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Shared Space Delineators

Are They Detectable?

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Introduction

One suggestion to make streets more pedestrian friendly is to remove the kerb and have a level surface for pedestrians and vehicles. Removing kerbs results in an area without clear vertical delineation between space reserved for pedestrians and space predominantly used by vehicles. Without clear delineation between a relatively "safe space" (Nyvig et al. 2006) and moving vehicles, some pedestrians have described feeling more anxious in these level areas than they do in areas where the delineation is clear. So much so that some people, especially those who are blind or partially sighted, have reported avoiding such spaces altogether (Carol Thomas et al. 2006). Conversely, a benefit of a level surface is improved access through the area for people in wheelchairs, those that use a wheeled-walker, push prams or have trolley type luggage. The question that arises from this is: can an alternative surface be used to delineate between an area where vehicles are not expected and one where they are free to travel through: an alternative surface that is both clearly detectable, yet not a barrier to pedestrians?

The most common delineator in the UK is a vertical kerb between 120mm and 150mm high. This is used as a guide by blind and partially sighted people and we are all taught as children to stop at the kerb, look right, left, right again, to check that it is safe before crossing the road. However, it is not possible for the majority of wheelchair users to cross such obstacles.

The Department for Transport (DfT) has identified a number of tactile surfaces with specific meanings, for example blister paving at controlled and uncontrolled crossings, Corduroy Hazard Warning Paving, and guidance paving (DfT 2003). Unfortunately the 'delineation meaning' required of a level surface does not directly match the understood meaning for any one of these tactile surfaces. For example, the kerb may be followed along the street (i.e. it could be used as a form of guidance paving), may be a warning of potential hazard from moving vehicles (i.e it could be used as a form of corduroy hazard warning paving), and it may indicate a place where one can cross the road to the other side (i.e. it could be used as a form of blister paving). If delineation between more and less safe areas within a shared space is required, and if the shared space is to be designed with a level surface, either the definition of one or more existing tactile surfaces would have to be extended to include this application or one or more different tactile surfaces will have to be designed or designated.

Before the question of creation or redefinition can be properly addressed, more information is required on what makes a surface suitably (reliably) detectable as a delineator, but yet does not constitute a barrier to pedestrian progress. To help with this, Transport for London (TfL) commissioned UCL to test certain surfaces for their suitability as a replacement to the vertical kerb with a view to determining (a) criteria for deciding which delineators might be suitable for a subsequent on-street trial and (b) those surfaces which would not be suitable for further trials. The tactile element (surface contrast) was to be tested in concrete and natural stone. This work does not consider visual contrast.

This report describes the surfaces tested in the current work, the tasks the participants were required to complete, the results and discussion with the aim of answering the following questions for each surface :

1) Can this surface be detected by people who are blind or partially sighted?
2) If so, can people who have mobility impairments cross the surface?

From the results of each of the surfaces there is a discussion on the attributes required of a surface to make it suitable as a delineator for level spaces.

Methods

The experiments were all performed at the Pedestrian Accessibility and Mobility Environment Laboratory (PAMELA) (Childs, Fujiyama et al. 2007). This facility was arranged with an 80m^2 test surface laid out as a simulated street environment including different surfaces (Figure 1). The basic action required in these experiments was to pass over a number of surfaces as if travelling through a normal street environment. This study was approved by UCL Ethics Committee (0410/005).

Layout

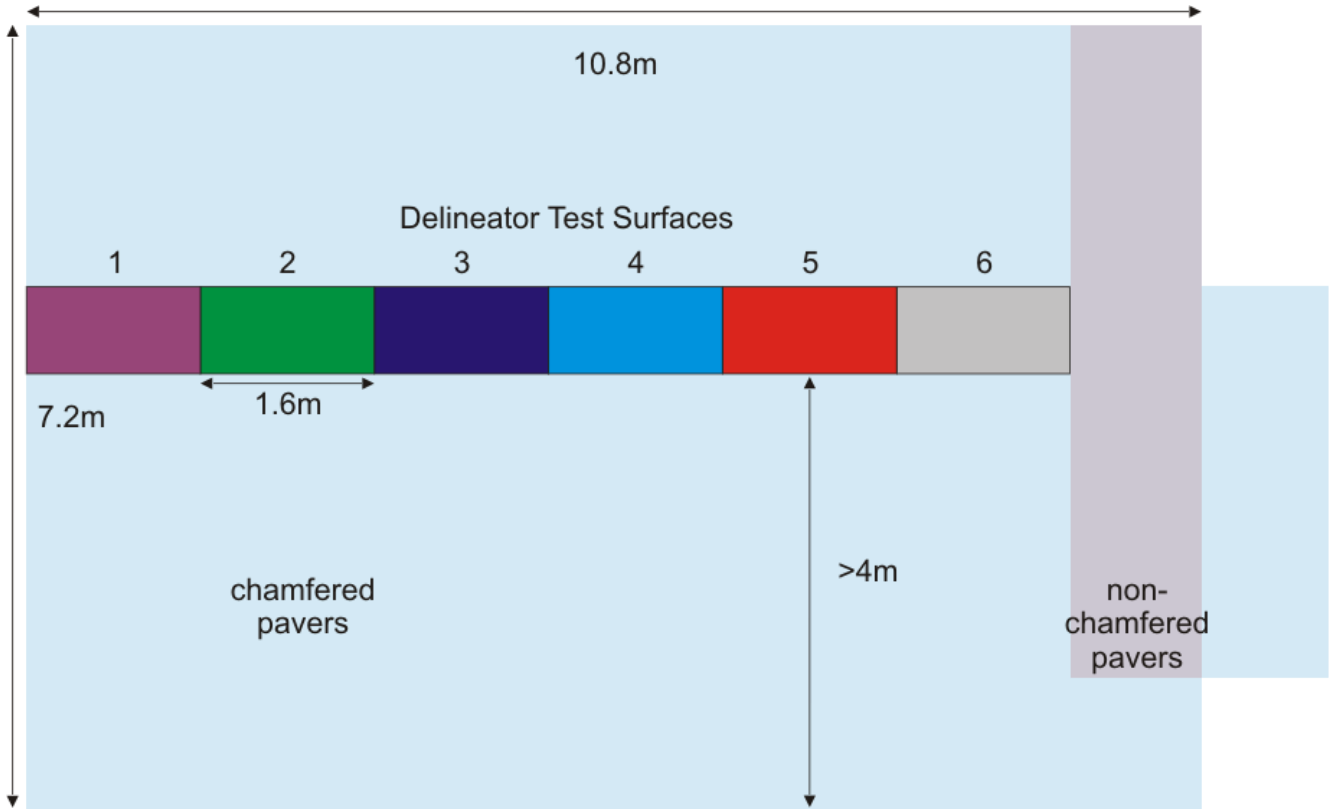

Figure 1 Plan view of laboratory layout

All the surfaces were designed in 400mm sections to match the standard dimensions of concrete pavers commonly available in the UK. Each surface was tested with a length of 1.6m (i.e. 4 pavers wide). This minimised the number of times the VI participants missed the surface when approaching it from an angle. In a single laboratory layout 6 different delineator surfaces could be tested. This limit was due to accommodating the 1.6m width of each surface and maximising the space available for the approach distance (the distance each participant had to travel before encountering the delineator surface). The minimum approach distance available for each surface was over 4m, with the actual distance dependent on the width of the delineator surface and the starting point chosen for each trial. With 6 different delineator surfaces for each laboratory layout, four layouts allowed 24 different delineator surfaces to be tested (Tables 5 to 8).

Participants

Two groups of participants were required, one to help answer question (1) and the other for question (2). People at most risk of not realising that they were walking out into an area with moving vehicles are blind or partially sighted people, people with hearing impairments, children, or those with cognitive impairments. This part of the study only included participants who were blind or partially sighted; people who used a long cane, had a guide dog, or did not use any aid to help them negotiate the street environment. For the purposes of this experiment, these are categorised as the 'Visually Impaired' group (VI group). For question (2) there is a wide range of conditions where changes in surface could cause problems for mobility. For example, uneven surfaces can be a problem for both people with back pain sitting in wheelchairs and for creating ankle

instabilities from awkward foot placement for those who have locomotory impairments, for example because they have had a stroke, or are wearing high heels. For the purposes if this experiment, these are categorised as the 'Mobility Impaired' group (MI group). To cover the required range of abilities and sight/mobility limitations, participants were recruited from a database of people who had participated in previous experiments at the laboratory or heard from other participants and offered their details. For both groups it was intended to get as broad a range of abilities as possible to highlight the range of difficulties that could result from use of each of the surfaces as a delineator. All the participants except for those in attendant controlled wheelchairs regularly used the street environment independently.

