



HIGHWAYS DEPARTMENT

**GUIDANCE NOTES
ON
DESIGN AND CONSTRUCTION OF
PAVEMENTS WITH PAVING UNITS**

Research & Development Division

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TABLE OF CONTENTS

1	INTRODUCTION.....	1
2	OBJECTIVE	1
3	TYPES OF PAVING UNITS	1
3.1	Precast Concrete Materials.....	2
3.2	Granite and Artificial Granite Materials	2
3.3	Clay Materials	3
3.4	Materials for Special Aesthetic or Memorial Features.....	3
4	AESTHETICS.....	4
4.1	Paving Theme	4
4.2	Detailed Attributes	4
4.2.1	Colours.....	4
4.2.2	Sizes.....	4
4.2.3	Laying Patterns	6
4.2.4	Textures	8
4.2.5	Rhythm and Rhyme	10
4.2.6	Harmony and Coherence	11
5	PAVEMENT STRUCTURE.....	11
5.1	Pavement Substructure.....	11
5.1.1	Bedding.....	12
5.1.2	Road-base and Sub-base	13
5.1.3	Sub-grade.....	13
5.2	Special Considerations.....	13
5.2.1	Carriageways and Run-in	13
5.2.2	Joint Stabilizing Sealers.....	14
6	GOOD PRACTICE FOR LAYING PAVING UNITS	15
6.1	Cutting and Trimming	16
6.2	Edge Restraints	17
6.2.1	Kerbs, Channels and Building Lines	18
6.2.2	Manholes and Utility Pits	21
6.2.3	Posts and Columns.....	22
6.2.4	Tree Pits	23
6.2.5	Irregular Obstructions.....	26
6.2.6	Interfaces with Other Paving Materials / Laying Patterns.....	26

TABLE OF CONTENTS (CONT'D)

7 APPLICATIONS AND LIMITATIONS	26
7.1 Applications	27
7.1.1 Aesthetics.....	27
7.1.2 Ongoing Settlement or Uneven Ground Displacement	27
7.1.3 Frequent Disturbance by Utilities.....	27
7.1.4 Poor Accessibility of Conventional Construction Plants.....	28
7.2 Limitations	28
7.2.1 Footways with Vulnerable Site Conditions	28
7.2.2 Carriageways	29
7.2.3 Industrial Areas.....	29
8 GUIDELINES TO AUTHORIZED PERSONS	30

PLATES

Plate 4.1 – Using colours of paving units to create interest and enhance local characters of the environment.....	5
Plate 4.2 – Using smaller-sized paving units on narrow footway to give better scale....	5
Plate 4.3 – Using larger-sized paving units on wide footway.....	6
Plate 4.4 – Using rectilinear laying pattern to align with straight kerbside	6
Plate 4.5 – Using transverse paving bands as transitional zones for aligning the direction of a laying pattern with the curvature of a footway to provide visual continuity	7
Plate 4.6 – Avoid using laying patterns with abrupt changes in direction	7
Plate 4.7 – Using an elaborate laying pattern design	8
Plate 4.8 – Using a simple laying pattern design	8
Plate 4.9 – Using a combination of different textures on a wide pavement to provide contrast and interest.....	9
Plate 4.10 – Using a simple texture and uniform laying patterns along a localized strip of pavement	9
Plate 4.11 – Using repetitive laying patterns tempered with change of colours to create rhythm and rhyme	10
Plate 4.12 – Using repetitive laying in-fill patterns tempered with variation on their sizes to create rhythm and rhyme.....	10
Plate 4.13 – Laying patterns and colours should be designed to harmonize and be coherent with local characters and the environment	11

FIGURES

Figure 6.1 – Sizes of paving units to be cut to suit different laying patterns.....	16
Figure 6.2 – Maximum allowable joint widths between cutting faces and adjoining paving units / edges.....	17
Figure 6.3 – Typical laying patterns for edge restraints.....	17
Figure 6.4 – Treatment to paving units against kerb edges for 90° herringbone bond laying pattern.....	18
Figure 6.5 – Treatment to paving units against kerb edges for 45° herringbone bond laying pattern.....	19
Figure 6.6 – Treatment to paving units against kerb edges for stretcher bond laying pattern.....	19
Figure 6.7 – Treatment to paving units against kerb edges for basket-weave bond laying pattern.....	20
Figure 6.8 – Treatment to paving units for kerb edges with curved alignment	20
Figure 6.9 – Treatment to paving units adjoining channel edges	21
Figure 6.10 – Treatment to paving units on or against manhole covers	22
Figure 6.11 – Treatment to paving units around posts and columns.....	23
Figure 6.12 – Reconstruction of tree pits without size modifications	24
Figure 6.13 – Reconstruction of tree pits with size modifications	25
Figure 6.14 – Edge treatment for paving units against other paving materials or laying patterns	26

APPENDICES

Appendix A – Examples for End Details of Edge Restraints.....	31
Appendix B – Particular Specifications Published by the Highways Department	43

1 INTRODUCTION

In the early 1980s, over 90% of footways in Hong Kong were constructed using in-situ concrete. In-situ concrete can offer simple, flexible and cheap construction for footways with basically satisfactory results attained. However, excessive noise and construction waste are generated during and after breaking of concrete footways for trench openings. Considerable time is also required for setting and curing of concrete for trench reinstatement. Given frequent trench works for utility services installation and maintenance, a lot of inconvenience and nuisance to the general public would be created by the footways constructed with in-situ concrete.

To address the above concern, the Highways Department had begun studying laying paving units on footways since 1982. Trials had been conducted at different locations, including central business areas and areas where there was a large variety of street furniture. Findings of the trials were satisfactory, with the paving units remained in good condition after laying, opening and reinstatement of trench works. With the positive outcome, the Highways Department promulgated specifications and standard drawings to promote the use of paving units on footways.

2 OBJECTIVE

This set of Guidance Notes updates and supersedes Road Note 9 – Precast Concrete Unit Paving System of 2006 edition and Guidelines on Good Practice for Laying Unit Pavers of 2012 edition, and serves as a guideline on design and construction of pavement using paving units.

3 TYPES OF PAVING UNITS

Paving units can be made of a variety of materials to meet functional and aesthetic considerations. Under the requirements on dimensions, strength, skid resistances and durability etc. as stipulated in the General Specification for Civil Engineering Works (GS) published by the Civil Engineering and Development Department and the particular specifications in Appendix B of this set of Guidance Notes, paving units come with different shapes, sizes, thickness and colours in the market.

3.1 Precast Concrete Materials

Paving units made of precast concrete materials should be generally used on footways. Their shapes, sizes, thickness, colours and laying patterns for construction shall follow the guidance shown in the Highways Department Standard Drawing Nos. H5101, H5102 and H5114. Past experience revealed that precast concrete paving units with a dimension exceeding 300mm could easily result in unsatisfactory workmanship and therefore are not recommended. Compared with clay paving units, precast concrete paving units have better durability and long term skid resistance. Currently, grey, brown and red are the most commonly used colours in precast concrete paving units as they can harmonize with the built environment and minimize glare under direct sunlight. Other colours may also be considered under recommendation of designers subject to confirmation of availability from suppliers.

To encourage recycling of construction and demolition materials, ETWB TCW No. 24/2004 requires public works contracts to use precast concrete paving units made of recycled aggregates in lieu of virgin aggregates. The Highways Department further requires its maintenance works and works to be conducted by Authorized Persons or Registered Structural Engineers to use precast concrete paving units made of recycled aggregates containing recycled glass cullet so as to facilitate recycling of waste glasses. Guidance to Authorized Persons and Registered Structural Engineers on using precast concrete paving units is further elaborated in Section 8 of this set of Guidance Notes.

3.2 Granite and Artificial Granite Materials

Granite and artificial granite materials are usually referred to natural granite stones and pulverized natural granite with other constituents, including feldspar, silica, clay, recycled glasses and pigments etc., respectively. Paving units made of these materials are commonly laid on the areas where aesthetic appearance is important, such as tourist areas. Granite paving units can provide a wide range of sizes varying from 100mm to 600mm along a dimension because of their high strength, however, artificial granite paving units can only provide up to 300mm with similar reason as that of precast concrete paving units. In general, granite and artificial granite paving units shall not be used in carriageways, run-ins and other paved areas onto which vehicles would have access.

When using granite paving units, particular attention should be paid on their surface textures since high roughness is normally incurred on their unpolished surfaces to provide a scene of natural environment. Such unpolished high roughness surfaces would cause inconvenience to the disabled or pedestrian using trolleys. To maintain aesthetic attractiveness and avoid causing inconvenience to road users, granite paving units with surface textures similar to those of artificial granite paving units should be used.

3.3 Clay Materials

Paving units made of clay materials were widely used on footways in the past. Their shapes, sizes and laying patterns for construction are almost the same as those of precast concrete paving units. The minimum thickness of clay paving units is 50mm for footways and cycle tracks, and 65mm for carriageways, run-ins and other paved areas to which vehicles would have access. Comparing with precast concrete paving units, clay paving units are more susceptible to damage and progressive deterioration of skid resistance based on past experience. In view of this, laying clay paving units shall only be considered at special locations where laying precast concrete paving units is justified not suitable to achieve the design intent, and the proposed clay paving units shall satisfy the requirements of the Regional Offices of the Highways Department on the aforesaid technical aspects.

3.4 Materials for Special Aesthetic or Memorial Features

Materials for special aesthetic or memorial feature paving units can be of any type that can suit the design objectives and the stipulated requirements for paving units. They should not cause undue difficulty in excavations and reinstatement of pavements. These paving units can be of any sizes, shapes and thicknesses, and shall only be used in exceptional cases. The usage and design of these paving units are required to satisfy specific technical and aesthetic requirements of the Regional Offices and the Landscape Division of the Highways Department, and would be considered on a case-by-case basis.

4 AESTHETICS

Aesthetics, including themes of paving and detailed attributes, is one of the considerations in designing footways for new and maintenance works. Themes of paving could affect coherence and harmony of footways to the surrounding environments, which in turn is dictated by detailed attributes, such as laying patterns and textures, etc. adopted.

4.1 Paving Theme

A theme of paving should be set down for a footway based on its pedestrian flow and prevailing use of the land where it locates so as to enhance streetscape in that area. For an area that would attract public's attention or is designed for recreational purpose, some preferable paving units such as granite, artificial granite or high quality paving units may be considered subject to the design justification submitted to the Landscape Division of the Highways Department for comment. Under most circumstances, precast concrete paving units should be considered as the norm. Where appropriate, they may be laid in combination with other types of paving units as highlight to enhance their visual appearance.

4.2 Detailed Attributes

The theme of paving should be clearly expressed and defined by using colours, sizes, laying patterns and textures. Visual rhythm, rhyme, harmony and other considerations at special areas should also be taken into account in the design stage.

4.2.1 Colours

Local characters and the environment of a district can be enhanced by virtue of the colour of the paving units as illustrated on Plate 4.1. Selection of the colour of the paving units could make reference to the chromatic composition and character of the district and its local environment.

4.2.2 Sizes

The proportion and scale of the paving units to the width of the footway would strongly influence the characters of the local environment. As a general rule,

smaller-sized paving units should be laid on narrow footways in confined areas, whereas larger-sized paving units should be used on wide footways and footways in open areas with spacious setting, as illustrated on Plates 4.2 and 4.3.



