gradients of 1%, 2%, 3%, and 4% were analyzed for mean subjective discomfort.	Similar surveys should be performed on uneven tracks whose cumulative level difference of points 500mm apart is less than 100mm.	In Survey 1B, the longitudinal profiles and the wheelchair traveling torque were measured on 45 sidewalk sections that had substantial unevenness because the sidewalks intersected driveways.	
							This research assumed that wheelchair traveling torque depends of the level difference between two points 500mm apart on the sidewalk (hereinafter referred to as the level difference between points 500mm apart), because the wheelbase of a typical wheelchair is approximately 500mm.	The maximum manual power output that the subject could cause to act on the wheelchair was measured with a digital force gauge installed on the frame (at a height of 300 mm) beneath the seat of the wheelchair used in the survey. (326 N for men and 185 N for women. The coefficients of variation in the maximum manual power output were 29% for men and 31% for women, and there were almost no differences in the variations in the maximum manuel power output by gender)	Height of unevenness		The mean discomfort ratings for 2%, 3%, and 4% longitudinal gradients plot as a nearly straight line. However, when the longitudinal gradient is 1%, the subjective discomfort is 0,8 unit grated that the corresponding rating for a 1% gradient on the line. When the longitudinal gradient is more than 2%, the subjective discomforts are the same as the ratings corresponding to the gradient on the line. This indicates that the subjective discomfort has a linear relation to the longitudinal gradient except for gradients less than 2%. When the gradient is less than 2%, the subjective discomfort tended to be greater than that estimated by the linear relation.		Survey 2: Forces for men were 1,8 times those for women. However, there were no significant differences in the variance and mean values of the ratings between men and women on all test tracks.	
							The subject traveled on an even test track with a 0% gradient (Standard Test Track 1) and an even track with a 5% gradient (Standard Test Track 2), which is the maximum value specified by MLIT. The subject then traveled on the test tracks and provided ratings of subjective discomfort. As a benchmark for the evaluation, Standard Test Track 1 was assigned a discomfort rating of 0 and Standard Test Track 2 was assigned a discomfort rating of 5.	The discomfort of traveling on the evaluation test track was rated in integers from -1 to 6. A rating of -1 means that the track affords comfort even greater than that of Standard Test Track 1, and a rating of 6 means that the track affords discomfort even greater than that of Standard Test Track 2.						
						n=224 subjects for the sloped test tracks	Survey 1: 11 sidewalk sections with even surfaces and gradients of 0 to 10% (Survey A) and measurements at 45 sidewalks sections that include substantial unevenness, such as boundaries between a driveway and a sidewalk and sidewalks intersected by driveways (Survey B). The length of sidewalk measurement was set at 5 m for Survey A and B, because the lengths of the sidewalk sections surveyed not intersected by driveways were about 5 m. Survey 1. A study on tracks set at 1%, 2%, 3%, and 4% gradients. The wheelchair traveling torque was measured for both the outbound leg and the homebound leg.	In all sections of Survey 1, the longitudinal profile was measured with a dipstick profilometer with a sampling interval of 250 mm.	Bumps				When the gradient exceeds 2%, the subjective discomfort and the longitudinal gradient have a linear relation. However, when the longitudinal gradient is less than 2%, the subjective discomfort is greater than that given by the linear relation.	
						n=324 subjects for uneven surfaces	Survey 2. A study on tracks set at 0% gradient with 12 patterns of uneven sidewalk surfaces		Cumulative level difference of points 500mm apart		The mean subjective discomfort increases with an increase in cumulative level difference of points 500mm apart.		On uneven tracks with similar levels of cumulative level difference of points 500mm apart, the mean discomfort ratings were similar. The mean discomfort rating increases with an increase in the cumulative level difference of points 500mm apart. It was proved that the cumulative level difference of points 500mm apart is an effective sidewalk unevenness index that correlates closely with wheelchair travel resistance and subjective discomfort evaluation.	
	Payne, A. (2009). Spatial Knowledge Acquired by Visually Impaired Users Through Change in Footpath Materials. The Ethical Design of Places, Proceedings of the	**North Carolina, United States**	**Visually impaired**	1) Investigate and compare 7 construction materials often used for sidewalks. 2) Determine the best combination or "material adjacency" to produce the greatest level of detection of change in materials among the users. **Research question:** 1) What role do changes in footpath materials	The difficulty of a way-finding task is affected by 2 major physical factors: the layout of the setting and the quality of the environmental communication. To accommodate all pedestrians, it is important to provide information that can be assimilated using more than one sense. Also, redundancy and consistency increase the likelihood that all users will be able to make informed traveling decisions. While directional changes can	n = 23 legally blind as determined by the state of North Carolina people interested in the study with varying degrees of vision and travel experience (14 men, 9 women), older than 18 (mean age of	7 materials were tested: concrete, brick pavers, stamped concrete, 12-inch slate tiles, 12-inch concrete pavers, manufactured cobblestone and applied non-slip grit over concrete. The materials selected to be compared were originally identified (n=3 first mentionned) in a study conducted by Jim Gibbons through the cooperative Extension System at the University of Connecticut. It was ensured that the joints between adjacent surfaces were non-existent or at least minimally detectable. The tests took place at the Governor Morehad School for the Blind in Raleigh, North Carolina. A matching pairs test was performed by comparing mixed pairs of the sidewalk materials in 23 combinations and was conducted in a semi-controlled outdoor environment to limit distractions. The researcher designed the sidewalk to allow for all 7 materials to be arranged in such a way that 21 unique combinations of adjacent materials were provided, allowing for 2	Observation and interview (2 questions): 1) As detected by the cane, is there a difference between the 2 materials? 2) As detected underfoot, is there a	Frequency and Valid percent	A series of binary logistic regression analyses using simultaneous entry were conducted to determine whether cane tip type would predict accuracy in	**Most correctly detected with cane:** Non-slip grit + Square concrete pavers (F=21, V=91,3%); Concrete + Slate tile (F=20, V=87%); Concrete + Cobblestone (F=20, V=87%). **Least correctly detected with cane:** Slate tile + Square concrete pavers (F=12, V=52,2%); Square concrete pavers + Cobblestone (F=12, V=52,2%); Stamped concrete + Cobblestone (F=10, V=43,5%). **Most correctly detected with foot:** Concrete + Cobbleston (F=21, V=91,3%); Slate tile + Non-slip grit (F=20, V=87%); Concrete + Slate tile (F=20, V=87%). **Least correctly detected with foot:** Square concrete pavers + Brick pavers (F=11, V=47,8%); Square concrete pavers + Cobblestone (F=11, V=47,8%); Stamped concrete + Cobblestone (F=11, V=47,8%); Slate tile + Square concrete pavers (F=10, V=43,5%) The material which was the **most often detected** as being different was Non-slip grit (highest number of positive detection).	1) Many other sidewalks and materials are being used throughout the U.S. and around the globe, therefore, similar research may be required for materials which are more suitable in other locations if these conclusions are to apply to a larger context. 2) A major limitation to the sample size was that the focus of this	Nonslip grit might be the most detectable material to use.	40