The range of ages and gender balance are listed in Tables 1 and 2 respectively. Table 3 lists the numbers of VI participants who used canes, had a guide dog or used no aid for these tests. Table 4 lists the number of MI participants who used electric, self-propelled, or attendant controlled wheelchairs, those that used crutches, sticks or a wheeled-walker, and the number of people with no mobility impairment, but who wore high heels, pushed a pram, or pulled trolley style luggage.

Table 1 Age	Layout 1		Layout 2		Layout 3		Layout 4	
	VI	MI	VI	MI	VI	MI	VI	MI
18-40	4	2	7	4	5	3	6	2
41-64	22	14	14	10	17	16	18	6
65+	3	3	4	4	3	3	3	6
Total	29	19	25	18	25	22	27	14

Table 2 Gender	Layout 1		Layout 2		Layout 3		Layout 4	
	VI	MI	VI	MI	VI	MI	VI	MI
Male	16	10	18	10	16	10	16	5
Female	13	9	7	8	9	12	11	9
Total	29	19	25	18	25	22	27	14

Table 3 VI aid	Layout 1	Layout 2	Layout 3	Layout 4
Cane	21	16	14	17
Dog	1	6	3	6
None	7	3	8	4
Total	29	25	25	27

Table 4 MI aid	Layout 1	Layout 2	Layout 3	Layout 4
Wheeled electrical	7	3	5	5
Wheeled manual	7	5	7	5
Wheeled attendant	2	1	2	0
Walker stick/crutch	3	6	6	2
Walker baggage	1	4	3	3
Total	20*	19*	23*	15*

- Wheeled electrical : people who used electric wheelchairs or scooters
- Wheeled manual : people who propelled themselves
- Wheeled attendant : people who were pushed by others
- Walker stick/crutch : people who walked with one or two crutches, one or two sticks, or a wheeled walker
- Walker baggage : people who wore high heels, pushed a buggy with 10kg mass, or pulley trolley style luggage with 10kg mass

* One participant participated in the tests using a manual wheelchair and two crutches

Delineator Surfaces

Layout 1

Table 5 Delineator Surfaces included in Layout 1

Figure	Code	Delineator Surface Description	Profile Height (mm)	Height (mm)	Width (mm)	Figure 1 location
2	SS	Single Slope 1:5	0	80	400	1
3	CD	modified Central Delineator as used to separate bicycles from pedestrians in shared lanes	150	20	150	4
4	RoRu	Rough Rumble paving with irregular surface	20 max	0	400	2
5	B.4	Blister 400mm wide	6	0	400	5
6	RiRu	Ridged Rumble paving with regular '^' shaped ridges	15	0	400	3
7	DS	Double Slope 1:7 with 200mm valley in-between two 400mm slopes	0	57	1200	6

Figure 2 Single Slope

Figure 3 modified Central Delineator

Figure 4 Rough Rumble

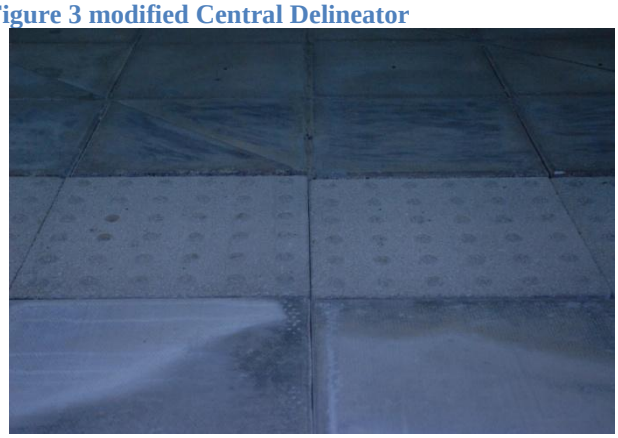

Figure 5 Blister

Figure 6 Ridged Rumble

Figure 7 Double Slope

Layout 2

Table 6 Delineator Surfaces included in Layout 2

Figure	Code	Delineator Surface Description	Profile Height (mm)	Height (mm)	Width (mm)	Figure 1 location
8	B	Blister	6	0	800	1
9	CC 8	Corduroy Warning one paver width level with surrounding pavers and one paver at 1:8	6	50	800	4
11	CF 8	Corduroy Warning one paver width level with surrounding pavers and one non-chamfered paver at 1:8	6	50	800	5
10	C	Corduroy Hazard Warning	6	0	800	2
12	C6	Corduroy Warning raised above surrounding pavers	15	6	800	3
13	FC 8	Corduroy Warning one paver width at 1:8	6	50	400	6

Figure 8 Blister

Figure 9 Corduroy on level and on 1:8 slope

Figure 10 Corduroy Hazard Warning

Figure 11 Level Corduroy and non-chamfered 1:8 slope

Figure 12 Corduroy Hazard Warning raised 6mm

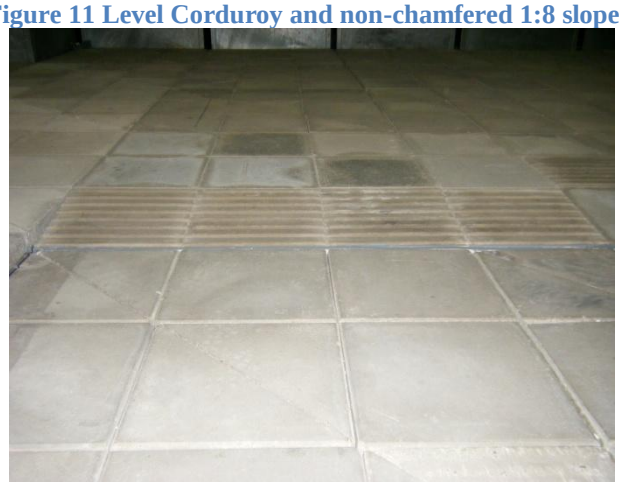

Figure 13 Corduroy Hazard Warning on 1:8 slope

Layout 3

Table 7 Delineator Surfaces included in Layout 3

Figure	Code	Delineator Surface Description	Profile Height (mm)	Height (mm)	Width (mm)	Figure 1 location
14	nC 24	Non-chamfered pavers at 1:24	0	33	800	1
15	CC 12	Corduroy Warning one paver width level with surrounding pavers and one paver at 1:12	6	33	800	4
16	C 24	Corduroy Hazard Warning at 1:24	6	33	800	2
17	CF 12	Corduroy Warning one paver width level with surrounding pavers and one non-chamfered paver at 1:12	6	33	800	5
18	B 24	Blister at 1:24	6	33	800	3
19	FC 12	Corduroy Warning one paver width at 1:12	6	33	400	6

Figure 14 non-chamfered pavers at 1:24 slope

Figure 15 Corduroy on level and on 1:12 slope

Figure 16 Corduroy Hazard Warning at 1:24 slope

Figure 17 Level Corduroy and non-chamfered 1:12 slope

Figure 18 Blister at 1:24 slope

Figure 19 Corduroy on 1:12 slope

Layout 4

Table 8 Delineator Surfaces included in Layout 4

Figure	Code	Delineator Surface Description	Profile Height (mm)	Height (mm)	Width (mm)	Figure 1 location
20	G	Guidance Path Surface Paving	6	0	800	1
21	B	Blister	6	0	800	4
22	Gpll	Guidance Path Surface Paving aligned to cross the road	6	0	800	2
23	Md	Dome set above surrounding surface	15	0	800	5
24	Cpll	Corduroy Warning aligned to cross the road	6	0	800	3
25	Hd	Dome set below surrounding surface	10	0	800	6