Plate 4.1 – Using colours of paving units to create interest and enhance local characters of the environment



Plate 4.2 – Using smaller-sized paving units on narrow footway to give better scale



Plate 4.3 – Using larger-sized paving units on wide footway

4.2.3 Laying Patterns

When designing a laying pattern, the overall configuration and main direction of the footway should be taken into account so as to minimize cutting of paving units at footway edges and allow major changes in direction of paving units without major variations on the laying pattern. An example is shown on Plate 4.4. The Highways Department Standard Drawing No. H5114 can also be referred to for laying patterns adopted in Hong Kong.

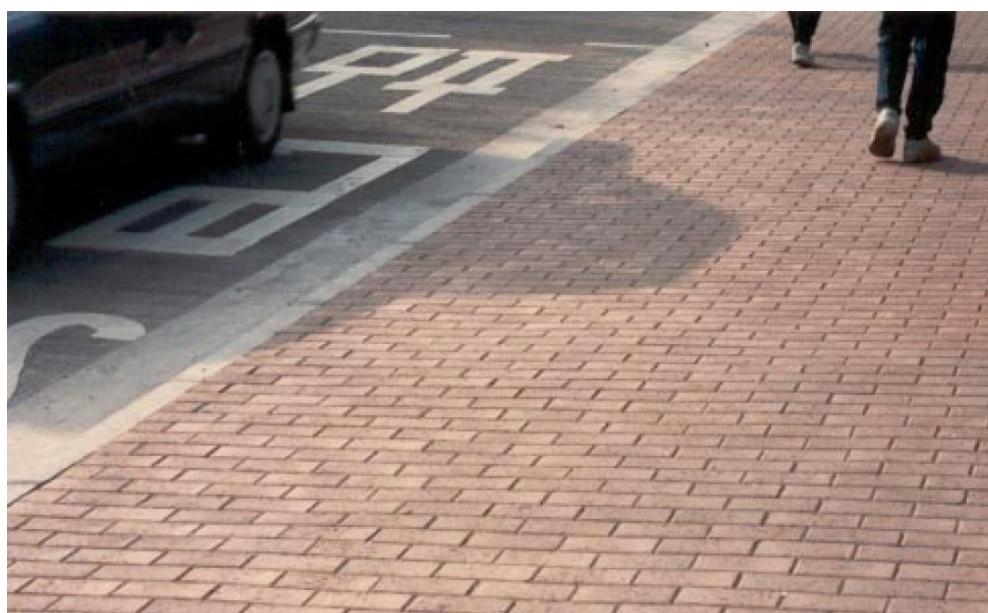


Plate 4.4 – Using rectilinear laying pattern to align with straight kerbside

An appropriate laying pattern with feature bands could be adopted at a curved footway to match with its curved character as shown on Plate 4.5. An abrupt change in directions of laying patterns in localized area as shown on Plate 4.6 should be avoided.



Plate 4.5 – Using transverse paving bands as transitional zones for aligning the direction of a laying pattern with the curvature of a footway to provide visual continuity



Plate 4.6 – Avoid using laying patterns with abrupt changes in direction

A wider footway with spacious setting allows using an elaborate laying pattern to break its monotony as shown on Plate 4.7, while a narrower footway with limited space prefers a simple pattern design as shown on Plate 4.8.



Plate 4.7 – Using an elaborate laying pattern design



Plate 4.8 – Using a simple laying pattern design

4.2.4 Textures

Appearance of a footway is significantly affected by the texture of its pavement which is governed by the sizes, shapes and laying patterns of the paving units. Different

textures can be used in combination on a wide pavement in order to modify apparent proportions and provide contrast and interest, as shown on Plate 4.9, whereas a simple texture using uniform laying patterns can be used along a localized strip of pavement as shown on Plate 4.10.



Plate 4.9 – Using a combination of different textures on a wide pavement to provide contrast and interest



Plate 4.10 – Using a simple texture and uniform laying patterns along a localized strip of pavement

4.2.5 Rhythm and Rhyme

Rhythm concerns regular repetition of features in a composition which should be uniform and simple in nature. Rhythm could be created by maintaining repetitive features (both laying patterns and / or their colours) at regular or varied intervals, alternative arrangements and graduate changes in a series. Rhyme, or “likeness tempered with difference”, gives variation on an object without breaking its rhythm as shown on Plates 4.11 and 4.12.



Plate 4.11 – Using repetitive laying patterns tempered with change of colours to create rhythm and rhyme



Plate 4.12 – Using repetitive laying in-fill patterns tempered with variation on their sizes to create rhythm and rhyme

4.2.6 Harmony and Coherence

A footway pavement should be designed to harmonize and be coherent with local characters and the environment of the district it is located. Harmony exists when the pavement complements with the surroundings to produce a synergetic effect that is more pleasing than their separate contributions, while coherence happens when the pavement together with the environment gives a unified impression without discordant character. An example of harmony is shown on Plate 4.13.

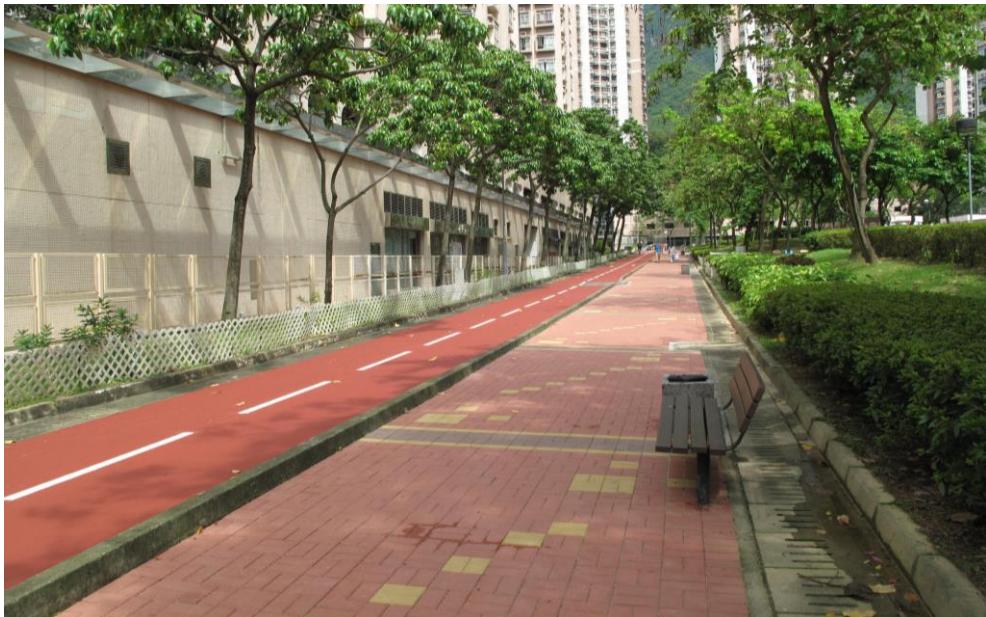


Plate 4.13 – Laying patterns and colours should be designed to harmonize and be coherent with local characters and the environment

5 PAVEMENT STRUCTURE

Pavement structure is one of the prime concerns when constructing pavements with paving units. It consists of paving units at the top, underlaid by bedding, road-base, sub-base and sub-grade, as shown in the Highways Standard Drawing No. H1103. Good practices for laying paving units are presented in Section 6, while practices for constructing the underlying substructure are discussed in the following paragraphs.

5.1 Pavement Substructure

The pavement sub-structure, including bedding, road-base, sub-base and sub-grade, shall be provided in a stabilized manner to achieve the required strength and durability.

Any failure of this substructure would cause settlement and stepping of the paving units, which affect the pavements and subsequently the road users.

5.1.1 Bedding

Bedding is the layer of materials directly beneath paving units. It shall be of a uniform thickness throughout to allow even distribution of loads and settlement. The GS shall be referred to for the requirements of laying bedding materials.

Sand Course Bedding

In general, paving units shall be laid on a layer of sand course bedding with a final thickness of 20-30mm. The quantity and thickness of the sand course bedding used during construction shall be appropriate to the methods of preparation to achieve the design finished level of the pavement.

Cement Stabilized Bedding

Paving units supported by sand course bedding may subject to loss of sand in some areas where frequent cleansing using high pressure water jets would be carried out. This problem could be addressed by adding cement to stabilize the bedding. The mixture of this cement stabilized bedding shall be of 15% cement and 85% sand by mass without addition of water. This kind of bedding may also be considered for footways facing stepping problems under normal loads and subgrade conditions.

Geogrid Reinforced Bedding

Defects in pavement substructure caused by loss of sub-base supports, settlement of trenches for utility services, or consolidation of isolated areas of soft or poorly compacted subgrade could cause stepping between adjacent paving units. Based on the site trials carried out by the Highways Department, using geogrid reinforcement underneath the cement stabilized bedding can mitigate the potential stepping problems, since the tensile elements and mechanical interlocking property of the geogrid reinforcement could provide greater stability to the bedding against stepping.

However, additional efforts would be involved in both initial construction and reinstatement of pavements using geogrid reinforcement. Hence, it shall only be

applied on a case-by-case basis for areas with repeated stepping problems or difficult to be maintained due to high pedestrian traffic. The Highways Department Standard Drawing Nos. H5136 and H5137 provide details for laying paving units with geogrid reinforcement for new works and reinstatement works respectively.

5.1.2 Road-base and Sub-base

Road-base is a bituminous or concrete layer between bedding and granular sub-base for construction of carriageways and run-ins. It is normally 100 to 200mm minimum thickness overlaid on a 225mm thick sub-base. Road-base is usually not required for footways construction, where a 100mm thick sub-base should be provided directly underneath the bedding. The Highways Department Standard Drawing No. H1103 and the GS give typical arrangements of road-base and sub-base for laying paving units and the requirements for constructing these road-base and sub-base layers.

During reinstatement or repair of pavements with paving units for the areas subject to heavy loading, the conditions of the bituminous road-base or concrete layer shall be inspected and repaired, as necessary, in addition to the relaying or replacement of the paving units.

5.1.3 Sub-grade

Sub-grade is the bottom layer supporting the substructure for pavements laying with paving units. The minimum elastic modulus of the sub-grade shall be 50MPa. For the case that it cannot be achieved, strengthening measures to the sub-grade as recommended under the Highways Department Guidance Notes No. RD/GN/042 should be provided.

5.2 Special Considerations

Some special considerations are required to be taken into account when designing pavements laying with paving units for the areas subject to heavy loading or abnormal operational conditions.

5.2.1 Carriageways and Run-in

Based on laboratory research and observations on pavements using paving units for

vehicular over-runs, it was found that opening of joints perpendicular to and horizontal creep of paving units along the direction of the predominant traffic flow are the two common modes of pavement failures. Selecting appropriate types of paving units and laying paving units with appropriate patterns would be useful to minimize their occurrence. In general, Type A precast concrete paving units would have better performance than Type B, and the herringbone bond laying pattern shall be used on run-ins for all types of pavers as illustrated in the Highways Department Standard Drawing No. H5134.

To further avoid cracking or breaking of paving units exposed to vehicular traffic, heavy duty paving units as specified in the Highways Department Standard Drawing No. H5135 and as required under the GS shall be used. The Highways Department Standard Drawing Nos. H5125, H5126 and H5133 also provide other construction details for pavements using paving units with vehicular over-runs.