TYPE OF INFRASTRUCTURES	REFERENCE	ORIGIN/CITY	TARGETED INDIVIDUALS	AIM / OBJECTIVES / HYPOTHESES	JUSTIFICATION	PARTICIPANTS	METHODOLOGY / SET UP	RESEARCH TOOLS	VARIABLES / INDICATORS STUDIED	ANALYSIS / INTERPRETATION	RESULTS	STATED LIMITS	CONCLUSION (THE BEST INFRASTRUCTURE/PRACTICE)	QUALITY
	40th Annual Conference of the Environmental Design Research Association, Kansas City, Missouri.	United States	impaired	play in the ability of visually impaired users to locate their position within a space? (evaluate the pedestrians understanding of their position within a complex urban setting based on the user's ability to detect changes in footpath materials).	make it more difficult to map a path, it is the number of intersections (decision points) that affects the difficulty of decision making. Pedestrians, particularly those who are visually impaired, can use the power of their feet not only to get around, but also to get important information about the spaces they are in, by discerning changes in materials they walk on.	50 years, 3 months (39-71 years), independent and efficient travelers who primarily use the assistance of a long cane.	duplicate combinations. Each test was conducted by the researcher who observed one participant at a time. The type of cane was noted by the researcher and calculated in the data analysis as a variable (nylon tip, roller tip, or metal tip), as for shoe type (tennis, casual, or dress). Procedure: The researcher positioned the subject at the first intersection of 2 materials and explained the process from that point forward. For the determination of textures, the subjects chose the sweep method. In addition to the long cane, subjects also explored sensations underfoot as generated by walking, scuffing, and tapping the foot. A fixed amount of time (30s) was given to explore the pairs of materials. Descriptive comments made by the subjects were also noted.	the 2 materials? 2) As detected underfoot, is there a difference between the 2 materials?		detecting changes in sidewalk materials while en route. The same was done for show type.	**Regression results for cane detection** indicate that, for brick pavers and concrete, the overall model approached significance in classifying participants' responses as correct or incorrect (X2=9,38, p=0,05, R2=0,34). For Concrete and Stamped concrete, the same conclusion (X2=8,67), p=0,07, R2=0,31). For Slate tile and Stamped concrete, same conclusion (X2=11,01, p=0,03, R2=0,38). The model correctly classified 78,3% of the cases as correct or incorrect in all cases presented. **Regression results for foot detection** indicate that, for Concrete and Slate tile, the overall model approached significance in classifying participants' responses as correct or incorrect (X2=12,25, p=0,02, R2=0,41). The model correctly classified 91,3% of the cases as correct or incorrect. For Cobblestone and Brick pavers, the same conclusion (X2=8,92), p=0,06, R2=0,32). The model correctly classified 78,3% of the cases as correct or incorrect in all cases presented.	limitation to the sample size was that the focus of this research is so narrow that a very special population was sought. Of the nearly 10 million Americans who are visually impaired, only about 1,2 million are legally blind adults.		
	Pearlman, J., Cooper, R., Duvall, J., & Livingston, R. (2013). Pedestrian pathway characteristics and their implications on wheelchair users. *Assistive Technology.* 25(4), 230-239.	**Pittsburgh, Pennsylvania, United States**	**Mobility impaired**	1) To provide a perspective on the types of measurements and instrumentation that have been used to establish design guidelines in related fields, and also a better understanding of the health implications of vibration exposure on seated individuals. 2) To understand the current state of research related to surface roughness measurement and analysis, as well as the implications of surface roughness on the health and safety of humans. 3) The long-term goals of this research are to be able to develop measurement tools and a standard of surface roughness to help ensure public right-of-ways are safe and comfortable for WC riders.	A factor that influences this activity level is the degree to which the wheelchair (WC) rider is comfortable and safe during these activities. One of the most widely used measures of comfort and safety is to determine the level of whole-body vibrations (WBV) exposed to the rider. Research suggests that exposure to shock and vibration may be linked to many symptoms such as muscle fatigue (Zimmerman, Cook, & Goel, 1993), back injury (Pope & Hansson, 1992; Pope, Wilder, & Magnusson, 1999), neck pain (Boninger et al., 2003), and disc degeneration. Literature suggests that the seated posture, which occurs during WC use, is a compromising position for the spine and many associated body tissues. Daily shock and vibration experienced during WC riding can also increase an individual's rate of fatigue (VanSickle, Cooper, Boninger, & DiGiovine, 2001) and limit their functional activity and community participation. Because of these harmful effects, it is critical to understand and attempt to reduce the amount of WBVs that are transmitted when navigating over rough terrains. (Cooper et al., 2004; Requejo, Maneekobkunwong, McNitt-Gray, Adkins, & Waters, 2009). According to the ISO 2631-1, an RMS value of 1.15 m/s2 over a 4–8 hour period is the maximum allowable vibration value. However, exposure of vibration levels within the caution zone may still result in elevated risk of health impairment (ISO, 1997) if they occur repeatedly over a long period of time (e.g., several years). the only guidelines related to floor or ground surfaces are that they "shall be stable, firm, and slip resistant" (ADA, 36 CFR Appendix D to Part 1191, § 302.1, 2010). Unfortunately, these restrictions can be interpreted differently, and do not directly address the issue of surface roughness. Typical ADA accessible pathways are made of asphalt, pavement, or concrete; however, other pathway materials–such as packed, crushed stone, gravel fines compacted with a roller, packed soil, and various natural materials bonded with synthetic materials–can provide the required degree of stability and firmness. The current ADAAG guidelines provide a description of the suggested width and slope, but do not provide guidance on pathway roughness except that obstacles should be no more than 0.5 inches high. The frequency (obstacles per unit length), profile, and orientations of safe and passable obstacles are not prescribed.		