Figure 20 Guidance paving

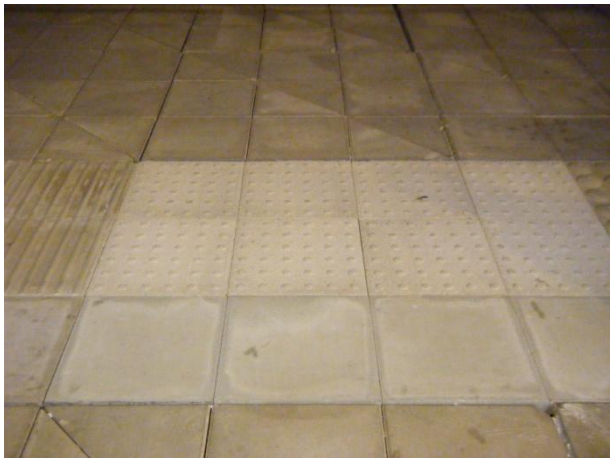

Figure 21 Blister

Figure 22 Guidance Paving aligned to cross the road

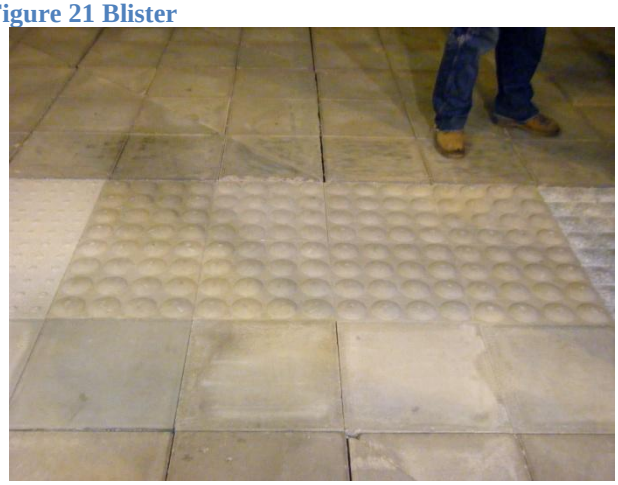

Figure 23 Dome set 15mm above surrounding surface

Figure 24 Corduroy Hazard Warning aligned to cross the road

Figure 25 Dome set 10mm below surrounding surface

Surface Choice

In a previous study (Childs et al. 2007) none of the surfaces tested (Nyvig et al. 2006) stood out as being ideal, but there was sufficient potential to warrant further trials. Of the slopes tested, 1:4 was too steep for those participants with mobility impairments, and 1:7 was too shallow to be reliably detected by the blind and partially sighted participants. The Central Delineator needed to be tested in materials suited to the street environment. As confirmed by Childs et al. (2009), a 30mm kerb upstand was not reliably detectable on its own. TfL requested UCL to follow on from these studies and it is this work that forms the basis for this report. For the first set of trials (Layout 1) Blister paving was used as a reference surface as this should have been familiar to all participants. The slope was modified to 1:5 'Single Slope' over 400mm and 1:7 'Double Slope'. Two forms of 'Rumble Strip' were included. This form of surface has been used around water features outside City Hall in London and is intended to be the pedestrian equivalent of the rumble strip that drivers encounter when approaching some roundabouts and pedestrian crossings. A manufactured alternative was sought that provided a consistent profile in materials currently used on street surfaces, presented a different surface 'attitude' at every foot-fall and sought to minimise any ankle instability when passing over it. The 10mm high dome prototype was manufactured in granite and the 15mm high dome in concrete. Both were included in Layout 4. The Central Delineator was modified to include gaps at 400mm centres that might aid wheelchairs and buggies to pass over easier. The results from the first layout indicated that the Ridged Rumble had potential if modified. When discussing these modifications the description fairly closely matched the design of the Corduroy Hazard Warning paving, hence its inclusion for later layouts. There was also the indication that the Single Slope would be more acceptable if less steep and preceded (from above) by a warning surface; hence the modified slopes in later layouts. Although alignment of Guidance Path Surface Paving and Hazard Warning paving is specified to indicate the direction of pedestrian travel/location of the potential hazard, by orientating these surface 90° to this alignment, car drivers would get a clear indication that they were driving onto a surface not suitable for vehicles; hence the inclusion of these alignments in Layout 4.

Task

The MI participants were asked to travel across each surface, turn around and return to their starting place. The experimenter evaluated each trial according to whether the participant failed to cross the surface, appeared to struggle but managed to cross the surface, or appeared to cross the surface easily. Immediately after the participant had finished each trial they were asked to rate the surface in terms of their perception of how easy it was to cross on a Numerical Rating Scale between '0' and '10'. A score of '0' being no problem, '10' being impossible to get over, and scores in-between relating to how much they felt they had to struggle.

The VI participants were positioned so that they were facing either perpendicular to the surface or approximately 45° to it. They were asked before starting each trial to stop if they encountered a change in surface, otherwise to walk towards the experimenter at their normal walking pace using the experimenter's voice to help with direction. The experimenter then went to the other side of the surface and asked the participant to walk towards them. The experimenter marked each trial according to whether the participant detected the surface before standing on it, whilst standing on it, after stepping over it, or if they failed to detect it. Once the participant had finished each trial they were asked to rate the surface in terms of their perception of how easy it was to detect on a Numerical Rating Scale between '0' and '10'. A score of '0' indicating that they had not detected any change in surface, '10' that they believed that there was definitely a delineator indicating a change of surface, and scores in-between indicating how much confidence they had that any difference in surface was intentionally there to indicate something. They were told to consider scoring 5 or more if they thought they would stop if they encountered the surface in the street situation, and less than 5 if they thought it was simply an irregular surface.

Layout Task Order

The surfaces were listed in an excel spreadsheet for each participant. Each task was given a random number (Excel function RAND()) and the trials ordered according to the resulting ranked random numbers. Two of the surfaces (chamfered and non-chamfered pavers) represented level pavement with no delineator surface. These were included to give a baseline for the MI participants and to reduce any expectation on the part of the VI participants that they would always encounter a delineator surface.

Results

Tables 9, 12, 15, and 18 list the number of participants that failed the task according to the experimenter's evaluation (VI fail and MI fail) out of the total number of trials for each Delineator Surface (VI n and MI n). Each delineator included in these experiments was compared with the performance of 800mm-wide Blister paving (Layouts 2, 3, and 4). Where the failure rate for a surface was worse than the Blister paving, this is indicated with an 'X' in the final column. Given the small sample sizes, where the margin in Detect or Overpass score is sufficiently small that it would be appropriate not to exclude this surface from further tests, this is indicated with an 'X*' in the final column. The MI group consisted of half the number of participants as the VI group and consequently a greater variation in Overpass Scores can be accepted. Tables 10, 13, 16, and 19 list the frequency of Detect scores given for each Delineator Surface. Tables 11, 14, 17, and 20 list the frequency of Overpass scores given for each Delineator Surface.

Due to the nature of Numerical Rating Scales these figures are descriptive; indicating differences in responses given between different surfaces, and should not be used for further numerical analysis. For example, a mean Detection score of 5 for one surface does not imply that it is half as detectable as a surface with a mean score of 10.

If the VI participant scored 5 or higher, this implied that they thought the delineator surface they had just detected was sufficiently obvious to make them stop to check the area to determine their location and future direction. A score just greater than 5 implies uncertainty that the surface has any meaning, but they would stop to check the area. A score just below 5 means that in spite of detecting a change in surface it was perceived as being most likely broken or misplaced pavement and not sufficient for them to stop. All the surfaces tested were intended to be detectable; therefore the Detect scores would be expected to be high.

On the Overpass scale, a score of 10 meant the surface was an insurmountable barrier : either they could not pass over at all, or required assistance to pass over the surface. All the surfaces tested were intended to be passable; therefore the Overpass scores would be expected to be low. For the purpose of this analysis an Overpass score greater than 5 indicated a surface that the MI participants struggled to get over.