Comparing with precast concrete paving units, clay paving units are more susceptible to damage and progressive deterioration of skid resistance based on past experience. When the footpath locations subject to heavy loading surfaced with clay paving units are damaged (e.g. uneven surface, damaged paving units, loosened paving units, etc.), all the clay paving units at the damaged footpath location shall in general be replaced with precast concrete paving units unless there are site specific reasons not to do so.

To avoid segregation of different paving materials along the same footpath affecting the quality of streetscape, replacement of the existing clay paving units with precast concrete paving units along the same footpath shall be considered on a case-by-case basis.

5.2.2 Joint Stabilizing Sealers

Joint stabilizing sealers can be epoxy based materials or similar for filling into the joints between paving units without adversely affect their colours or skid resistance. Details of application are presented in the Highways Department Standard Drawing No. H5127.

As extra efforts would be required for application and removal of the joint stabilizing sealers between paving units, thorough consideration should be given for application to a specific location taking into account the site conditions, including but not limited

to the utilities installations underneath, appearance, pedestrian flow volume, safety and security of general public.

In general, they should only be applied to the situation for preventing:

- (a) uneven settlement/damage due to high pedestrian flow/frequent illegal parking/heavy loading;
- (b) frequent growth of moss and grasses between the gaps of paving blocks due to environmental factors;
- (c) vandalism;
- (d) jointing sand or bedding materials from being eroded by frequent use of high-pressure water jet cleansing (such as at hygienic black spots); and/or
- (e) other specific reasons considered appropriate by the Regional Offices of the Highways Department.

Apart from the above, for paving units at footways with steep gradients (8% or larger) or adjacent to slopes leading to possible washout of jointing sand or bedding materials during rainstorms, joint stabilizing sealers can be used as a stabilization measure for preventing dislocation of paving units.

The project proponents should consult the Highways Department at an early stage before application of the joint stabilizing sealers for a specific site if considered necessary.

6 GOOD PRACTICE FOR LAYING PAVING UNITS

Paving units should be laid in a proper manner to ensure performances of pavements in the aspects of safety of pedestrians, aesthetic, operation and maintenance. Any unsatisfactory workmanship on laying paving units would produce unpleasant feeling or cause inconvenience to road users and require frequent repairing. The Highways Department promulgated standard drawings and specifications to set down requirements of laying paving units for pavements to ensure adequate laying standards could be achieved. Some good practices based on past experience are elaborated in the following paragraphs, which may serve as practice guidance for laying paving units.

6.1 Cutting and Trimming

To minimize cutting and trimming, proper setting out of paving units to suit the sites with frequent checking on their alignments during laying should be done. Ornamental fixtures (if any) used with paving units should also be carefully selected to ensure their shapes and sizes are compatible with those of the paving units and their laying patterns. Special attention should be paid on cutting and trimming, including use of proper equipment such as hydraulic or mechanical block-splitters for precast concrete paving units and multi-bladed-splitters for clay paving units, to achieve straight cutting faces. Besides, sizes of paving units should not be less than 1/4 of their original sizes for laying 45° herringbone bond laying patterns, and not less than 1/3 of their original sizes for other laying patterns. Figure 6.1 provides some examples of cutting paving units to suit different laying patterns.

Pre-fabricated or pre-cut paving units may be used in laying to minimize on-site cutting. For example, half blocks and triangular blocks may be used for 90° herringbone / stretcher and 45° herringbone bond laying patterns respectively. Joints between the cutting faces and adjoining paving units or edges shall not be more than 5mm, except along curved adjoining paving units or edges as shown in Figure 6.2.

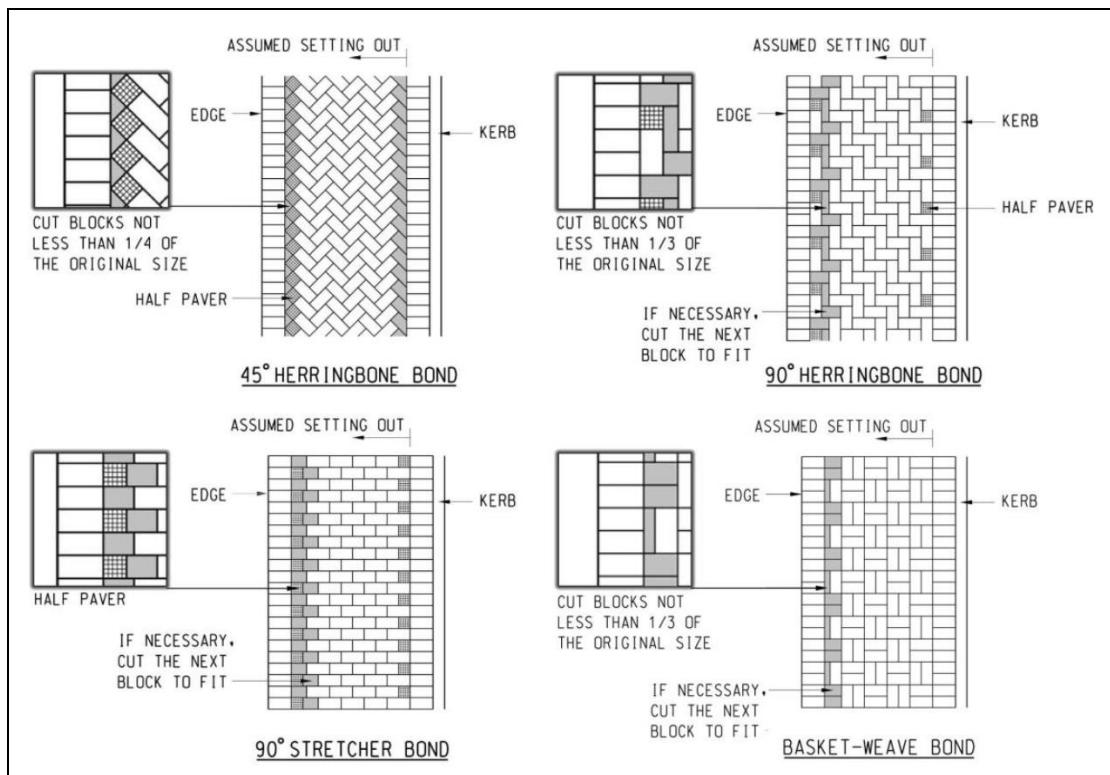


Figure 6.1 – Sizes of paving units to be cut to suit different laying patterns

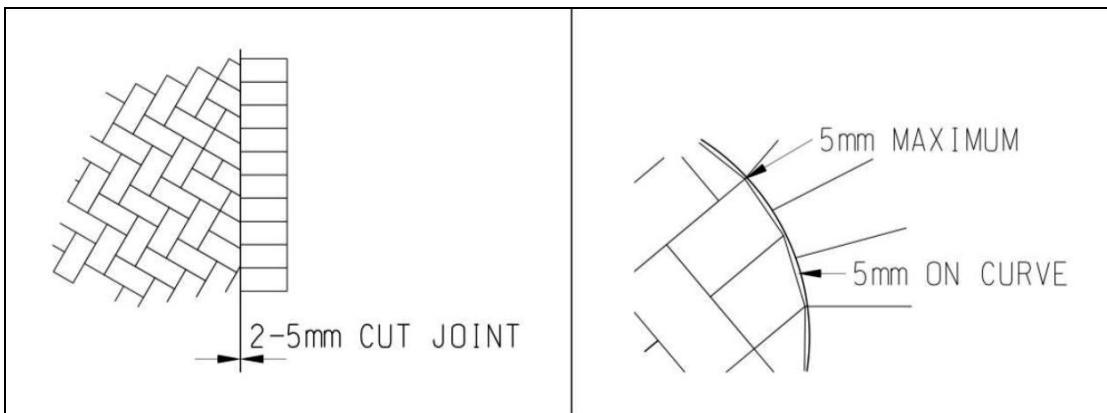


Figure 6.2 – Maximum allowable joint widths between cutting faces and adjoining paving units / edges

6.2 Edge Restraints

Edge restraints are important for preventing movement of paving units in operation. They sometimes create difficulty in laying paving units since additional cutting and trimming are required. In most cases, edge restraints should be formed before laying and compacting the adjacent paving units, and in parallel or perpendicular to main directions of laying patterns of the footways. They should also be supported by concrete backings with details shown in the Highways Department Standard Drawing No. H1103. Typical laying patterns for edge restraints are shown in Figure 6.3.

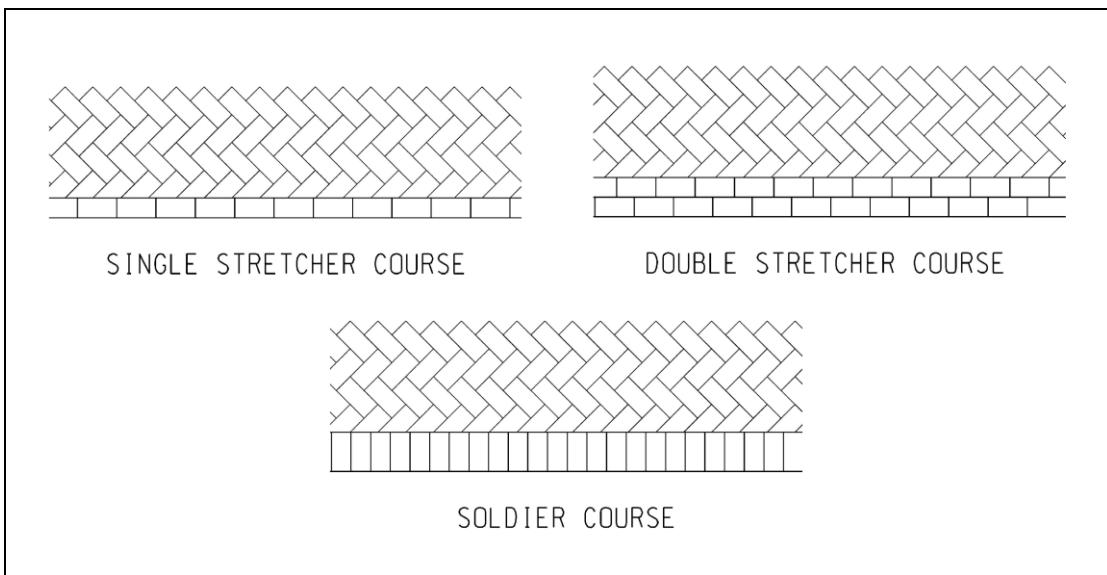


Figure 6.3 – Typical laying patterns for edge restraints

Some good practices for end details of paving units laying against edge restraints are elaborated in the following paragraphs and relevant examples are presented in Appendix A.

6.2.1 Kerbs, Channels and Building Lines

Paving units against kerbs, channel edges and building lines shall be treated differently for unalike laying patterns. Apart from following the guidance of cutting and trimming for paving units as mentioned in Section 6.1, details illustrated in Figures 6.4 to 6.9 should also be taken into account. When laying paving units, the existing granite kerbs, unless seriously damaged, should be retained as far as practical and their uneven portions should be either saw-cut or hand-chipped to provide straight backings. Use of coloured mortar to form aligned edges behind granite kerbs shall only be considered as exceptional cases subject to agreement of the Landscape Division of the Highways Department.