There were 2 topics. The first is a review of the literature focusing on the effects of surface roughness on the health and safety of WC riders. The second topic is to explore ways to measure, design, and monitor the quality of pathway surfaces for WC users. Therefore two separate searches were conducted. A literature review was completed using searches on PubMed and Google Scholar in October of 2010, and more recently in November of 2011 to identify any new articles. First, abstracts of all of the papers identified through the keyword searches were compiled into a single document, and each was reviewed by at least two of the authors of this article. If at least one reviewer believed the abstract suggested the manuscript was relevant to the topic, the entire manuscript was then reviewed by at least two of the authors. Only manuscripts that two reviewers deemed irrelevant were then discarded, and the remaining manuscripts were included in this review article.	For the search on WC vibrations, both databases were searched for titles that had the word wheelchair and any of the following: vibration, shock, surface, roughness, firmness, sidewalk, or pathway. The second search was conducted by searching titles for the word roughness and any of the following: road, roadway, measurement, profile, or profiling. This second search was only conducted on Google Scholar and was limited to the fields of engineering, computer science, and mathematics.	Vibration Surface roughness and firmness Sidewalk or pathway		The database search for WC vibrations resulted in 217 articles on PubMed and 117 on Google Scholar. After scanning the titles for relevancy, 21 articles from PubMed and 32 articles from Google Scholar remained, with 5 articles appearing in both. The database search for roughness measurements resulted in 398 titles. These articles were scanned for relevancy and organized. It was found that there are several approaches to the measurement and analysis of surface roughness. In Wolf et al. (2007) looked at the effects of roughness of 9 different sidewalk surfaces; 6 studied over 3 years and 3 surfaces added in the last year. They concluded that for manual WCs, the 90° surfaces with 0- and 2-mm bevels resulted in significantly lower WBV than the standard poured concrete surface. For power WCs, the 90° surface with no bevel resulted in significantly less WBV at the seat and the 90° surfaces with 0-, 2-, and 4-mm bevels resulted in significantly less WBV at the footrest than the poured concrete surface. The results also showed that the 90° surface with an 8-mm bevel had the highest WBV while the 90° surface with no bevel resulted in the lowest WBV. The fact that the poured concrete surface resulted in significantly higher vibrations than some brick surfaces was most likely caused by the large gaps between the slabs of concrete. Cooper et al. (2004) conducted another study on 6 of the same surfaces (poured concrete; 90° surface with 0-, 2-, and 8-mm bevels; 45-degree surface with 0- and 4-mm bevels) showed that for power WCs traveling at a speed of 1 m/s, the ISO 2631 limit for an 8-hour exposure to vibrations was exceeded by the 90° surface with 8-mm bevel and 45° surface 4-mm bevel. At a speed of 2 m/s the exposure limit would be exceeded in less than 3 hours of continuous driving on all surfaces. Tolerico (2006) points out that while WC users do not typically drive continuously for 3 hours, they do travel more than 8 hours a day on average and experience some amount of vibrations during all movement. Axelson and Chesney (1999) investigated surface firmness (materials such as sand and wood) by asking WC users how difficult it is to traverse over different surfaces using a Likert scale. Difficulty level was correlated with the following conditions: (a) a decrease in traveling speed, (b) an increase in heart rate, and (c) increase in total energy consumption.The most firm and stable surfaces in dry conditions were asphalt, unpaved road mix, path fines (a type of decomposed granite), path fines with stabilizer, and native soil. Meruani (2006) conducted a study to compare two types of wheels on multiple surfaces (i.e., smooth and rough concrete, grass, gravel, and sand) and analyzed many outcome variables, such as durability, impact of vibration and surface roughness, obstacles, and comfort levels. Only low speed mobility on smooth concrete surfaces using standard tires fell below the ISO caution zone; all other test values fell above the upperboundary set by ISO standards for 4-hour period (root mean square [RMS] = 1.15 m/s2). Evidence suggests prolonged exposure at these levels may have detrimental impact on the health effects and comfort on WC users. The relationship between WC users' awareness and the physical effects caused by the rough terrains has been studied by Maeda, Futatsuka, Yonesaki, and Ikeda (2003). Results showed surfaces affected ride comfort with the most common areas affected being the neck, lower back, and buttocks. Ishida et al. (2006) evaluated the unevenness of sidewalks and the association between unevenness and the torque required to propel. The results revealed a very strong correlation between surface unevenness and comfort. Not only did the torque data show effects of the uneven traveling paths, but the users also agreed with the difficulty of the tracks. The three principle rules being: "(a) sidewalks should have a continuous level surface with an effective width of at least 2 m; (b) sidewalks should have a standard gradient of less than 5% and a standard cross slope of less than 1%; and (c) the standard difference in the level at the boundary between the roadway and the sidewalk should be no more than 2 cm". Yamanaka & Namerikawa (2006): The results showed that there was a strong relationship between user assessment and vibration data. However, the relationship between the IRI (equivalence between several methods of roughness measurements) and user assessment was not significant. The researchers concluded that this was probably due to the fact that the front tires of the WC would produce vibrations while running over small cracks and bumps that the Profilograph, with a 10-mm interval, could miss.		Research efforts to develop guidelines for pathway roughness should focus on adapting measurement instrumentation and indices currently used for roadway roughness. This will help streamline the process of developing and gaining acceptance for the roughness standards, as standards will be based on science similar to what is currently accepted. To accomplish this, 3 measurement techniques need be employed to characterize a series of sidewalk surfaces with varied roughnesses. First, accurate profiles need to be collected of these sidewalk surfaces with an accuracy level that is relevant to WC riders (1 mm). This would most easily be accomplished by adapting or developing a rolling profiler. The profiles should then be filtered and analyzed in a manner that develops a useful roughness index. Second, subjective comfort measurements (similar to PSR) need to be collected from WC riders after traversing these sidewalk surfaces. Third, WBV measurements need to be collected while the rider is traveling over each surface. Relationships between profile roughness, subjective comfort measurements, and WBV can then be explored to determine the maximum surface roughness that still ensures comfort and safe levels of WBV. There are many other factors, such as WC type, suspension, wheel diameter, and injury manifestations, that will cause the vibrations and riders comfort level to change. These factors should be recorded. Additionally, it is unknown how surface characteristics at short (Wolf et al., 2007) and longer (Ishida et al., 2006) wavelengths interact to influence comfort. As found in the Wolf et al. (2007) study, poured concrete surfacing can create significantly higher vibrations for WC users than brick paver surfaces. This potentially indicates a benefit of a properly laid brick paver surfaces that can have lower vibration than the typical concrete panels that have large gaps or large transition heights between them. This leads us to believe that the type of surface may not be as important as how the surface was laid and how it maintains its form over time.	31