Layout 1

Table 9 Experimenter Evaluated Pass/Fail Results for Layout 1									
		VI				MI			
Code	Delineator	fail	n	fail %	Worse than B8	fail	n	fail %	Worse than B8
B4	Blister 400mm	10	54	19%	X	0	39	0%	
CD	Central Delineator	6	54	11%	X	0	39	0%	
RoRu	Rough Rumble	5	52	10%	X	1	42	2%	X
RiRu	Ridged Rumble	2	53	4%	X	2	41	5%	X
SS	Single Slope 1:5	1	82	1%		3	77	4%	X
DS	Double Slope 1:7	0	52	0%		2	37	5%	X

Table 10 Frequency of Participant Evaluated Detect Scores for Layout 1														
	Detect Score Value													
Code	0	1	2	3	4	5	6	7	8	9	10	n	% <5	Worse than B8
B4	4	2	3	0	1	2	3	6	9	5	19	54	19%	X
CD	4	1	0	0	1	1	3	6	7	7	24	54	11%	X
RoRu	3	1	0	0	0	0	2	6	4	8	29	53	8%	X
DS	0	0	0	2	1	2	1	3	7	7	30	53	6%	X
RiRu	1	0	0	0	0	1	1	5	2	5	38	53	2%	
SS	0	0	0	1	0	3	5	3	6	12	52	82	1%	

Table 11 Frequency of Participant Evaluated Overpass Scores for Layout 1														
	Overpass Score Value													
Code	0	1	2	3	4	5	6	7	8	9	10	n	% >5	Worse than B8
RiRu	4	7	4	3	9	2	5	4	3	2	2	45	36%	X
DS	2	6	7	5	7	5	3	0	2	1	3	41	22%	X
RoRu	7	7	7	3	2	10	2	3	1	2	1	45	20%	X
CD	2	7	8	6	4	6	2	2	2	2	0	41	20%	X
SS	13	12	13	9	17	7	2	4	1	2	4	84	15%	X
B4	16	11	8	1	3	0	1	0	1	0	0	41	5%	

Layout 2

Table 12 Experimenter Evaluated Pass/Fail Results for Layout 2									
		VI				MI			
Code	Delineator	fail	n	fail %	Worse than B8	fail	n	fail %	Worse than B8
FC 8	Corduroy Warning 1:8	4	96	4%	X	0	55	0%	
C8	Corduroy Hazard Warning	1	97	1%		0	55	0%	
B8	Blister 800mm	1	99	1%		0	55	0%	
C6	raised Corduroy Warning	0	95	0%		0	55	0%	
CC 8	Corduroy Warning level & 1:8	0	97	0%		0	56	0%	
CF 8	Corduroy Warning level & flat paver 1:8	0	100	0%		0	55	0%	

Table 13 Frequency of Participant Evaluated Detect Scores for Layout 2														
	Detect Score Value													
Code	0	1	2	3	4	5	6	7	8	9	10	n	% <5	Worse than B8
FC 8	1	3	1	0	1	5	4	22	8	11	40	96	6%	X*
C6	1	3	1	1	0	3	12	12	8	9	48	98	6%	X*
CF 8	1	1	3	1	0	3	10	13	11	10	47	100	6%	X*
C8	1	2	0	1	1	3	14	11	12	8	43	96	5%	X*
B8	1	0	1	2	0	4	8	13	8	13	49	99	4%	
CC 8	0	0	2	0	0	1	7	8	14	10	55	97	2%	

Table 14 Frequency of Participant Evaluated Overpass Scores for Layout 2														
	Overpass Score Value													
Code	0	1	2	3	4	5	6	7	8	9	10	n	% >5	Worse than B8
CC 8	14	12	12	7	3	0	2	5	1	0	0	56	14%	X
CF 8	12	17	15	3	3	0	3	2	0	0	0	55	9%	X
FC 8	22	15	6	4	1	2	2	3	0	0	0	55	9%	X
C8	18	16	9	5	1	2	2	1	1	0	0	55	7%	X*
C6	23	15	6	3	3	2	1	2	0	0	0	55	5%	X*
B8	29	8	10	3	2	1	0	1	1	0	0	55	4%	

Layout 3

Table 15 Experimenter Evaluated Pass/Fail Results for Layout 3									
		VI				MI			
Code	Delineator	fail	n	fail %	Worse than B8	fail	n	fail %	Worse than B8
nC 24	Non-chamfered 1:24	69	96	72%	X	0	57	0%	
C 24	Corduroy Warning 1:24	3	98	3%	X*	0	57	0%	
B 24	Blister 1:24	3	98	3%	X*	0	57	0%	
FC 12	Corduroy Warning 1:12	1	98	1%		0	57	0%	
CF 12	Corduroy Warning level & flat paver 1:12	1	100	1%		0	57	0%	
CC 12	Corduroy Warning level & 1:12	0	99	0%		0	57	0%	

Table 16 Frequency of Participant Evaluated Detect Scores for Layout 3														
	Detect Score Value													
Code	0	1	2	3	4	5	6	7	8	9	10	n	% <5	Worse than B8
nC 24	57	5	7	5	2	9	3	2	4	1	5	100	76%	X
CF 12	0	0	1	4	2	4	10	13	12	10	44	100	7%	X*
FC 12	0	0	2	4	1	5	11	12	12	11	42	100	7%	X*
C 24	2	0	1	0	1	9	6	15	19	7	39	99	4%	
B 24	2	0	0	0	1	5	3	12	11	18	46	98	3%	
CC 12	0	0	0	0	0	1	5	19	15	12	48	100	0%	

Table 17 Frequency of Participant Evaluated Overpass Scores for Layout 3														
	Overpass Score Value													
Code	0	1	2	3	4	5	6	7	8	9	10	n	% >5	Worse than B8
CC 12	17	15	14	5	3	3	1	5	0	0	0	63	10%	X
B 24	20	13	15	6	4	0	2	3	0	0	0	63	8%	X*
C 24	27	11	11	3	4	3	2	2	0	0	0	63	6%	X*
FC 12	21	15	11	8	3	1	0	2	0	2	0	63	6%	X*
CF 12	21	16	10	8	5	1	0	1	1	0	0	63	3%	
nC 24	47	7	2	3	1	2	1	0	0	0	0	63	2%	

Layout 4

Table 18 Experimenter Evaluated Pass/Fail Results for Layout 4									
		VI				MI			
Code	Delineator	fail	n	fail %	Worse than B8	fail	n	fail %	Worse than B8
GpII	Guidance Path Surface Paving aligned to cross the road	22	100	22%	X	0	57	0%	
CpII	Corduroy Warning aligned to cross the road	8	100	8%	X	0	57	0%	
G8	Guidance Path Surface Paving	4	100	4%	X	0	57	0%	
B8	Blister 800mm	1	99	1%		0	57	0%	
Md	Dome 15mm above surrounding	0	100	0%		2	58	3%	X
Hd	10mm Dome below surrounding	0	100	0%		0	56	0%	

Table 19 Frequency of Participant Evaluated Detect Scores for Layout 4														
	Detect Score Value													
Code	0	1	2	3	4	5	6	7	8	9	10	n	% <5	Worse than B8
GpII	17	2	0	4	3	18	17	12	9	2	16	100	26%	X
CpII	6	1	2	1	5	10	16	17	12	8	22	100	15%	X
G8	2	2	1	1	3	6	23	11	16	8	27	100	9%	X
B8	1	0	1	2	0	3	11	22	16	13	31	100	4%	
Hd	0	0	0	0	0	0	6	14	14	18	48	100	0%	
Md	0	0	0	0	0	0	3	7	11	24	55	100	0%	

Table 20 Frequency of Participant Evaluated Overpass Scores for Layout 4														
	Overpass Score Value													
Code	0	1	2	3	4	5	6	7	8	9	10	n	% >5	Worse than B8
Hd	8	22	3	9	5	0	1	2	2	4	0	56	16%	X
Md	4	15	11	15	3	2	2	1	2	2	1	58	14%	X
G8	10	23	7	5	4	1	5	2	0	0	0	57	12%	X
B8	28	6	6	9	3	1	3	1	0	0	0	57	7%	X*
GpII	34	8	6	5	1	1	1	1	0	0	0	57	4%	
CpII	36	4	5	8	2	2	0	0	0	0	0	57	0%	