Same principles for treatment to paving units against kerbs and channel edges shall be applied to the paving units against building lines.

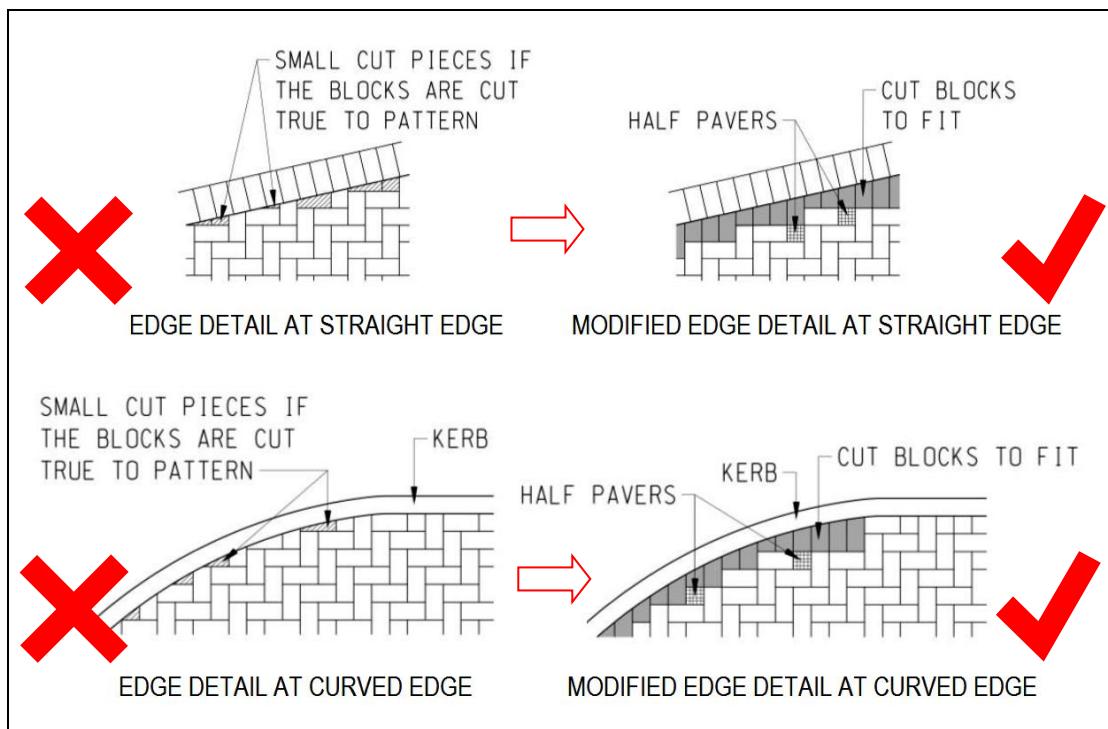


Figure 6.4 – Treatment to paving units against kerb edges for 90° herringbone bond laying pattern

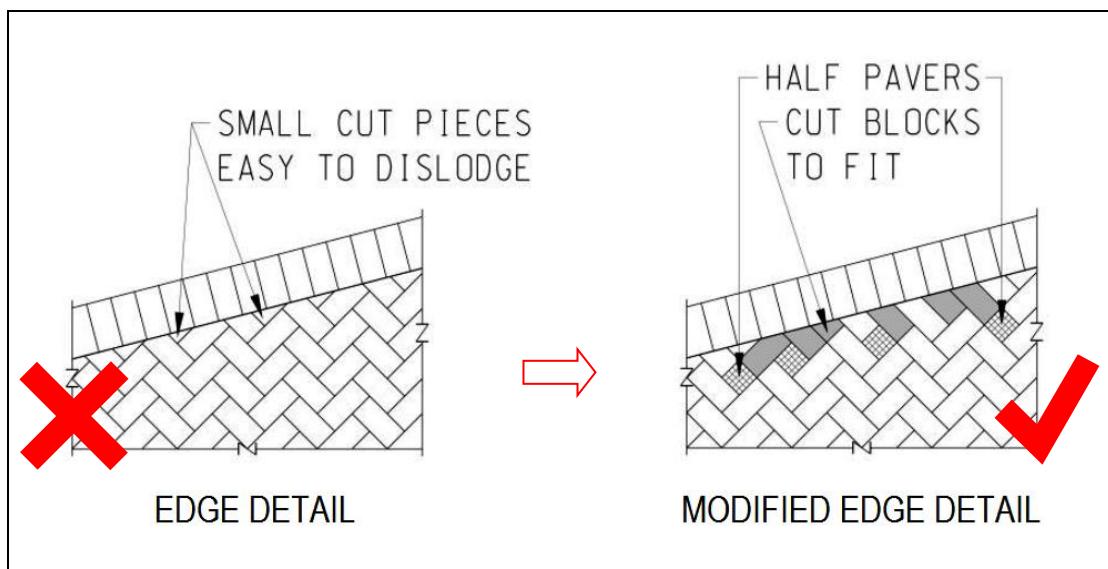


Figure 6.5 – Treatment to paving units against kerb edges for 45° herringbone bond laying pattern

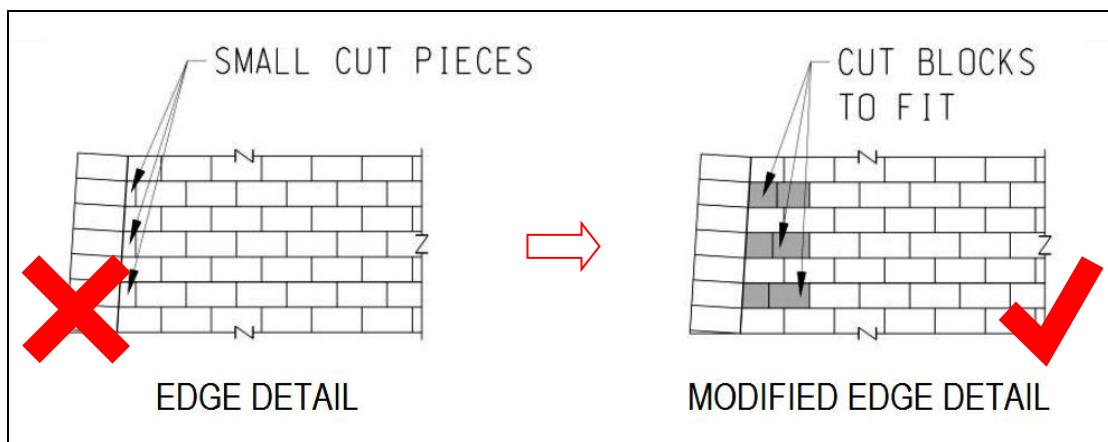


Figure 6.6 – Treatment to paving units against kerb edges for stretcher bond laying pattern

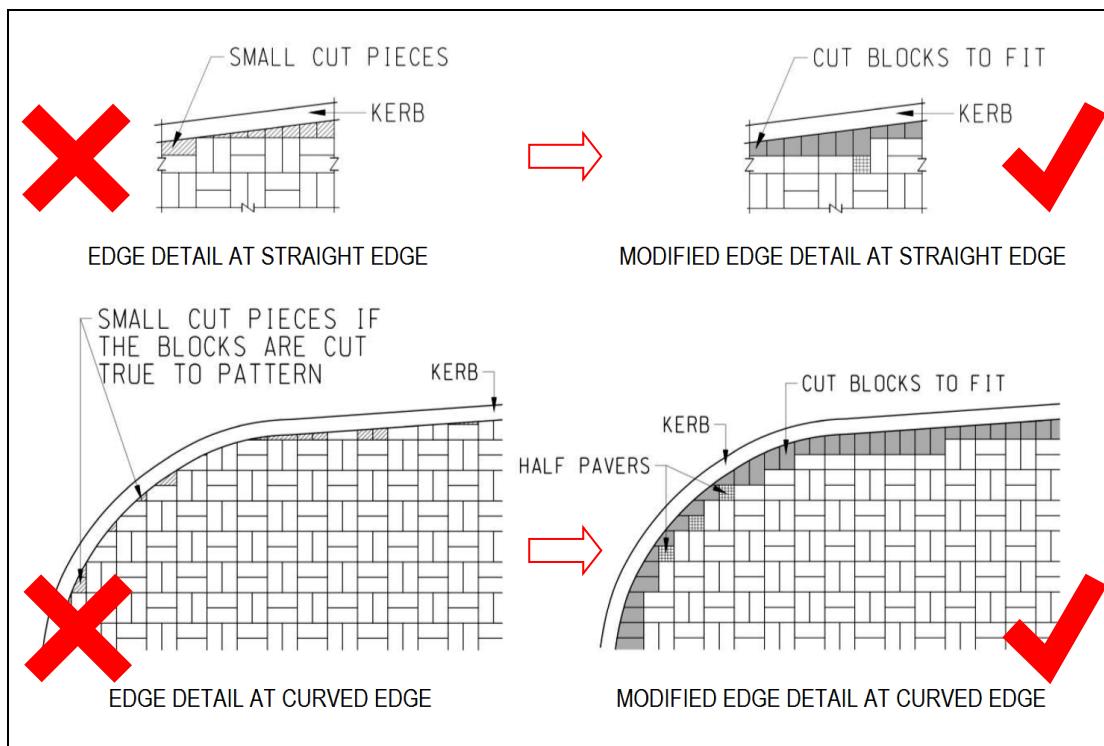


Figure 6.7 – Treatment to paving units against kerb edges for basket-weave bond laying pattern