	Savill, T.A., Gallon, C.& McHardy, G. (1997). Delineation for cyclists and visually impaired pedestrians on segregated, shared routes, *TRL Report 287* (Crowthorne, Transport Research Laboratory).	**West Malling, Kent, United Kingdom**	**Visually impaired**	To test a variety of central delineators to determine whether: a) the existing profile line 1049.1 is effective when formed from a thermoplastic material, b) the existing profile line 1049.1 is effective when formed from other materials, c) whether a different profile is required.	In the 1980's it was reported that visually impaired people were experiencing difficulties using segregated, shared routes. As they could not see the white line, they found it difficult to stay on their side of the facility, and often did not realize they were walking along a facility that was shared with cyclists. Instead of a painted white line, a profiled line was found to be an effective means of helping visually impaired people keep to the pedestrian side of the shared footway (Diagram 1049.1 in the Traffic Signs Regulations and General Directions). This profiled line, called a 'central delineator', was originally tested with visually impaired people and cyclists in both thermoplastic and rubber materials. Some visually impaired people have reported difficulties keeping to one side of the central delineator. There appear to be two main reasons for this difficulty: deficiencies in the delineator profile and developments in the design of long canes. Some local authorities have claimed that it is difficult to lay the central delineating strip with the recommended profile in thermoplastic, and that the material is prone to losing its profile and height ('slumping'). Roller ball canes are increasing in popularity. With these, the cane maintains contact with the ground as it is swept from side to side. Some people have commented that the thermoplastic strip is harder to detect with the roller ball cane than with the traditional types of long canes because of the way it responds to the normal roughness of the footway.	n = 48 visually impaired people (age range: 16-73 years). 27 of the participants could see nothing at all or could only perceive light from dark. These people have been classified in this report as having 'no useful vision'. 16 people said they normally used a guide dog. When taking part in the trial, most people (85%) used a long cane and the remainder used a symbol or guide cane. 21 of those using a long cane had the new type of roller ball tip which maintains contact with the ground in a sweeping motion across the body. The remaining 20 long cane users had the traditional cane tip which is used for tapping from side to side. No statistically significant relationship was found between participants' level of vision and Voluntary organizations and a college for visually impaired people were contacted and asked to provide adult participants for the study. The volunteers were either totally blind or had little useful residual vision. As people using the roller ball type of cane had particular difficulties with detecting the current thermoplastic strip, the organizations were also asked to ensure that some of the volunteers used this type of long cane. Guide dog owners receive long cane training as part of their mobility training to use guide dogs. This ensures that they are able to maintain independent mobility when their dogs are unwell or unavailable. Volunteers who normally worked guide dogs were asked to use their normal long cane in the trials. This was because difficulties with guide dogs had not been reported and in any case, guide dogs would be unlikely to be able to keep to one side of a raised strip without training.	10 delineating strips were tested on a disused airfield. Each strip was laid as a 10m straight section, followed by a shallow bend to the right and then a shallow bend to the left to give a total strip length of 20m. All the strips were installed to a width of 150mm. To ensure that the participants evaluated the tactile qualities of the profiles, as opposed to any differences in contract between the strip and the surrounding footway, the delineating strips were all painted white. Delineating strips 1 to 5 were installed in accordance with Diagram 1049.1, with heights of both 12 and 20mm. **Strip 1:** 12mm thermoplastic This strip was laid to the minimum recommended height of 12mm and was formed from thermoplastic which was used in accordance with BS 3262 parts 1, 2 and 3, class A. The material was formed using rib line plastic 70/20 BS 5659 and the strip was laid by hand. This strip is currently used on existing segregated, shared facilities. **Strip 2:** 12mm blocks. This strip had the same profile and height as Strip 1, but consisted of concrete blocks, 200mm long, provided by Marshalls Mono. The blocks were manufactured in accordance with BS 6717. The blocks were set in a shallow trench. **Strip 3:** 20mm thermoplastic. This strip was laid to the maximum height of 20mm. It was formed from a thermoplastic material to BS 3262 parts 1, 2 and 3, class A and was formed using vibraline. The strip was laid with a machine with gave a visibly better finish than strip 1, which was hand laid. **Strip 4:** 20mm brick. This surface was in accordance with Diagram 1049.1 and was in current use. It has the same profile as Strip 3, but was made from clay blocks, supplied by Blockleys Brick Ltd. The blocks were manufactured in accordance with BS 6677. The blocks were set in a shallow trench. **Strip 5:** 20mm Imprint. This surface was installed in accordance with Diagram 1049.1, but the material tested had not been used for this application before. It had a similar profile to Strips 3 and 4, but was made from a material which consisted of a hot applied polymer modified bitumen based compound incorporating graded rubber and granite aggregates, reinforced with metal and glass fibres. The material was formed by hand using a mould. **Strip 6:** Raised Rib Line. The idea for this strip was taken from the prescribed roadmarkings 1012.2 and 1012.3, commonly known as raised rib markings. These were developed to improve visual delineation of the carriageway edge in wet conditions at night, and provide an audible/vibratory warning to drivers should they stray from the carriageway. Hi Way Services provided the ribbed strip for testing. The material consisted of preformed rectangular ribs laid on a screed thermoplastic, in accordance with BS 3262 and BS 6088. The dimensions of the ribs were as follows: Width 45mm, Height 6mm, Length 150mm. The bars were laid 200 mm from centre to centre. **Strip 7:** Plastiroc. This material, plastirocagate, was a 2 component methacrylic road cold plastic. It was laid to a width of 150mm using a hand screed at a thickness of 5 - 6mm. The surface was then given a crosshatch pattern, formed by rolling the material with a special roller. **Strip 8:** Horizontal Bars. This strip was put forward as a way of helping people to know which side of the delineating strips they were walking along. It consisted of preformed strips laid on top of a thermoplastic screed, 