Table 21 Summary Results					
		Experimenter Evaluated		Participant Evaluated	
Layout	Delineator	VI fail to Detect worse than B8	MI fail to Overpass worse than B8	VI Detect Score worse than B8	MI Overpass score worse than B8
2	Blister 800mm (B8)				
4	Blister 800mm (B8)				X*
3	Blister 800mm at 1:24	X*			X*
2	Corduroy Hazard Warning 800mm level			X*	X*
2	Corduroy Warning 800mm raised 6mm			X*	X*
3	Corduroy Warning 800mm at 1:24	X*			X*
2	Corduroy Warning 400mm level & 400mm at 1:8				X
3	Corduroy Warning 400mm level & 400mm at 1:12				X*
2	Corduroy Warning 400mm level & 400mm flat paver at 1:8			X*	X
3	Corduroy Warning 400mm level & 400mm flat paver at 1:12			X*	
4	Dome 10mm below surrounding				X
2	Corduroy Warning 400mm at 1:8	X		X*	X
3	Corduroy Warning 400mm at 1:12			X*	X*
4	Corduroy Warning aligned to cross road	X		X	
4	Guidance Path Surface Paving 800mm	X		X	X
4	Guidance Path Surface Paving aligned to cross the road	X		X	
4	Dome 15mm above surrounding		X		X
1	Rough Rumble	X	X	X	X
1	Ridged Rumble	X	X		X
1	Blister 400mm	X		X	
1	Single Slope 400mm at 1:5		X		X
1	Double Slope 1:7		X	X	X
1	Central Delineator	X		X	X
3	Non-chamfered 800mm at 1:24	X		X	

Table 21 summarises the results tables showing an X where the delineator tested performed worse than 800mm wide Blister Paving and X* where although the delineator performed worse than 800mm wide Blister paving the difference is likely to be within participant variation.

Discussion

The delineator surface that all participants should have been familiar with was the Blister Paving, as this is a standard tactile surface extensively used in the UK. Hence it was used in these experiments as a reference surface. In Layout 1 the 400mm width of Blister paving (B.4) was insufficient to be reliably detected. The increased width used in Layouts 2, 3, and 4 were detected. It is not clear if 800mm width is the minimum width of Blister paving that is reliably detectable. Due to participant variation (some different participants and some participants responding differently) there is variation in response for Overpass scores on different days. This is shown in Table 21 where the response to B8 in tables (Layouts 2 and 4) resulted in both an X and an X*.

In Layout 1 the Single Slope (SS) was too steep and the combination of slopes in the Double Slope (DS) delineator was too difficult for some MI participants to get over. In Layout 3 a surface sloping at 1:24 with non-chamfered pavers was not reliably detected (69 out of 96 fails). There were subjective responses indicating that a slope could still be a good delineator if less steep (than 1:7) and indicated by another delineator at the top. It was thought that this additional delineator would both warn blind and partially sighted people that the slope was there and that the combination indicated a change of space. This resulted in the inclusion in Layouts 2 and 3 of the combined Corduroy profiles, with a level surface and a sloped surface. The Corduroy Hazard Warning Paving combined with a slope was effective for detection and resulted in Overpass scores comparable to the Blister paving for all conditions tested except the Corduroy top and Corduroy on a 1:8 slope (Layout 2).

In Layout 1 the Roughened Rumble (RoRu) was insufficient to be reliably detected. On one occasion one MI participant refused to go over the Roughened Rumble and others commented on their concern regarding ankle instability. It was suggested that this surface may be suitable if the peaks were not so widely spaced, resulting in an uneven surface that did not compromise ankle stability. It was decided that other possible surfaces took priority and this modification has not yet been tested.

In spite of the modified Central Delineator (CD, Layout 1) being higher than the Blister paving (20mm compared to 5mm) this delineator was still passed over without being detected on 4 occasions (out of 46). This is probably due to the delineator only being 150mm wide. Although all MI participants managed to get over this delineator it was not popular, as evident from the high Overpass scores (Table 11).

From Layout 1, participants' comments on the Ridged Rumble (RiRu) delineator indicated that this might be suitable but would have to be modified. The outer edges were too steep causing 2 failures for MI participants passing over and some discomfort for VI participants particularly those using long canes. The suggestions were to reduce the abrupt edge of the delineator, but keep the regular ridged pattern. It was noted that the Corduroy Hazard Warning Paving may fit this description and was thus suggested for later layouts.

Corduroy Hazard Warning paving (6mm) has a similar profile height to Blister paving (5mm), therefore Corduroy Hazard Warning Paving was not tested at 400mm wide as it was unlikely to be reliably detected. The 800mm wide Corduroy Hazard Warning Paving, when laid perpendicular to crossing the road, not when laid parallel to crossing the road, resulted in comparable Detection and Overpass scores to the Blister paving. When laid 6mm above the surrounding surface, the Corduroy Hazard Warning Paving did not result in noticeably improved Detection scores (Table 13).

Layout 4 included Guidance Path Surface Paving both perpendicular and parallel to the direction of crossing the road. The direction of the delineator does matter. Guidance Path Surface Paving in line with the direction of walking being difficult for many participants to detect (22 out of 100 trials) and Corduroy Hazard Warning Paving being detected fewer times in this orientation than for other layouts.

The Domed surfaces both scored well for detection, but poorly for participants to pass over. It may be that narrower sections of these surfaces could be as detectable, but easier to pass over. It is likely that 10mm (Hd Dome) is the limit as one participant required assistance to pass over the 15mm Md Dome. It is not clear what

effect the Hd Domes being recessed had on the Detectability and Overpass scores, therefore it would be useful to test this profile laid above the level of the surrounding surface, with narrower sections and lower profiles.

Conclusions

This work was designed to try to determine the suitability of different surfaces to act as a replacement to the traditional 120mm kerb upstand for level surfaces in Shared Spaces with a view to determining (a) criteria for deciding which delineators might be suitable for a subsequent on-street trial and (b) those surfaces which would not be suitable for further trials. The requirements of such a surface include the ability for people with mobility impairments to be able to cross the surface and the ability for blind or partially sighted people to be able to detect the surface. Solutions to one requirement will usually compromise the ability of the solution to achieve the other requirement. For example, the traditional 120mm kerb upstand is easy for blind or partially sighted people to detect, but very difficult, if not impossible for many people with mobility impairments to get over.

The tests commissioned by Guide Dogs Association (Childs et al. 2007; Childs et al. 2009) showed that a 30mm step did not satisfy as a suitable delineator, being a problem for some VI participants to detect and a problem for some MI participants to get over. The Central Delineator showed promise from a VI perspective, and the MI participants thought that with some gaps, it may be easier for them to pass in wheelchairs. The recommendation for the slopes tested was that they should be tested over wider sections. These modifications were incorporated into the experiment presented in this report:

- The Central Delineator was modified to include gaps for wheels.
- Blister paving, a familiar surface used in the street environment, was introduced as a comparison.
- The slopes were modified to cover a wider area and in one case two slopes were combined.
- A Rumble Surface was introduced, one surface being ridged, the other irregular.

As might be expected, the delineators that were easy for VI participants to detect were difficult for the MI participants to get over. Conversely, the surfaces that the MI participants found easy to get over were difficult for the VI participants to detect. This led to further suggestions for optimal delineators, including Corduroy Hazard Warning Paving; a combination of Corduroy Hazard Warning Paving with a section of slope at two different gradients (1:8 and 1:12); a modification of Blister paving; and two different domes.

These results indicate that the Blister profile is not reliably detected when it is one paver wide (400mm), but is when two pavers wide (800mm). It would be worth further experiments to determine if 600mm wide Blister is similarly detectable.

Compared to the Blister paving, Corduroy Hazard Warning Paving gives comparable detection and ease of getting over when laid perpendicular to the crossing-the-road direction. The addition of a slope with the Corduroy Hazard Warning Paving along the top surface can help detection, but does make the surface more difficult for people with mobility impairments to get over. If the sloped surface also has Corduroy profile a gradient of 1:12 was not deemed too difficult for most participants to pass over, whereas a gradient of 1:8 was more of an obstacle.

The rates of detection were lower when the Corduroy Hazard Warning and Guidance Path Surface Paving were laid in line with the crossing-the-road direction, than when they were laid perpendicular to the crossing-the-road direction. That is, when approached from different angles, surfaces like Blister or the Dome appear to be easier to detect than Corduroy Hazard Warning and Guidance Path Surface Paving. This raises the question of whether a tactile surface that has a repeating pattern in two planes (e.g. a blister or dome) would be more suitable as a delineator in Shared Space environments than one that repeats in only one plane (e.g. corduroy paving).