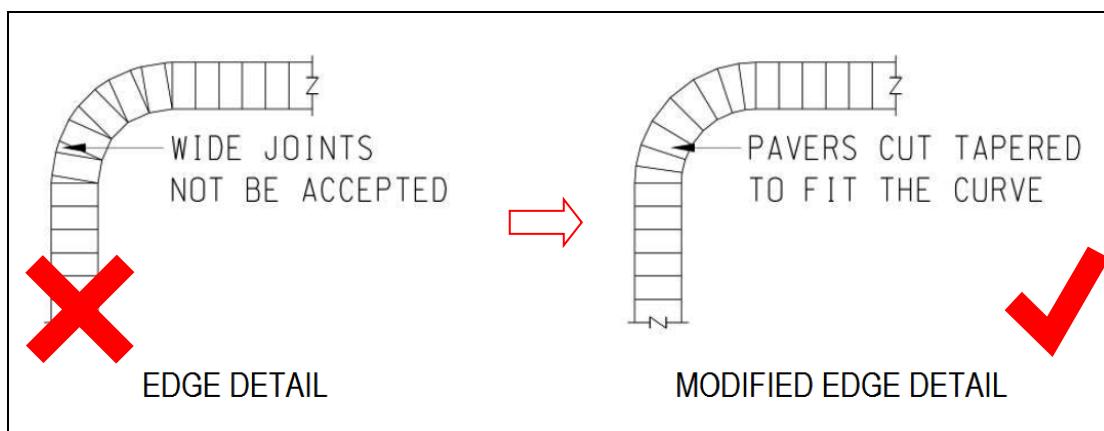


Figure 6.8 – Treatment to paving units for kerb edges with curved alignment

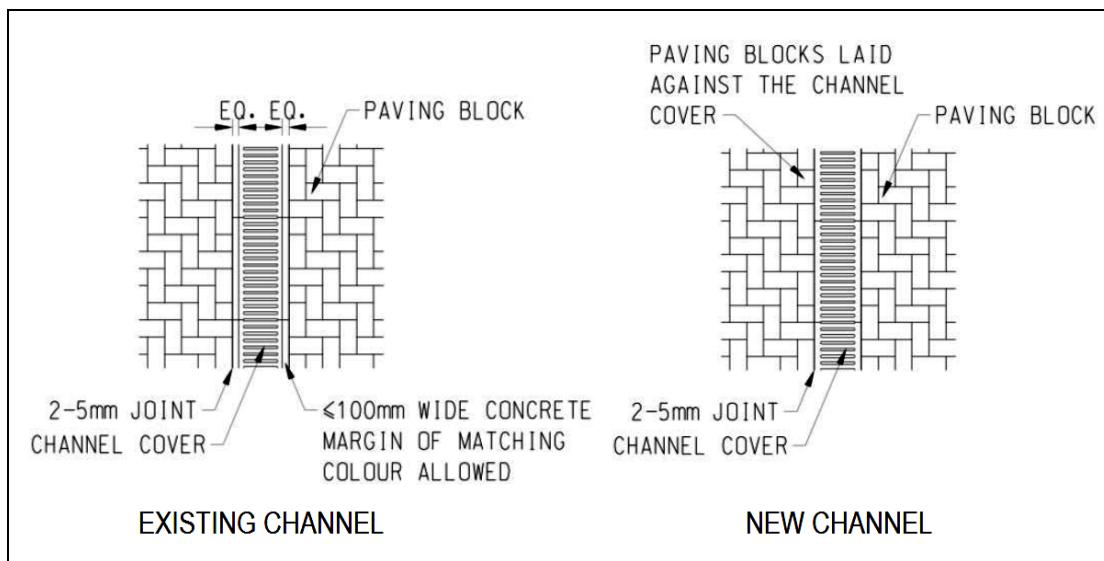


Figure 6.9 – Treatment to paving units adjoining channel edges

6.2.2 Manholes and Utility Pits

To provide a uniform laying pattern across and along a pavement, positions and orientations of manhole / utility pit covers shall be aligned as appropriate to suit the laying pattern. Paving units shall be laid abutting directly against frames of the covers for manholes and utility pits, and recessed matching covers as shown in Figure 6.10 shall be provided on footways and preferred on carriageways laid with paving units. However, paving units of higher standard than those used on footways and supported by recessed double matching covers should be considered for carriageways. A “scaled layout plan” showing laying patterns of recessed matching covers for manholes / utility pits, and with their abutting paving units, shall also be prepared to ensure proper laying of paving units with good workmanship for a pavement.

Regarding the paving units laid in recessed matching covers, their sizes should not be less than 1/3 of their original sizes, with colours and patterns consistent with the abutting paving units and overall laying pattern of the pavement. The requirement of not less than 1/3 of their original sizes may be relaxed at specific locations as a fall back where it is difficult to comply with, and without compromising the consistency of the colours and patterns. Cement mortar should be used to ensure secure bonding between the paving units in recessed impervious matching covers. In circumstances that recessed matching covers cannot be used, concrete surrounds of width smaller than 100mm for cast iron manhole covers / gratings and 50mm for valve pit covers

with colours consistent with the adjacent paving units may be constructed as edge restraints for laying paving units, as shown in Figure 6.10.

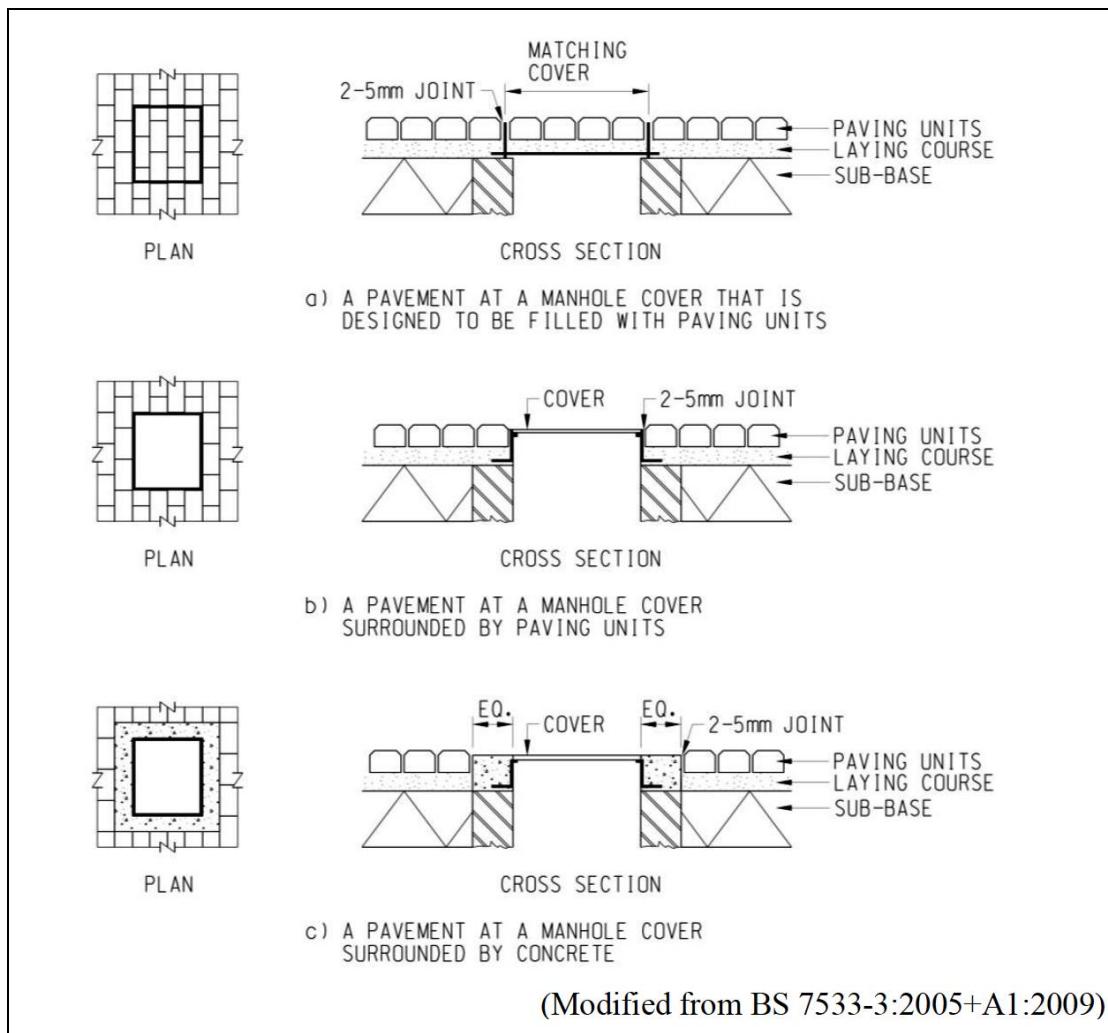


Figure 6.10 – Treatment to paving units on or against manhole covers

6.2.3 Posts and Columns

Footings and foundation slabs of posts and columns, especially for those of bus shelters and telephone kiosks, should be constructed below the level for laying paving units so as to minimize cutting and trimming. Pre-fabricated half-round paving units could be considered for abutting around posts and columns, and their integration with the adjacent paving units could be improved by cutting 2 or more rows of units instead of just the adjoining one in some cases, as shown in Figure 6.11. However, they cannot be used in every situation, in particular for those areas where a lot of posts or columns are close together, or for posts and columns with large diameters.

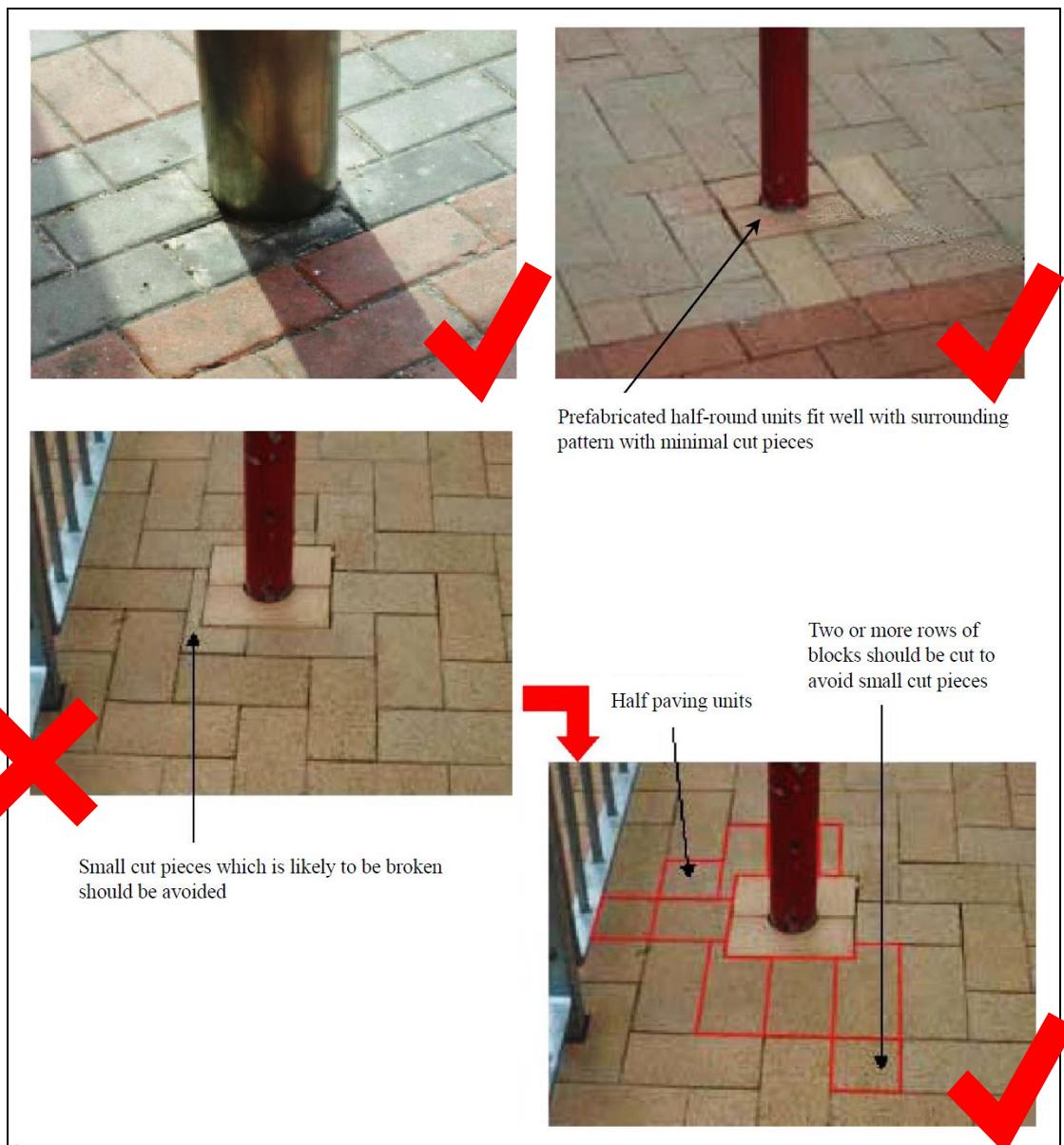


Figure 6.11 – Treatment to paving units around posts and columns

6.2.4 Tree Pits

With continuous growth of trees, the root actions may cause upheaval of tree pits and surrounding paving units which would require their reconstruction and relaying. The reconstruction of tree pits may or may not involve modification of their sizes, as illustrated in Figures 6.12 and 6.13, where the Transport Department should be consulted if sizes of tree pits would be modified and affect effective widths of footways.