3-5mm thick and 150mm wide. A continuous bar was laid along one side of the 150mm wide base line with small bars at 90° to this at 500mm centres. The supplier was Hi Way Services. **Strip 9:** Inverted T Shape. This profile was made from the same material as strip 5, but the profile was of an inverted 'T' which was 5 - 6mm thick with an upstand of 50mm wide in the centre of 12mm. **Strip 10:** Flexitec Delineators. The preformed profiles making up this strip were 1200mm long by 45mm high with a chamfered dome shape. The product consists of rubber, recycled from vehicle tyres. A binder is added to the rubber and the mixture moulded under pressure, incorporating a metal strengthening bar to obtain the finished profile. The bars were bolted to the airfield asphalt surface. The participants were first asked a series of questions relating to their level of vision and mobility aid, their use of a segregated, shared route and, if they had, whether they had encountered any difficulties. They were then asked to evaluate each of the delineating strips in a random order. On each strip, the participants were positioned a metre back from the start of the strip, and asked to walk forward and see if they could detect the strip. If the participant failed to locate the strip, the experimenter showed them where the strip was. If the participant was still unable to detect the strip with their cane, they were escorted to the next strip. In order to assess whether, once having detected the strip, the person could walk keeping to one side of the delineating strips, the participants were asked to walk to one side of the strip until they reached the end (20m). If the participant lost contact with the strip, the experimenter helped them to relocate the strip. If the person lost contact with the strip more than three times, the exercise was abandoned. This procedure was repeated with the strip on the person's left hand side. The participants were asked to rate how easy they had found it to keep to the correct side of the line. They were also asked to state which strip they preferred overall.	Questionnaire. Level of vision and mobility aid, whether they had ever used a segregated, shared route and, if they had, whether they had encountered any difficulties.	Height of the tactile surface Width of the tactile surface Material of the tactile surface Recognition of the tactile surface Level of vision Cane tip type Surface maintenance		**Detection of the delineating strips.** Participants detected strips 4, 5 and 10 when it was on their right hand side (the results from the left hand side are similar and so are not presented here). Generally, a higher percentage of participants who had some useful residual vision detected each strip, compared with participants who had no useful vision. For example, 81% of participants with residual vision detected strip 7, compared with 37% of totally blind participants. **Keeping to one side of the delineating strips: People with no useful vision.** All 27 participants with no useful vision were able to follow delineating strips 5 and 10. 90% or over followed strips 2, 3, 4, 8 and 9 to their end. Substantial proportions of these participants lost contact at least once with delineating strips 2, 3 and 9 (37%, 40% and 30%, respectively). People with no useful vision were unable to follow strip 7. **Keeping to one side of the delineating strips: People with some useful vision.** All 21 participants with some useful residual vision were able to follow and therefore keep to one side of delineating strips 2, 4 and 5, and 90% or more followed strips 3, 8, 9 and 10. Substantially fewer participants with residual vision lost contact with the delineating strips, compared with participants who were either totally blind or had no useful sight. **Keeping to one side of the delineating strips: Roller ball canes.** All 21 participants who used roller ball canes followed strips 5 and 10 to the end, although 2 participants lost contact at least once with strip 5 and 1 person lost contact with strip 10. Most of the participants were able to follow strips 2, 3, 4, 8 and 9. However, a higher proportion of people lost contact at least once with delineating strips 2, 3 and 9. **Keeping to one side of the delineating strips: Traditional tip canes.** All 27 participants who used canes or sticks with traditional tips followed strips 2, 4, 5, 6 and 8 to the end. However, a high proportion of participants lost contact with strip 2 at least once. Most of the participants could follow strip 10 to the end without losing contact with the strip, whereas a similar number were able to follow strip 3 but a higher proportion of people lost contact with the strip. Strip 7 could not be followed by many of the participants. **Ease of keeping to one side of the delineating strip.** Strips 4, 5 and 10 were rated as easy to follow. These are the surfaces that most of the participants were able to follow to the end of the strip. Overall, strips 1, 6 and 7 were not favoured by the participants, which corresponds with the low numbers who were able to follow them. **Preference for delineating strip.** When asked for their preference of strips 1 to 9, most of the participants (55%) said that they would prefer strip 5 to be used on segregated, shared routes. The second highest percentage (48%) preferred strip 4. Both of these delineating strips were the 20mm version of profile line 1049.1. **Comments about the delineating strips.** Although the participants could follow most of the delineating strips, some experienced difficulties with following them. In particular, bars which were horizontal to the participant caused problems because the traditional type of cane became snagged (e.g. strips 6 and 8). Strip 5 caused the cane to snag because it had a rough surface. **Strip 1:** Initially the profile obtained was as laid out in Diagram 1049.1, however the material tended to 'slump' over time. Over four weeks, the surface slumped by about 2mm.The profile can cause drainage problems, but this may be overcome by providing sloping gaps at predetermined intervals. **Strip 2:** The concrete blocks are manufactured in the factory in preset moulds to give a uniform 1049.1 profile. The blocks can be manufactured in a variety of colours. If required, the blocks can be coated with an epoxy paint and ballotini beads to provide a white reflective surface. Drainage would be a problem unless blocks were installed with a sloping edge at regular intervals. **Strip 3:** This strip had the same problems as the 12mm profile in thermoplastic (strip 1), i.e. the material was prone to slumping and gaps would be required to prevent drainage problems. **Strip 4:** The maintenance of this strip would be similar to that of strip No. 2. Blockleys have considered the drainage problem and can produce taper/end units to overcome this issue. **Strip 5:** The material tended to slump when laid hot and drag when too cold, leading to an uneven finish. The material has in the past been used to construct flat topped humps and is claimed to be hard wearing although the laying technique needs improving. Drainage is a problem with the material. The material is available in a range of colours, but not white, so would require spraying. **Strip 6:** Although the preformed ribs were set onto the hot-applied thermoplastic, problems were experienced with maintaining this surface. During the trials, the ribs were knocked by the long canes, and some became dislodged. The strips were readily replaced, but this could prove costly over time. As there were gaps between the ribs, water would not collect at the surface. However, silt etc. may build up against the ribs over time. **Strip 7:** The material has been used in France at zebra crossings and is claimed by the manufacturer to have a very long life. **Strip 8:** This strip suffered the same problems as strip 6 - i.e. the bars became dislodged during the trials. Drainage was a problem with the profile. **Strip 9:** The maintenance issues for this surface are similar to those for Strip 5. **Strip 10:** The units did not butt up tightly as they have rounded ends. As they are straight and rigid, they would be difficult to lay on radii. The surface has been used in France and Germany on the carriageway to divide the vehicles from cyclists.		