As tested, the prototype Dome delineator surfaces were detectable but difficult to pass over. The high level of confidence in detection indicates that these are worth further investigation to improve the profile to accommodate people with mobility impairments whilst maintaining the detectability for blind and partially sighted people.

In summary, the surfaces tested in layout 1 were not suitable. Corduroy Hazard Warning paving could be suitable, when laid 800mm wide, perpendicular to the crossing-the-road direction, and level with the surrounding surface. The smaller Dome may be suitable if modified. If the kerb is to be replaced by a delineator that does not need to be level with the surrounding surface, Corduroy Hazard Warning paving could be suitable combined with a short slope, though probably not 1:8.

Recommendations

As a result of these experiments, we recommend that further tests be carried out before final acceptance of a horizontal delineator is made. These tests involve both laboratory and on-street activity and are required to determine:

Laboratory tests

1. the detectability of delineators surrounded by different broken or uneven paving
2. the detectability of corduroy paving when approached at a more acute angle
    a. close to in-line with the direction of the corduroy bars
3. the optimal width for different delineators
4. if a modified Dome profile that is less of an obstacle for people with mobility impairments is still detectable for blind and partially sighted people,
5. what level of seasonal/temporary surface material renders the delineator undetectable, e.g. fallen leaves, dirt, snow, ice.

On-Street tests (with good quality level adjacent pavers)

6. the impact of Corduroy Hazard Warning Paving in a ‘Shared Space’ environment on all street users
    a. including children and those with cognitive and/or hearing limitations
7. the impact of modified Dome Paving in a ‘Shared Space’ environment on all street users
    a. including children and those with cognitive and/or hearing limitations

These tests need to be properly designed, undertaken and analysed in such a way to ensure that the results take account of a wide range of participants and in different weather and lighting conditions.

The work presented here refers to experiments carried out in a safe laboratory setting. This enabled many environmental factors to be controlled, but it is acknowledged that people’s activities in real street environments will differ from that witnessed during these experiments. These experiments should be regarded as providing criteria for surfaces which could be tested further in a street environment and identifying those which would not be worth testing in such circumstances. With this in mind further tests are required before any of these surfaces can be recommended as delineators of pedestrian space within level surfaces. In particular, the delineator surfaces were all tested laid next to level concrete pavers in good condition and further tests are needed to determine the level of broken/uneven paving that can surround such a delineator before the level of detectability reduces beyond an acceptable level.

Acknowledgements

We are particularly grateful for the time, effort, and honesty that the participants gave us throughout the experiments, for their many repeated visits to the laboratory.

We would also like to thank Dave Berry at Marshalls and Asil Besim of Hardscape and their colleagues for providing the delineator surface materials, including much communication to get the correct surfaces sometimes at very short notice.

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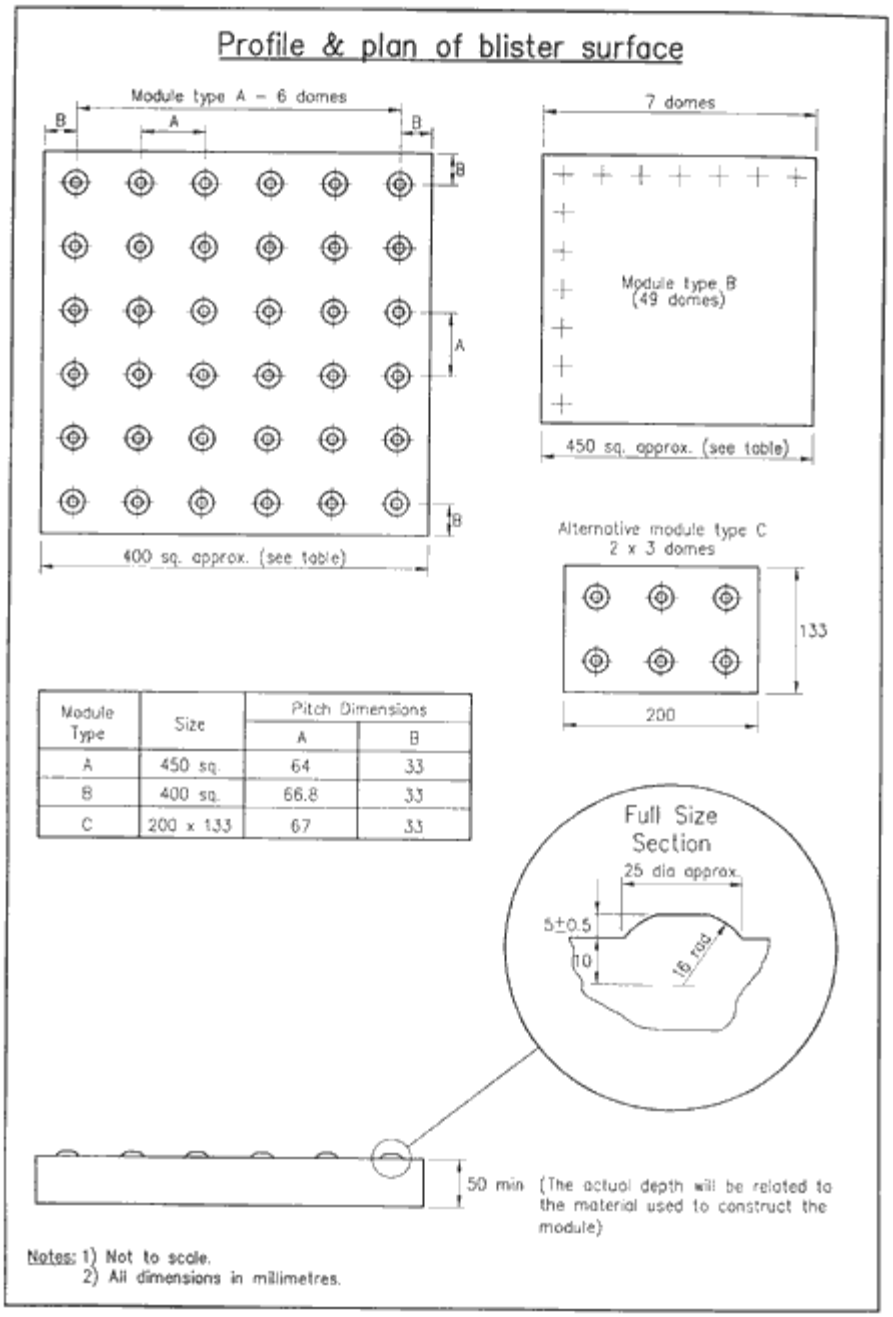
Thomas, C. et al., 2006. *Shared Surface Street Design Research Project The Issues: Report of UK Focus Groups*, Available at: http://www.guidedogs.org.uk/sharedstreets/fileadmin/sharedsurfaces/user/documents/Shared_space_-_safe_space_Ramboll_Nyvig_report.pdf.

Appendix Delineator Surface Details

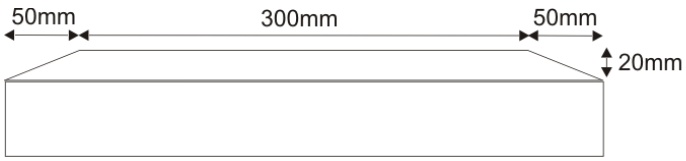
Blister Paving



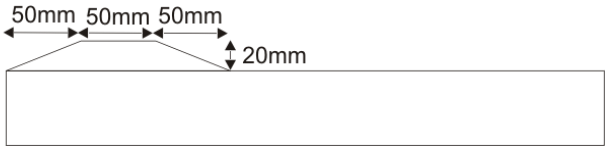
http://www.dft.gov.uk/transportforyou/access/peti/guidanceontheuseoftactilepav6167?page=2#a1010