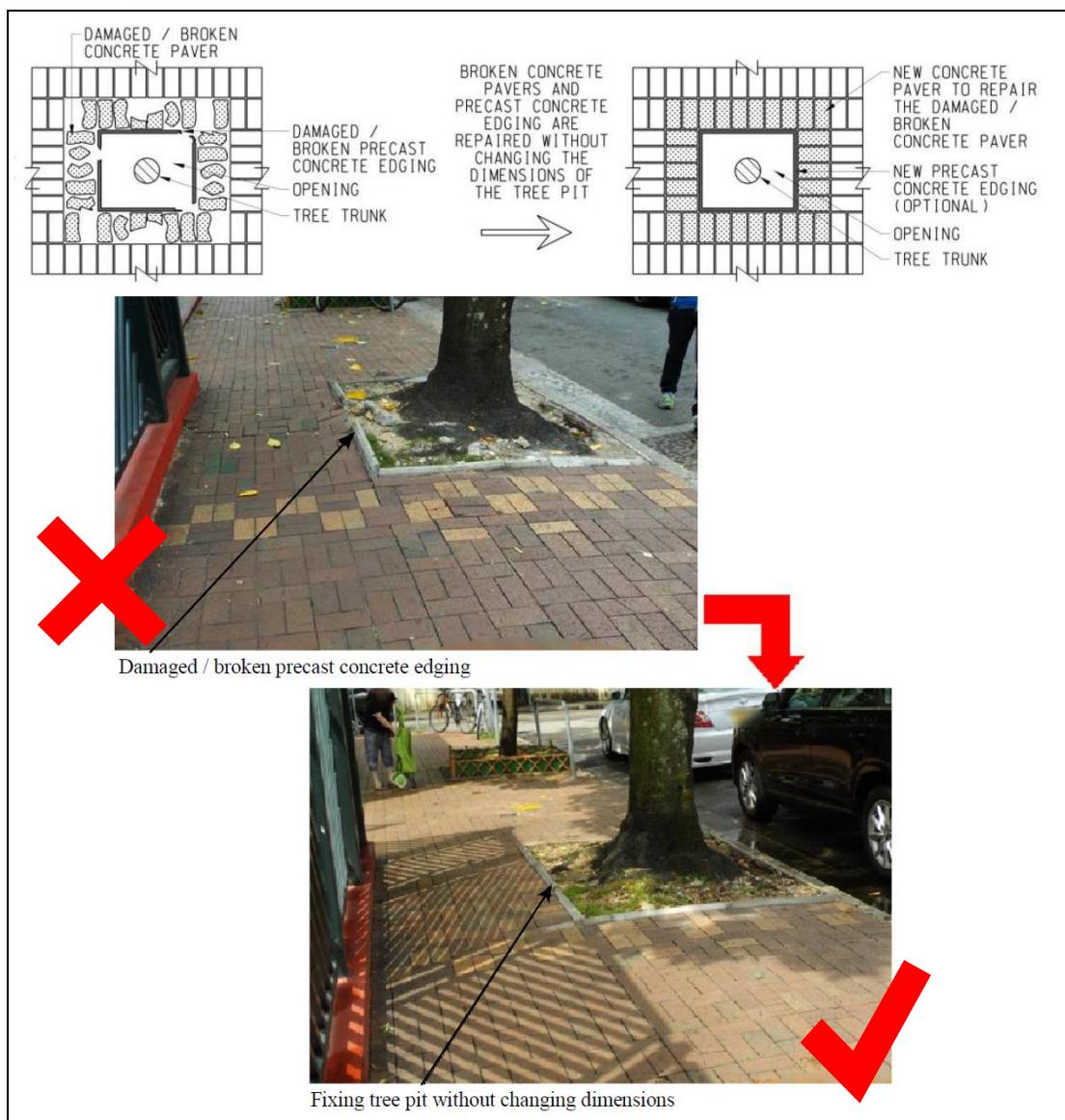


Figure 6.12 – Reconstruction of tree pits without size modifications

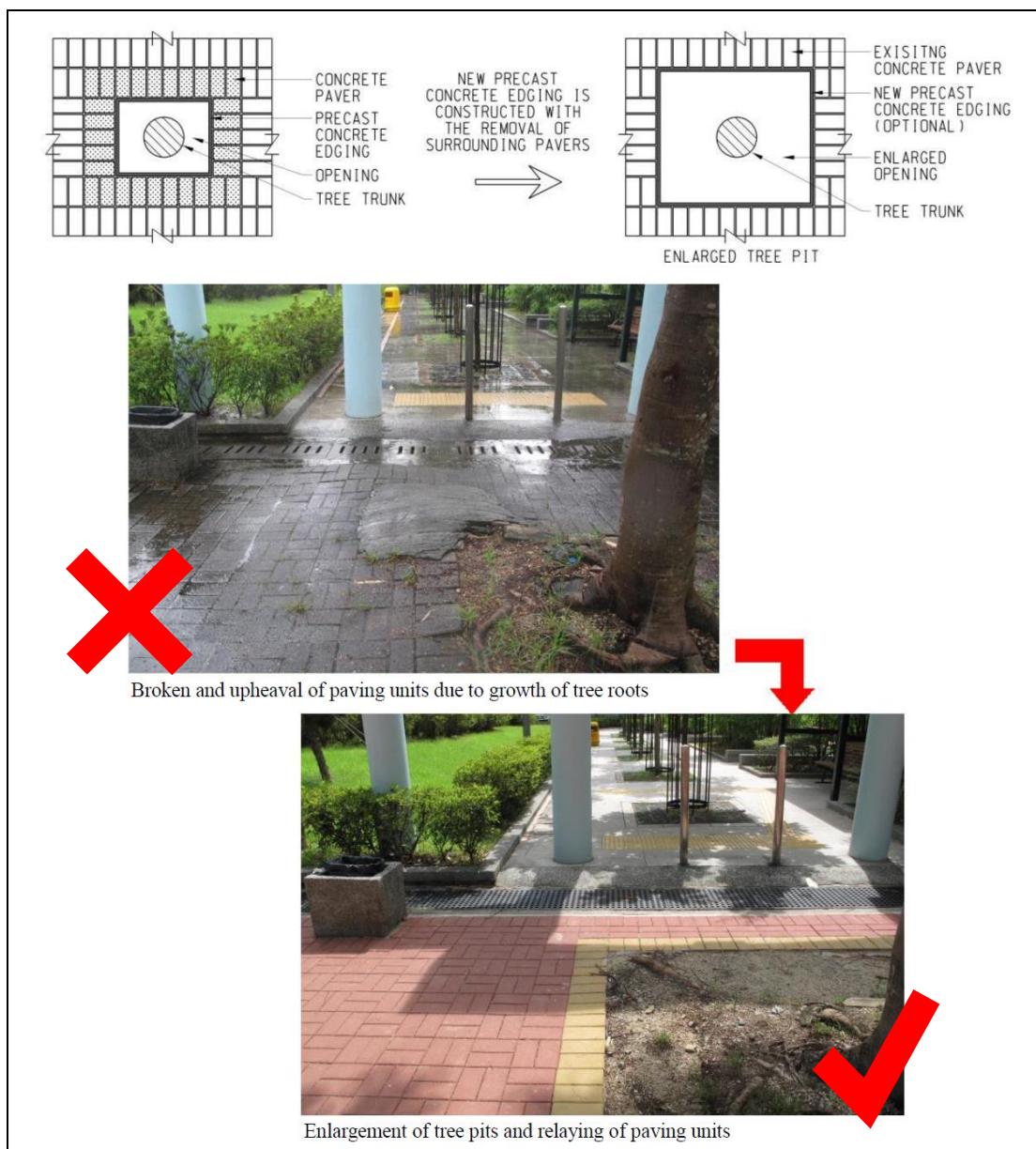


Figure 6.13 – Reconstruction of tree pits with size modifications

For the cases where tree roots with diameters exceed 100mm and are too shallow for the reconstruction or relaying, the respective tree maintenance departments shall be invited for carrying out or furnishing arboricultural advice on root pruning works. The Landscape Division and the Regional Offices of the Highways Department should always be consulted prior to the reconstruction of tree pits and relaying paving units.

6.2.5 Irregular Obstructions

Irregular obstructions include holes for roller shutters, building extension and protrusions of ironworks, etc.. Paving units shall be cut to fit and abut irregular obstructions with 2 to 5mm joints in between. To provide structural integrity, 100mm wide concrete surrounds of thicknesses not less than those of and with colours consistent with the adjacent paving units should be constructed.

6.2.6 Interfaces with Other Paving Materials / Laying Patterns

Edge restraints in form of securely fixed paving blocks shall be provided at the intersections between different paving materials, different laying patterns, and footways and run-ins. Typical construction details for edge restraints between different paving materials or laying patterns are shown in Figure 6.14, and those between footways and run-ins are shown in the Highways Department Standard Drawing No. H5133.

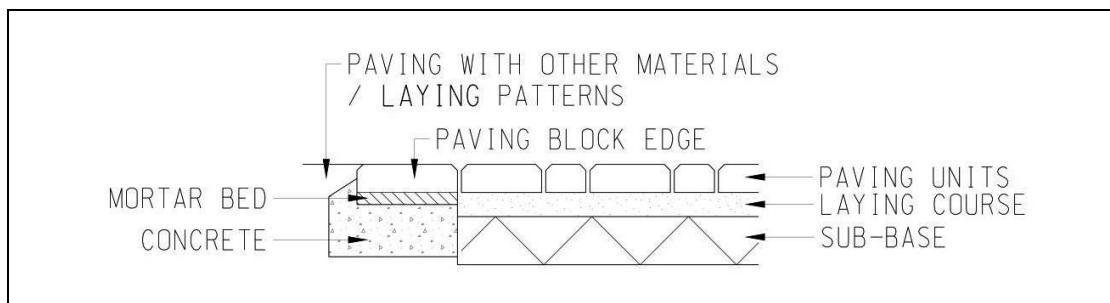


Figure 6.14 – Edge treatment for paving units against other paving materials or laying patterns

When designing a laying pattern for paving units to be laid on where tactile tiles to be installed at adjacent areas, considerations on providing good visual contrast between the paving units and tactile tiles as specified in the Highways Department Standard Drawing No. H5118 and causing discontinuity to the laying pattern should also be taken into account.

7 APPLICATIONS AND LIMITATIONS

Based on the experience gained from maintaining paving units locally and overseas, using paving units inappropriately would cause a number of defects, including dislocation and missing of paving units, and cracking and unevenness of pavement

surfaces. Common defects of paving units with possible causes and recommended remedies are described in the Highways Department Guidance Notes No. RD/GN/015. General guidance, in terms of applications and limitations, for good design and practice for laying paving units, are described in the following paragraphs.