It was found that the participants who had no useful vision were able to both detect and follow the higher profile of 20mm without losing contact with the strip, and hence having to relocate it with their cane. In contrast, many of the participants with no useful vision lost contact with strips 1 and 2. However, similar numbers also found it difficult to maintain contact with strip 3 which comprised the 20mm profile in the thermoplastic material currently used by local authorities when installing shared routes. The brick and Imprint versions of the profile 1049.1 appeared to be easier for people to follow than the thermoplastic versions. It has been reported by some local authorities that the thermoplastic material can lose its profile and height ('slumping'). Over the month this research was conducted, the material did slump by around 2 mm. If the surface is installed to a height of 12 mm, and the surface then slumps, it will not be able to serve its intended purpose of providing a tactile line between the cyclist and pedestrian sides of the route. However, if the surface is installed to a height of 20mm, it may still be fairly effective if it slumps by a couple of millimeters. People using long canes with roller ball tips are more likely to lose contact with the current recommended profile of 12mm in thermoplastic (strip 1) than those using canes with traditional tips. Just over half of the people using roller ball canes lost contact with strip 1 when trying to keep to one side of it, whereas only 5% of participants using traditional tipped canes lost contact with it before following it to the end. It seems likely that, as the thermoplastic material may slump, the users of roller ball canes fail to distinguish the strip from the surrounding footway which may be uneven. However, with the brick profiles (strips 2 and 4), the profile is pronounced with defined edges, and the cane users, including those using roller ball canes, seemed to be able to detect this fairly readily. Strips 4 and 5 (20mm brick and imprint) performed well with people using the traditional type of cane. Strip 5 had a rough surface in places, and this roughness seemed to help people locate the strip but at the same time meant that the cane occasionally became caught in the rough material. This material would however be an effective alternative to thermoplastic if the profile could have a smooth finish, as it is not prone to slumping and can be applied on top of the existing footway surface. In terms of performance, therefore, the brick and imprint versions of the existing profile were superior to the thermoplastic, although the latter was fairly detectable where it had been laid as the higher profile of 20mm. The cyclists generally preferred the lower profile, although around half rated the higher profiles as safe to cross. Performance with the experimental profiles was mixed. Strip 7, the plastic material, was not readily detectable as its low profile meant it could not be distinguished from the surrounding footway material. This surface was not suitable for people who had no useful vision. Those strips that consisted of horizontal bars (strips 6 and 8) caused problems for both pedestrians and cyclists. The cyclists commented that they were concerned about losing control of their bicycles. Many visually impaired people could follow the delineating strips, but only with difficulty because their canes tended to get caught on the bars, or, in the case of strip 6, go between the bars and so not detect the strip. The inverted T shape (strip 9) performed fairly well but some did not feel it was pronounced enough and the upstand was likely to cause problems for cyclists and pedestrians. The existing profile (1049.1) was the best compromise between the needs of visually impaired pedestrians and cyclists. It is recommended that the current profile be retained in the DETR guidelines, but with a preferred installation profile at 20mm high. The thermoplastic version of the profile was less expensive than the brick and imprint materials, but it was less effective and prone to losing its profile and height. However, thermoplastic and imprint from the currently available materials would be most suitable where the delineating strip had to be installed on top of the footway. The cost of the brick versions is likely to prevent their wider use, especially on an asphalt or concrete surface where the surface would need to be cut out to allow the installation of the pavers. In the past, rubber has been used to form the profile. However, this material was found to be prone to vandalism as it could be removed from the route surface. Other substantial materials, however, may be suitable. Both the cyclists and visually impaired pedestrians had concerns about shared use routes. A third of the visually impaired participants said that they currently used this type of facility and most had experienced problems. The most frequently mentioned difficulties were staying on the pedestrian side, cyclists riding on the pedestrian side, detecting the delineating strip and determining the start and end of the facility. The current specification, 12mm high thermoplastic delineating strip which is widely used, has been shown to be difficult to detect by some participants. It is likely that the incidence of these problems will be reduced if the 20mm profile is installed in thermoplastic, or the 12mm constructed in a different material. However, shared use routes will always create some difficulties for visually impaired people. They should not be the first option for separating cyclists from road vehicles, but should only be installed where other options are not possible. The effectiveness of a delineating strip will partly be determined by the width of the footway. If the pedestrian side of the facility is too narrow to allow two pedestrians to pass, a person to work their guide dog, use a wheelchair or walk with a buggy, then pedestrians will occasionally need to cross the central delineator. If the shared use route is designed with adequate widths, then there will be less need for pedestrians and cyclists to cross the delineating strip and the strip may be perceived as more effective in these situations.	39