modified Central Delineator

Facing view

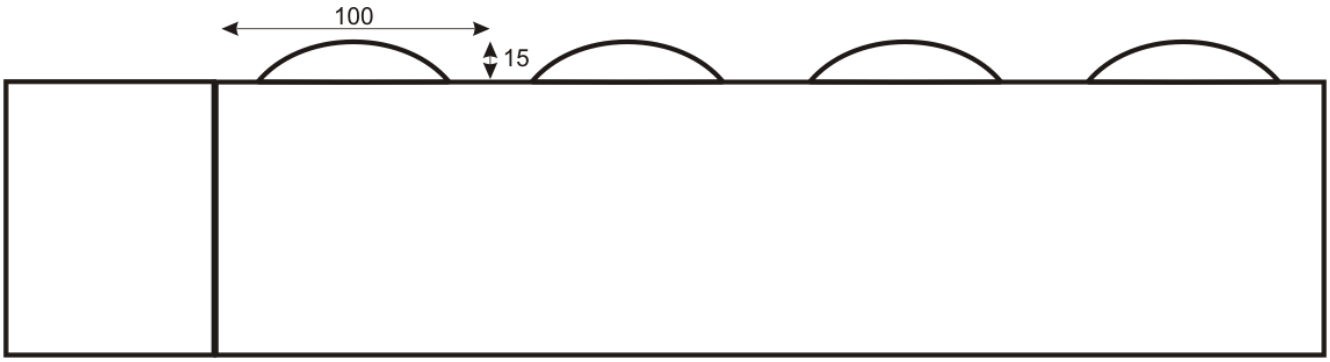


Profile view



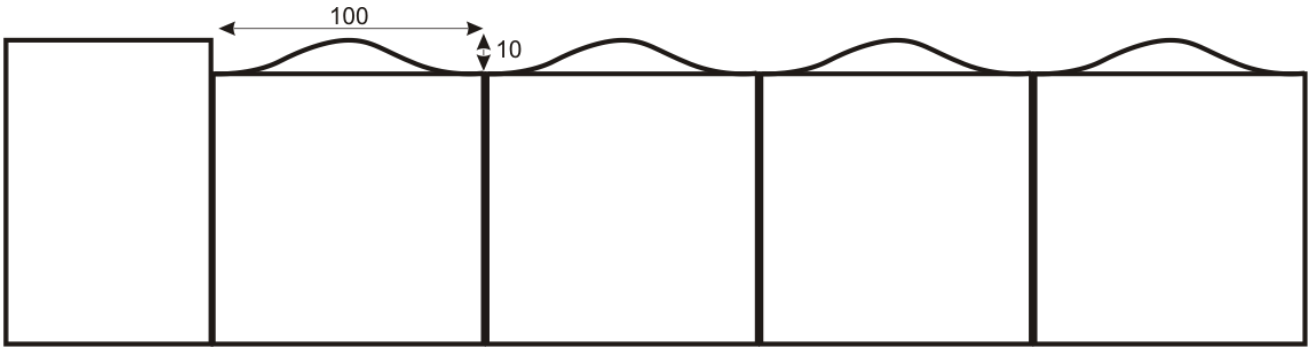
Dome

Md Dome



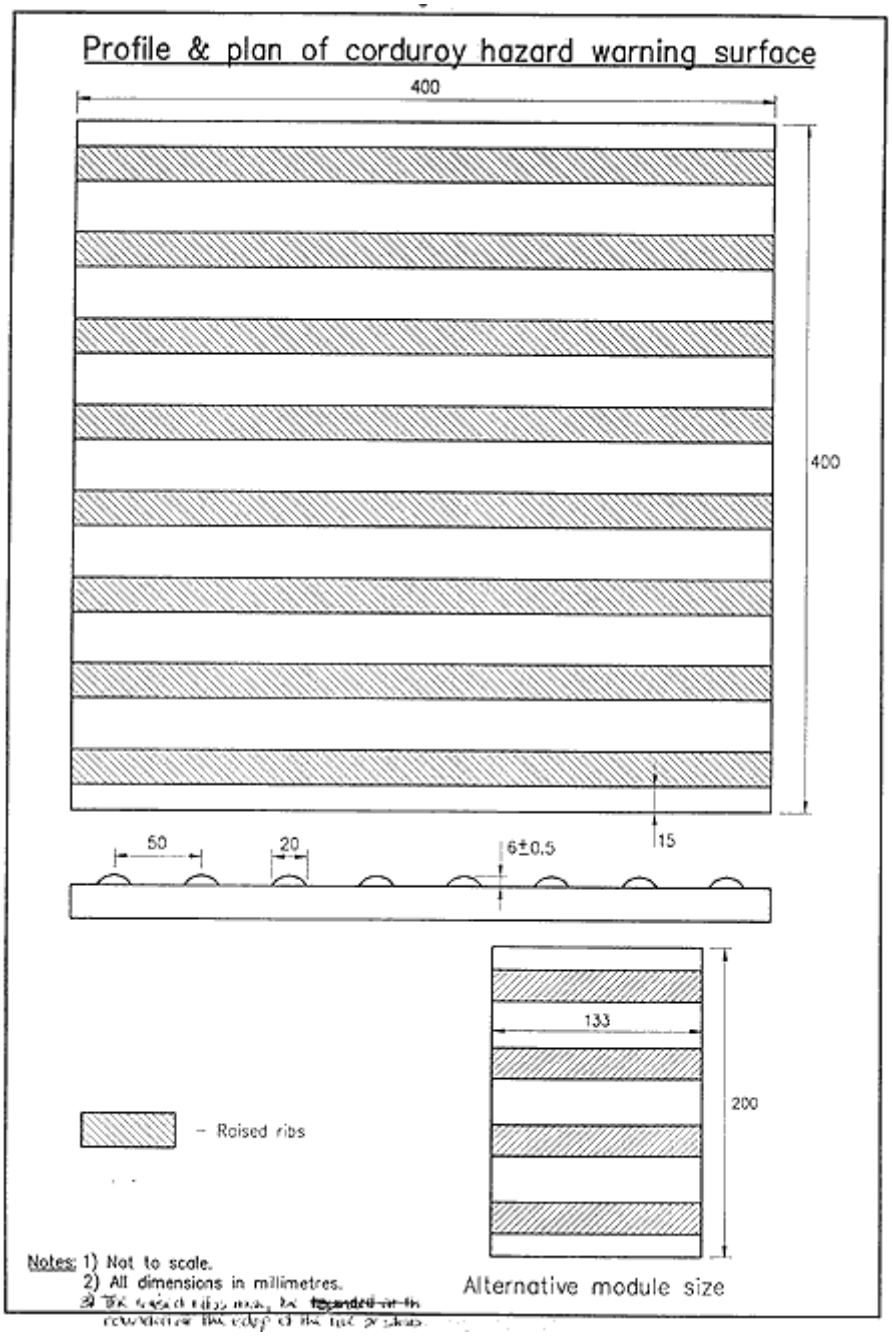
This dome, pressed concrete, is raised 15mm from the surrounding surface

Hd Dome



This dome, cut from granite, is raised 10mm, but the top of the dome is level with the surrounding surface.