7.1 Applications

Paving units are suitable for areas where aesthetic considerations are important and where there are ongoing settlement or uneven ground displacement, frequent disturbance by utility services and poor accessibility of conventional construction plants.

7.1.1 Aesthetics

The aesthetic benefits brought by using paving units are discussed in Section 4. Since paving units can offer different sizes, colours, textures and laying patterns, they can provide flexible design to blend in with the surroundings.

7.1.2 Ongoing Settlement or Uneven Ground Displacement

Reclaimed areas or fills are always subject to ongoing vertical or differential settlement which causes uneven pavement surfaces. The uneven pavement surfaces could be easily rectified by removing and replacing paving units after leveling and compacting the pavement substructure. The Port of Rotterdam in Holland which was built at a reclaimed area from the sea demonstrates satisfactory performances of using paving units on strengthened road-base and sub-base layers.

7.1.3 Frequent Disturbance by Utilities

Use of paving units on areas subject to frequent trench excavation is beneficial in that it could minimize noise and construction waste generation when comparing with concrete pavements. The considerable time required for setting and curing of concrete for trench reinstatement could also be saved. As paving units are reused, there is no noticeable colour or texture difference between reinstated areas and the adjacent original paving areas.

7.1.4 Poor Accessibility of Conventional Construction Plants

In remote areas such as outlying islands where access for conventional construction plants or application of normal construction materials is difficult, use of paving units is beneficial since only minimal basic construction equipment is required for skilled labour to lay paving units by hand.

7.2 Limitations

Paving units may not be suitable for use in some areas of footways, carriageways and industrial areas where they are easily susceptible to damage or require frequent maintenance.

7.2.1 Footways with Vulnerable Site Conditions

From past experience, the following site conditions may render the use of paving units not appropriate:

- (i) footways of steep gradients (say 8% or larger) or adjacent to slopes leading to possible washout of jointing sand or bedding materials during rainstorms;
- (ii) footways on embankments or at crest of filled slopes causing possible instability of embankments or slopes by infiltrated rainwater during heavy storms;
- (iii) footways with problems of underground seepage or subject to frequent ponding or pouring of water, such as wet food stalls in markets;
- (iv) footways with considerable numbers of utility pits or street furniture which pose difficulties in achieving proper laying of paving units and compaction of pavement substructure around the pits and street furniture;
- (v) footways likely to be stained by oil or fuel spillage, including petrol station forecourts, fronting of car repairing shops and markets, where use of paving units may lead to extra difficulty on cleansing;
- (vi) footways likely to be occupied by cooked-food stalls or hawkers, or where refuse collection points are situated; and
- (vii) footways likely to have weeding problems at areas with low pedestrian usage, for example, footways with high density of roadside planting at remote areas.

Notwithstanding the above, engineering judgment with appropriate measures could be applied to facilitate the use of paving units under some of the aforesaid site conditions.

For example, judgment could be made on authenticating suitability of laying paving units for a footway under site condition (i) or (ii) with the following measures provided:

- stabilization measures for jointing sand / bedding materials and preventing dislocation of paving units during rainstorms for site condition (i);
- provision of drainage layers under embankments or filter blankets under filled slopes to avoid building up pore water pressures during heavy storms to enhance stability for site condition (ii).

Judgment with appropriate measures could also be applied to cope with site condition (vii) since the weeding problems could be resolved by removal of weeds where its cost and effort would sometimes be outweighed by the benefits brought by using paving units as discussed in Section 7.1.

The Regional Offices of the Highways Department should be consulted before using paving units for these particular site conditions.

7.2.2 Carriageways

In general, paving units are confined to be used on vehicular run-ins and carriageways with operational speeds not exceeding and not anticipated to approach 50km/h, since a pavement constructed with paving units cannot offer an appropriate riding quality to vehicles travel at higher speeds. For road junction and locations with frequent stop and go, paving units are not recommended to be used at such locations as they are subject to easy dislocation. Paving units in form of paving slabs are not recommended to be used for vehicular passage due to their relatively low load bearing capacity. The Highways Department Standard Drawing Nos. H1103, H5125 to H5126, and H5133 to H5135 shall be referred to for laying paving units on vehicular run-ins and carriageways.

7.2.3 Industrial Areas

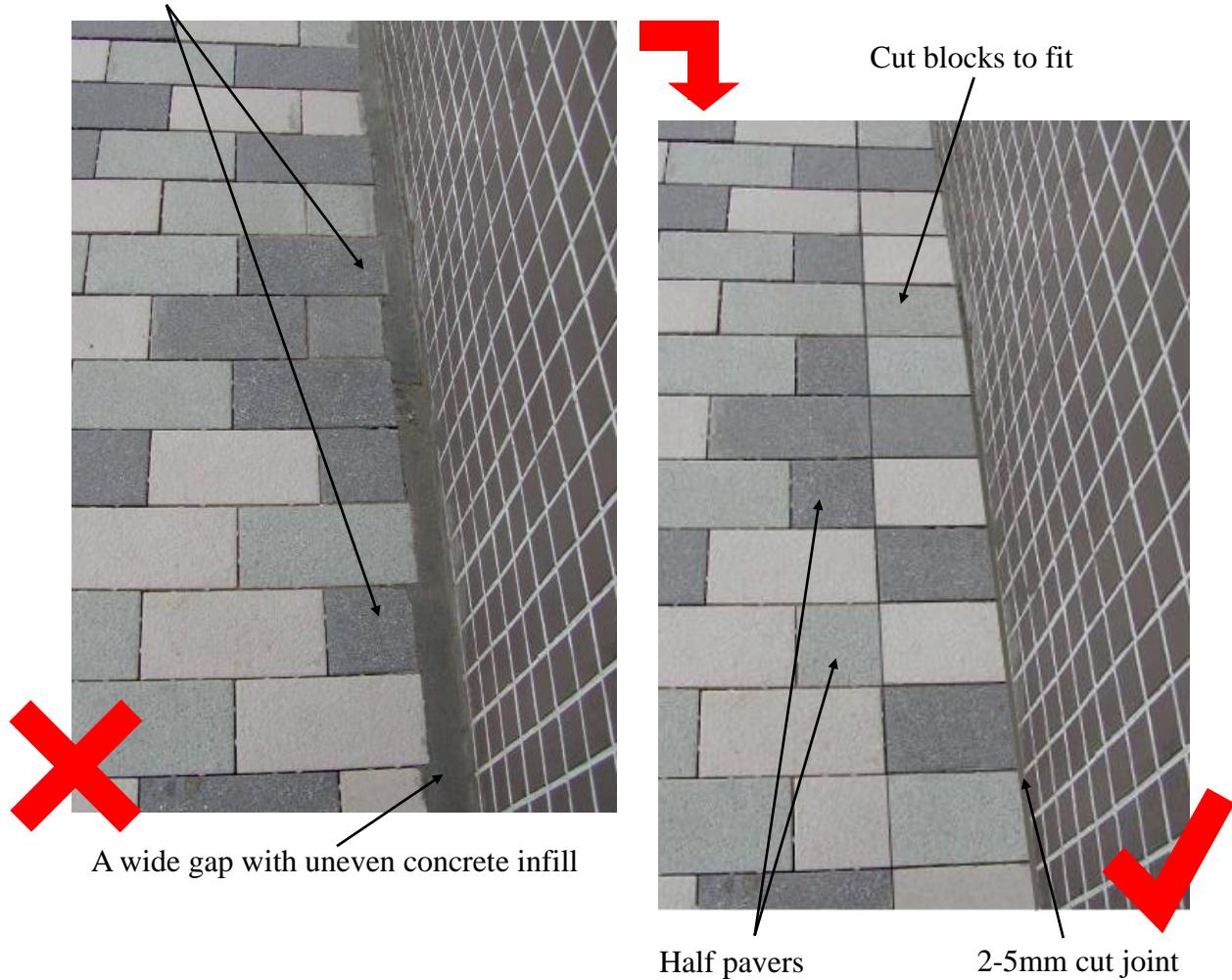
Carriageways and footways located within industrial areas, which are subject to frequent parking and loading / unloading activities, are not suitable for laying with paving units because the heavy loading from trucks would cause severe deformation and punching shear failures of the units.

8 GUIDELINES TO AUTHORIZED PERSONS

The “Practice Note for Authorized Persons, Registered Structural Engineers and Registered Geotechnical Engineers” APP-144 published by the Buildings Department requires the Authorized Persons to follow the requirements of the Highways Department for designing and constructing vehicular ingress and egress points on public footways. The requirements of the Highways Department include the guidance provided in this set of Guidance Notes, GS, standard drawings and particular specifications published by the Highways Department. This set of Guidance Notes and the standard drawings are available in the homepage of the Highways Department (https://www.hyd.gov.hk/en/technical_references/), and the particular specifications are enclosed in Appendix B. As the particular specifications would be updated from time to time, the Authorized Persons should consult the Regional Offices of the Highways Department before application.

Appendix A – Examples for End Details of Edge Restraints**Appendix A1 – Examples for Cutting at Kerb and Channel Edges and along Building Lines**

Irregular alignment of cutting



Appendix A1 – Examples for Cutting at Kerb and Channel Edges and along Building Lines (Cont'd)