	Wolf, E., Cooper, R. A., Pearlman, J., Fitzgerald, S. G., & Kelleher, A. (2007). Longitudinal assessment of vibrations during manual and power wheelchair driving over select sidewalk surfaces. *Journal of Rehabilitation Research and Development.* (44)4, 573-580.	**Pittsburgh, Pennsylvania, United States**	**Mobility impaired**	To evaluate the whole-body vibrations (WBV) experienced by manual and power wheelchair users as they traveled over select sidewalk surfaces as well as differences in exposure over time. **Hypothesis 1:** different surfaces would induce significantly different WBV, which suggests that some surfaces are less likely to cause secondary injuries to wheelchair users. **Hypothesis 2:** over time, the surfaces would become smoother from weather-related wear and thus result in significantly lower WBV.	Users of both manual and power wheelchairs use their wheelchairs for mobility for extended periods of time every day. This extensive use, combined with bumps, uneven driving surfaces, and other obstacles, can expose wheelchair users to harmful whole-body vibrations (WBV), which can lead to secondary injuries, such as low-back and neck pain, muscle ache and fatigue, and other harmful effects. Little research has been conducted on exposure to WBV over various surfaces during wheeled mobility, such as bicycle riding, inline skating, baby stroller use, and motor-scooter driving. Wheelchair companies have attempted to address this problem by adding suspension to manual and power wheelchairs; however, studies have demonstrated that these additions do not necessarily reduce the amount of oscillatory and shock WBV.	**n = 10** nondisabled subjects recruited in each of the 3 testing years (They tried to recruit either the same subject each year or subjects with matching weights and heights to account for variability in the subject population). **Study requirements**: between 18-65 years, be free of any shoulder pain that would prevent them from propelling, have no history of cardiopulmonary disease, and be free of a physical disability.	6 different sidewalk surfaces were tested in 3 consecutive years (May 2002, July 2003, and June 2004). All the sidewalk surfaces were approximately 1.2 m wide and 7.6 m long. **Surface 1** was a poured concrete sidewalk with a brush finish, which acted as the control surface. **Surfaces 2, 3, and 4** were made from ICP installed to industry specifications and were installed in a 90° herringbone pattern. The blocks used for **surface 2** had no bevel, the blocks used for **surface 3** had a 2 mm bevel, and the blocks used for **surface 4** had an 8 mm bevel. Sidewalk **surfaces 5 and 6** were constructed of fired clay bricks in a 45° herringbone pattern. The blocks used for **surface 5** had a 4 mm bevel, and the blocks used for **surface 6** had no bevel. We added 3 additional concrete surfaces in the third year of the study. **Surfaces 7 and 8** both had a 6 mm bevel and were installed in 90° and 45° herringbone patterns, respectively. **Surface 9** had a 4 mm bevel and was installed in a 90° herringbone pattern. Subjects were asked to propel a manual wheelchair (at 1 m/s) and drive a power wheelchair (at 1 m/s and 2 m/s) over 6 sidewalk surfaces a total of 3 times each. The manual wheelchair (Quickie® GP, Sunrise Medical, Carlsbad, California) had a rigid-frame design, with 127 mm-diameter polyurethane tires and standard 610 mm diameter rear wheels. The seat width was 406 mm, the seat depth was 458 mm, and the backrest height was 410 mm. The rear axles were placed 45 mm in front of the backrest tubes. The power wheelchair (Quickie® P200, Sunrise Medical) had a rigid-frame design, with 203 mm front casters and 254 mm-diameter rear wheels. The seat width was 406 mm, the seat depth was 415 mm, and the backrest height was 435 mm. A standard position-sensing joystick was mounted to the right-side armrest, and the default manufacturer controller settings were used. All tires were properly inflated to the rated air pressure (248.2 kPa for the caster and 344.7 kPa for the rear wheels). The approximate mass of the power wheelchair with batteries was 89.0 kg. All subjects sat on a 50 mm-thick polyurethane foam cushion during all testing.	A triaxial accelerometer was used to collect vibration data in three orthogonal axes at the seat and the footrest. Acceleration data were collected at 200 Hz. The ISO 2631- 1 standard describes the minimum collection rate for accelerations as 160 Hz. The seat accelerometer was attached to a 40.64 × 40.64 × 0.64 cm aluminum plate. The footrest accelerometer was attached to a 7.62 × 15.24 × 0.95 cm aluminum plate, which in turn was attached to the wheelchair footrest. Based on the ISO 2631-1 standard, we analyzed the WBV defined along the vertical z-axis (along the spine of a seated subject and along the legs transmitted through the footrest) using the RMS method. The choice to only measure the z-axis acceleration direction was based on the ISO 2631-1 standard, which states that measurements should be made in SmartWheels® (Three Rivers Holding, Mesa, Arizona) were used for the rear wheels during this study. They were used in the first year of testing to evaluate differences in work during propulsion over all the surfaces and therefore included in the following years for consistency. SmartWheels have solid-foam inserts. The approximate mass of the manual	Type of surface (bevel) Type of wheelchair Vibration Time (years of surface wear) Speed (controlled variable)	The acceleration data were calibrated and converted for analyses with custom software written in MATLAB (The MathWorks Inc, Natick, Massachusetts). Statistical analyses were performed with SAS (SAS Institute Inc, Cary, North Carolina). We analyzed the data using a mixed model to evaluate the differences in RMS vertical vibrations at the seat and footrest between surfaces and between years. Analyses between years included surfaces 1 through 6 only (poured concrete; concrete with 0 mm, 2 mm, and 8 mm bevels; and brick with 4 mm and 0 mm bevels, respectively) because surfaces 7 through 9 (concrete with 6 mm, 6 mm [45° pattern], and 4 mm bevels, respectively) were only tested in the third year. Post hoc analysis was completed with a Tukey pairwise comparison test.	**Manual wheelchairs and surfaces.** Significant differences in vibrations at the seat and the footrest for the manual wheelchair were found between surfaces (p < 0.001). Post hoc analysis revealed that the standard poured concrete surface (surface 1) resulted in significantly higher WBV than surfaces 2 and 3 (concrete with 0 mm and 2 mm bevel, respectively) and significantly lower WBV than surfaces 4, 7, and 8 (concrete with 8 mm, 6 mm, and 6 mm [45° pattern] bevel, respectively). No significant differences were noted for surfaces 5 and 6 (brick with 4 mm and 0 mm [45° pattern] bevel, respectively). **Manual wheelchairs and years.** For RMS vibrations at the seat and the footrest, significant differences were found between the 3 years (p < 0.001). Post hoc analysis revealed that for RMS vibrations at the seat, year 1 was significantly lower than years 2 and 3 and year 2 was not significantly different than year 3 (p = 0.3). For RMS vibrations at the footrest, all 3 years were significantly different (p < 0.001). **Power wheelchairs and surfaces.** We found significant differences between surfaces in WBV for the seat and footrest at 1 m/s (p < 0.001). Post hoc analysis of the data from the 1 m/s speed revealed that at the seat, surface 2 (concrete with 0 mm bevel) resulted in significantly lower WBV than surface 1. Surfaces 3, 5, 6, 8, and 9 (concrete with 2 mm bevel, brick with 4 mm bevel, brick with 0 mm bevel [45° pattern], concrete with 6 mm bevel, and concrete with 4 mm bevel, respectively) were not significantly different than the standard poured concrete surface. Surface 4 (concrete with 8 mm bevel) and surface 7 (concrete with 6 mm bevel) resulted in significantly higher WBV. than surface 1 (poured concrete). At the footrest, surfaces 2, 3, and 9 resulted in significantly lower WBV than surface 1; surfaces 5 to 8 were not significantly different, and surface 4 resulted in significantly higher WBV. Significant differences were found between surfaces in WBV for the seat and footrest at 2 m/s (p < 0.001). Post hoc analysis of the data from the 2 m/s speed revealed that at the seat, all surfaces resulted in significantly lower WBV than the standard poured concrete surface. At the footrest, all surfaces resulted in significantly lower WBV than the standard poured concrete surface except surface 4, which did not result in significantly different WBV. **Power wheelchairs and years.