Corduroy Hazard Warning Paving



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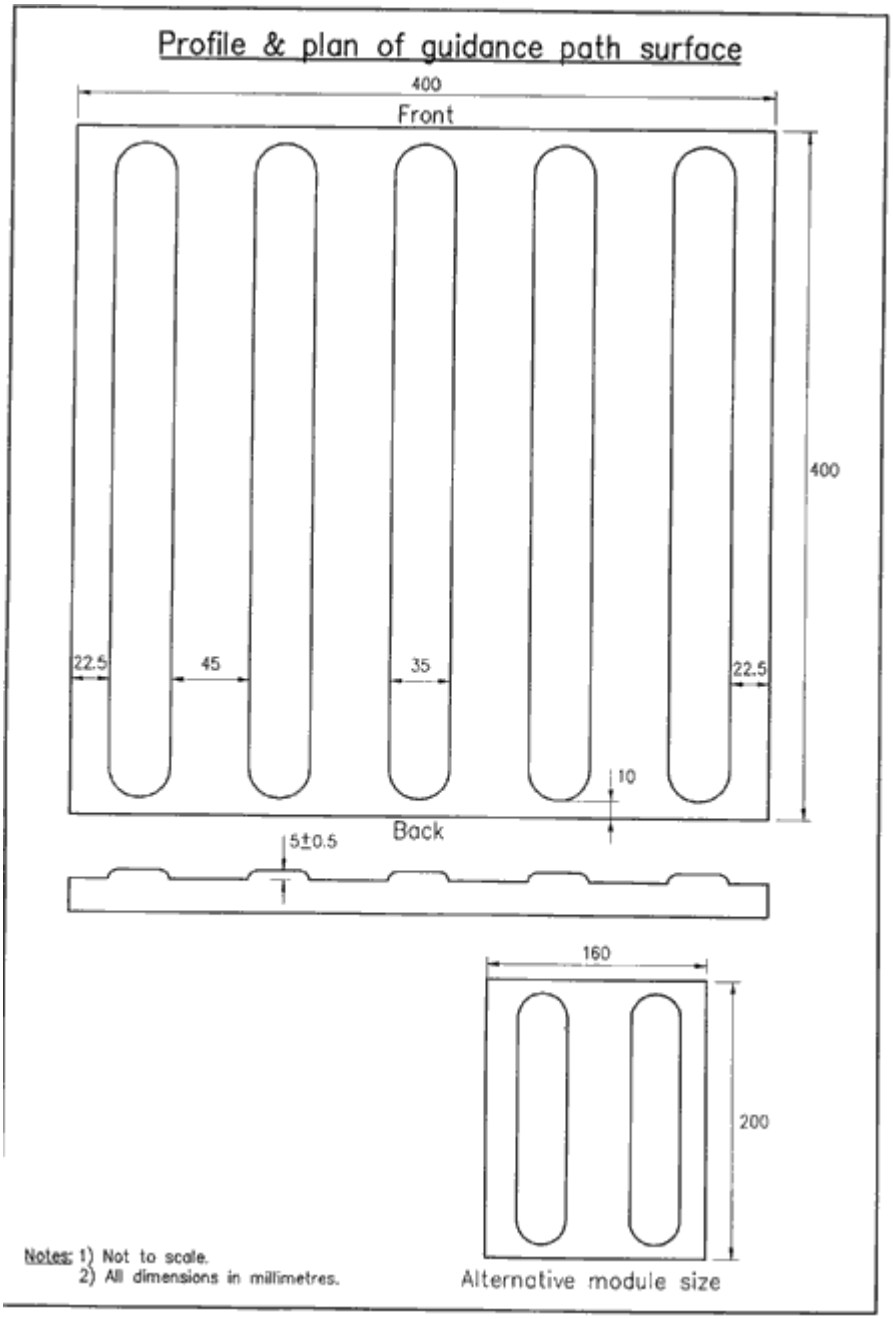
Guidance Path Surface Paving

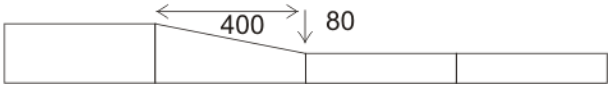


http://www.dft.gov.uk/transportforyou/access/peti/guidanceontheuseoftactilepav6167?page=11#a1044

Layout 1

Facing view (1600mm overall width)

Profile view



Single Slope

Facing view (1600mm overall width)

Profile view

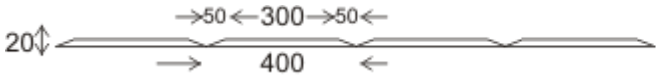
Rough Rumble

Facing view (1600mm overall width)

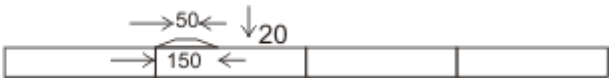
Profile view

Ridged Rumble

Facing view (1600mm overall width)



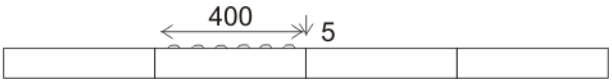
Profile view



modified Central Delineator

Facing view (1600mm overall width)

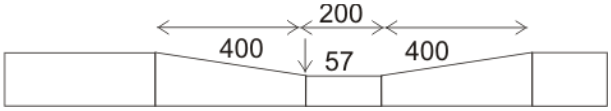
Profile view



Blister

Facing view (1600mm overall width)

Profile view

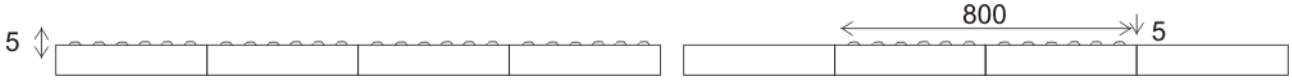


Double Slope

Layout 2

Facing view (1600mm overall width)

Profile view



Blister

Facing view (1600mm overall width)

Profile view

Corduroy Hazard Warning

Facing view (1600mm overall width)

Profile view

Corduroy Hazard Warning raised 6mm above surrounding surface

Facing view (1600mm overall width)

Profile view

Corduroy Hazard Warning on level and on 1:8 slope

Facing view (1600mm overall width)

Profile view

Corduroy Hazard Warning on level and non-chamfered 1:8 slope

Facing view (1600mm overall width)

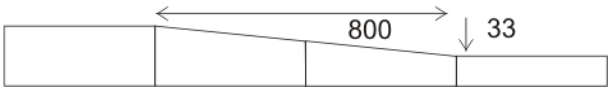
Profile view

Corduroy Hazard Warning on 1:8 slope

Layout 3

Facing view (1600mm overall width)

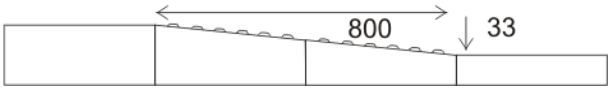
Profile view



non-chamfered pavers at 1:24 slope

Facing view (1600mm overall width)

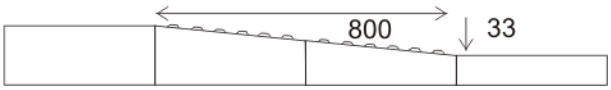
Profile view



Corduroy Hazard Warning at 1:24 slope

Facing view (1600mm overall width)

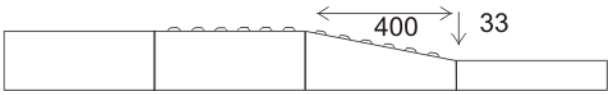
Profile view



Blister at 1:24 slope

Facing view (1600mm overall width)

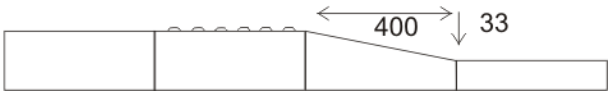
Profile view



Corduroy Hazard Warning on level and on 1:12 slope

Facing view (1600mm overall width)

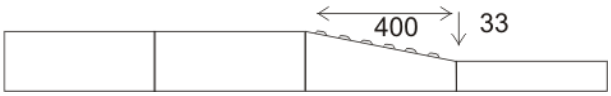
Profile view



Corduroy Hazard Warning on level and non-chamfered 1:12 slope

Facing view (1600mm overall width)

Profile view

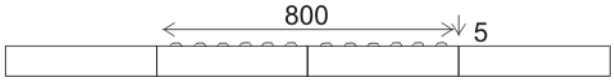


Corduroy Hazard Warning on 1:12 slope

Layout 4

Facing view (1600mm overall width)

Profile view



Blister

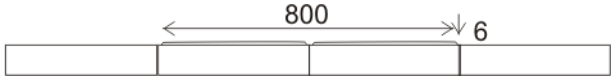
Facing view (1600mm overall width)

Profile view

Guidance Path Surface paving

Facing view (1600mm overall width)

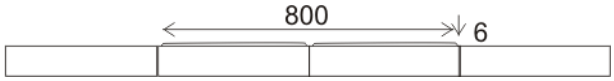
Profile view



Guidance Path Surface paving aligned to cross the road

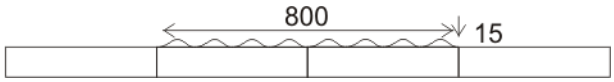
Facing view (1600mm overall width)

Profile view



Corduroy Hazard Warning aligned to cross the road

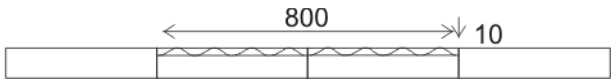
Facing view (1600mm overall width) **Profile view**



Dome set 15mm above surrounding surface

Facing view (1600mm overall width)

Profile view



Dome set 10mm below surrounding surface