** For RMS vibrations at the seat and the footrest, we found significant differences in years at 1 m/s and at 2 m/s (p < 0.001). For RMS vibrations at the footrest, post hoc analysis revealed that year 1 was not significantly different from year 3 (p = 0.2) at 1 m/s.	The 9 testest surfaces were isolated and did not see normal wear from travel and use, which could result in similar results over multiple years. Heaving and settling of the ICP and brick pavers may occur ober time and could cause sharper transitions, resulting in higher RMS vibrations. Nno use of a standard surface, such as smooth tile, for comparing surfaces with a baseline control. However, the standard poured concrete was used as the control surface because it is the most common outdoor pedestrian surface. No additional pedestrian wear on any of the surfaces was noted (but wearing was equal for all surfaces). Only one manual and one power wheelchair were used. Certain wheelchairs are capable of reducing the amount of WBV transmitted to wheelchair users, however because differences in surfaces were being examined, rigid-frame manual and power wheelchairs were selected for this study. The recruitment of nondisabled subjects and different subjects over the years is a further limitation of this study and could have resulted in differences in propulsion style during manual wheelchair driving. This population was chosen based on ease of recruitment over multiple years and because the metric of interest was the difference between a standard poured concrete surface and ICP or brick surfaces.	**Surfaces** other than poured concrete should be considered for pedestrian access routes. ICP and brick surfaces that have small bevels may decrease the amount of WBV that are transmitted to wheelchair users during propulsion, especially at higher speeds (Surface 4 largest bevel (8 mm) = most vibration; **Surface 2** smallest bevel (0 mm) = lowest vibration). **Manual wheelchairs: Surfaces 2 and 3** (concrete with 0 mm and 2 mm bevel, respectively) produced significantly lower RMS vibrations than the poured concrete surface. These surfaces present a good alternative to the standard poured concrete because they transmit less WBV to wheelchair users. (contradicts the statement from the Public Rights-of-Way Access Advisory Committee, who claim that surfaces composed of individual units are undesirable because of the vibrations they cause) Differences were found in RMS vibration between surfaces over years for the manual wheelchair at both the seat and the footrest, with RMS vibrations increasing over time. **Power wheelchairs: At 1 m/s**, **surface 2** resulted in significantly lower WBV at the seat than the standard poured concrete surface and **surfaces 2, 3, and 9** resulted in significantly lower WBV at the footrest. **At 2 m/s**, all surfaces resulted in significantly lower WBV than the standard concrete surface at the seat; at the footrest, only surface 4 was not significantly different, while all other surfaces resulted in significantly lower WBV. The results from the data collected at 2 m/s are most likely caused by breaks in the poured concrete surface. The higher speed of the wheelchair causes greater transmission of shocks from breaks in the sidewalk. There were also significant differences in years at the seat and the footrest for both speeds. **Wear on the bevels from weather or normal use:** an increase in RMS vibration at the seat and the footrest for the manual wheelchair and the power wheelchair at 2 m/s.	45

TYPE OF INFRASTRUCTURES	REFERENCE	ORIGIN/CITY	TARGETED INDIVIDUALS	AIM / OBJECTIVES / HYPOTHESES	JUSTIFICATION	PARTICIPANTS	METHODOLOGY / SET UP	RESEARCH TOOLS	VARIABLES / INDICATORS STUDIED	ANALYSIS / INTERPRETATION	RESULTS	STATED LIMITS	CONCLUSION (THE BEST INFRASTRUCTURE/PRACTICE)	QUALITY
See also "Descriptive-Comprehensive"	**Duncan-Jones**, B. (2001). Modern road crossing designs and visually impaired people. *Municipal Engineer*. 145 (2): 185-190.													
See also "Descriptive-Comprehensive"	**Laakso**, M., Sarjakoski, T., & Sarjakoski, L. T. (2011). Improving accessibility information in pedestrian maps and databases. *Cartographica* . 46(2), 101-108.													
See also "Descriptive-Comprehensive"	**Nodin**, Y. (2006). Faciliter la ville aux personnes à mobilité réduite. *Le Moniteur.* 16 juin 2006: 62-64.													
See also "Descriptive-Comprehensive"	**Norgate**, S. H. (2012). Accessibility of urban spaces for visually impaired pedestrians. *Proceedings of the Institution of Civil Engineers: municipal engineer*. 165 (4): 231-237.													
See also "Descriptive-Comprehensive"	**York**, S.L. (2009). Residential design and outdoor area accessibility. *NeuroRehabilitation*.25 (3): 201-208.													
See also "Descriptive-Comprehensive"	**Tomic**, S. (2003). Hamilton Urban Braille System: Urban design for an Aging Society. *Plan* , Spring/Printemps 2003: 41-43.													
See also "Sidewalk-kerb"	**Ståhl**, A., Newman, E., Dahlin-Ivanoff, S., Almén, M, & Iwarsson, S. (2010) Detection or warning surfaces in pedestrian environment: the importance for blind people of kerbs, depth and structure of tactile surface. *Disability and Rehabilitation* 32 (6):													
See also "Shared space"	**Imrie**, R. (2012). Auto-disabilities: the case of shared space environments. *Environment and Planning Architecture* . 44: 2260-2277.													
See also "Street-Comprehensive"	**Li**, Y., Hsu, J. A., & Fernie, G. (2013). Aging and the use of pedestrian facilities in winter-the need for improved design and better technology. *Journal of Urban Health* . 90(4), 602-617.													
See also "Street-Comprehensive"	**Lavery**, I., Davey, S., Woodside, A., & Ewart, K. (1996). The vital role of street design and management in reducing barriers to older people's mobility. *Landscape and Urban Planning* . 35, 181-192.													
See also "Street-Comprehensive"	**Newton**, R., Ormerod, M., Burton, E., Mitchell, L., & Ward-Thompson, C. (2010). Increasing independence for older people through good street design. *Journal of Integrated Care* . 18 (3): 24-29.													
See also "Street-Comprehensive"	**Rosenberg**, D.E., Huang, D.L., Simonovich, S.D., & Belza, B. (2012). Outdoor built environment barriers and facilitators to activity among midlife and older adults with mobility disabilities. *The Gerontologist* . 53 (2): 268-279.													
See also "Street-Comprehensive"	**Walker**, J.M., Horton, S.A., Wright, J.M., Chan, S.W., & Conway, L.R. (1987). Walking velocities of older pedestrians at controlled crossings. *Topics in Geriatric Rehabilitation*. 3(1), 65-70.													
See also "Descriptive-Comprehensive"	**Sharp**, S. & Savill, T. (1998). The pedestrian environment – user friendly or 'no-go' for blind and partially sighted people? *8th International conference on transport and mobility for elderly and disabled people.* Perth, Western Australia, September, Vol 1: 267-72.													