Unsightly concrete infill



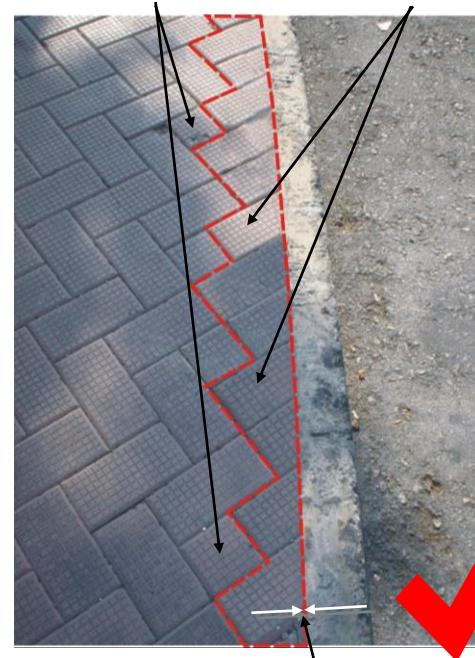
Half pavers



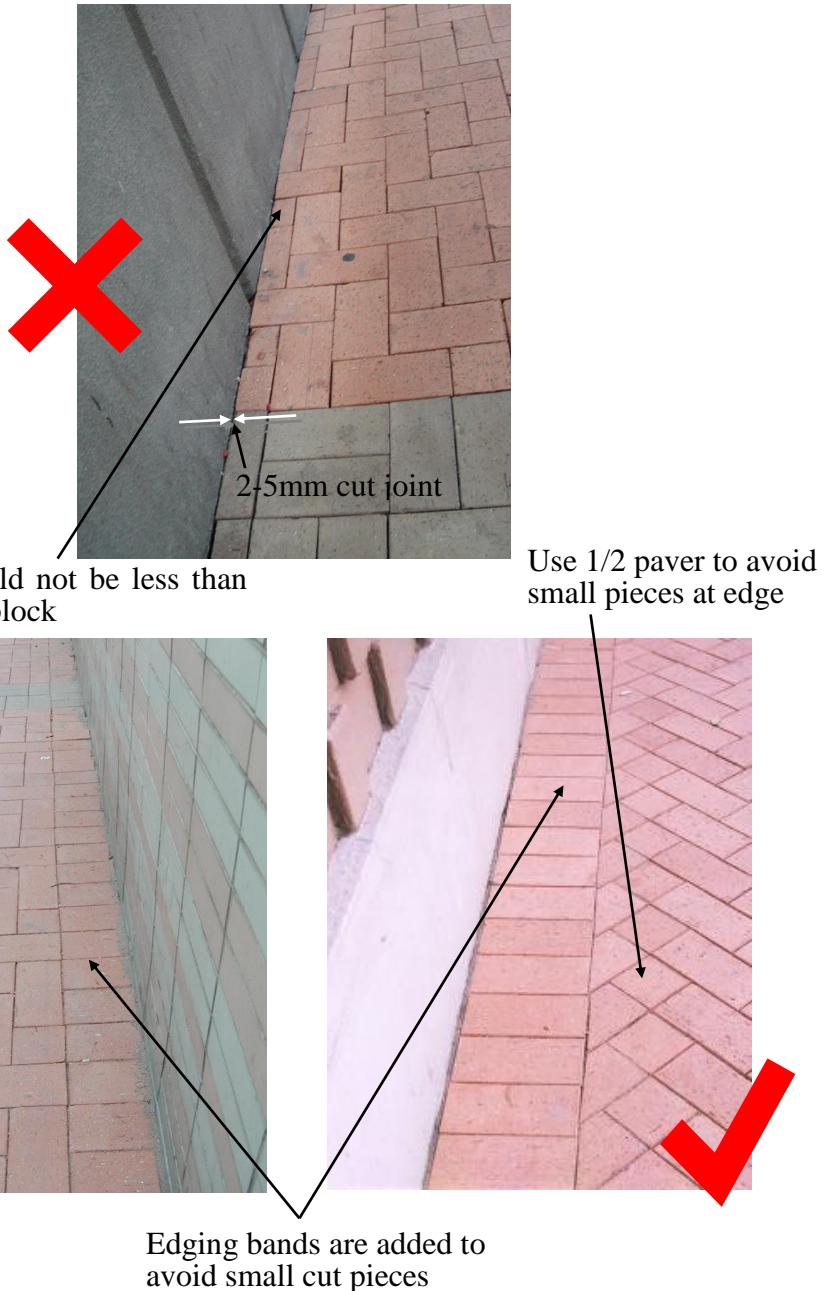
Untidy concrete infill due to irregular edge line of cut blocks



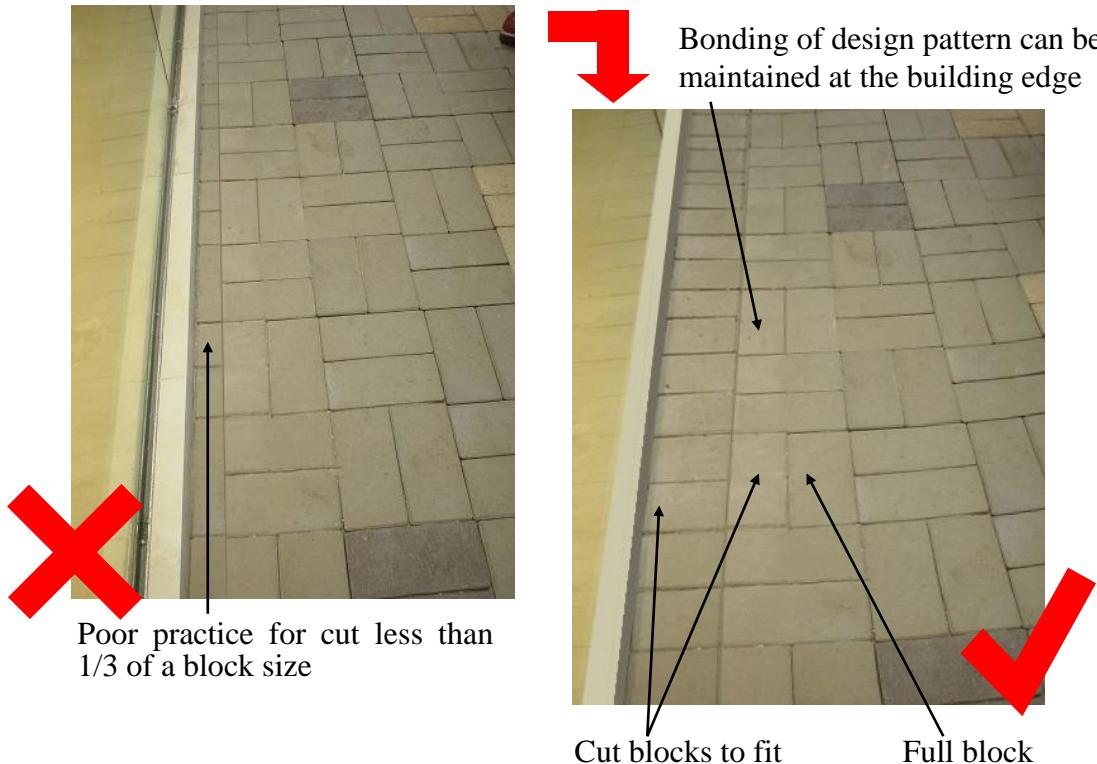
Half pavers Cut blocks to fit



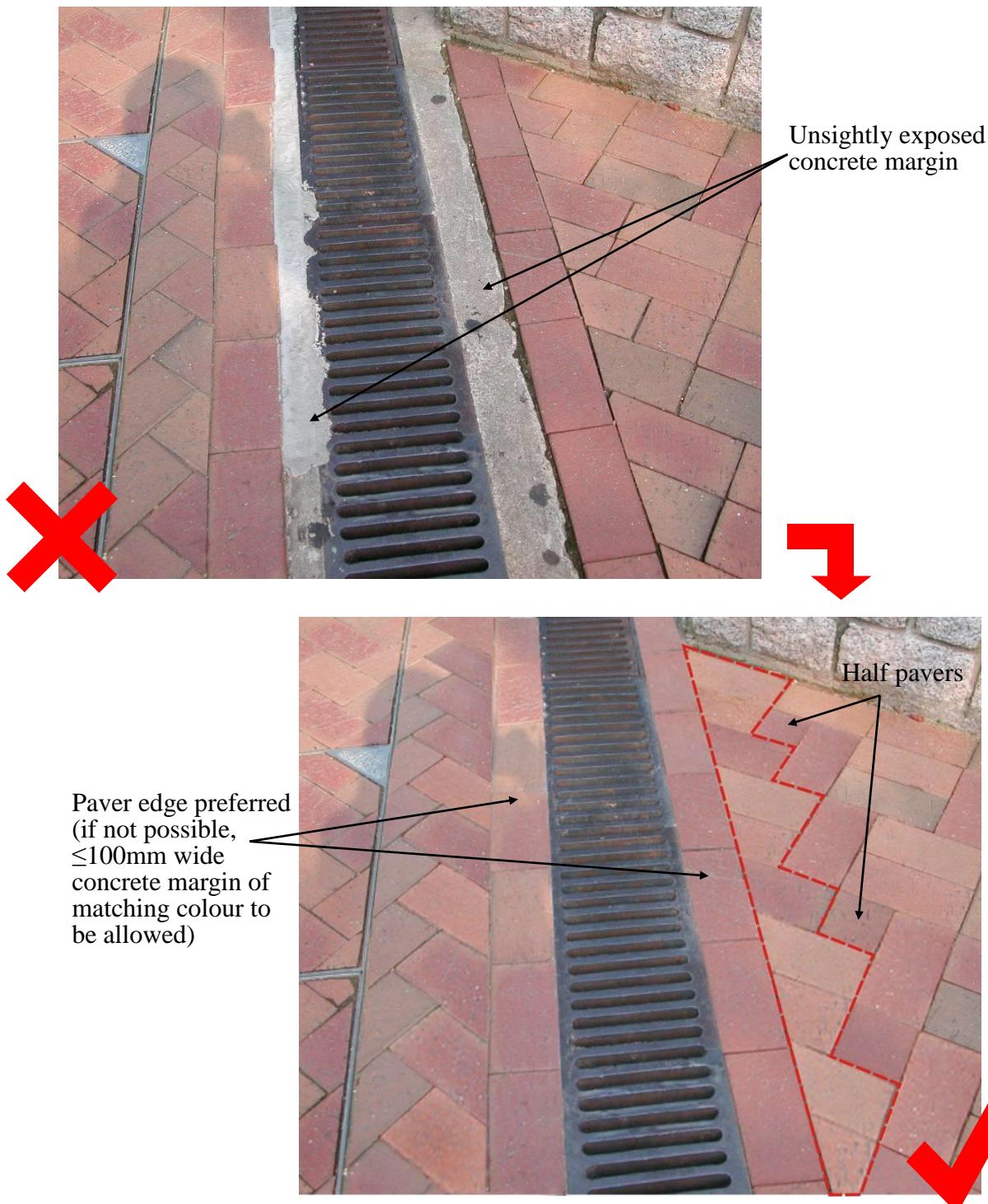
Appendix A1 – Examples for Cutting at Kerb and Channel Edges and along Building Lines (Cont'd)



Appendix A1 – Examples for Cutting at Kerb and Channel Edges and along Building Lines (Cont'd)



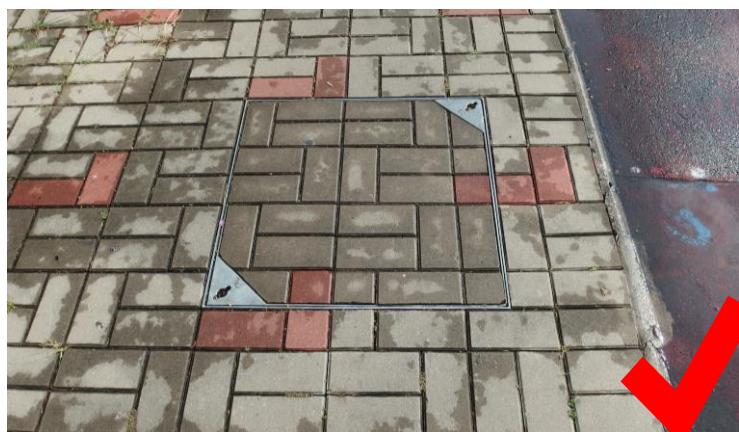
Appendix A1 – Examples for Cutting at Kerb and Channel Edges and along Building Lines (Cont'd)



Appendix A2 – Examples for Cutting around Manholes and Utility Pits



Prefer to adjust orientation of matching cover to align with laying pattern direction



Paving patterns and colours are maintained by using recess tray cover to become less noticeable. The metal surfaces of the recess tray cover should be located at two opposite corners of the cover to minimize slippery



Good alignment of laying pattern against an existing cover to be replaced with a matching cover to minimize cutting of paving units

Appendix A2 – Examples for Cutting around Manholes and Utility Pits (Cont'd)

Uncoordinated works in arranging matching covers. Excessive matching covers should be avoided



Misaligned manhole cover with excessive concrete margin

Matching cover should be arranged asap or to avoid having excessive concrete margin



Matching cover should be aligned with laying patterns to minimize cutting of paving units



Unmatched concrete margin

Cut blocks to fit

Laying patterns and colours should be maintained by using recess tray cover which is less noticeable

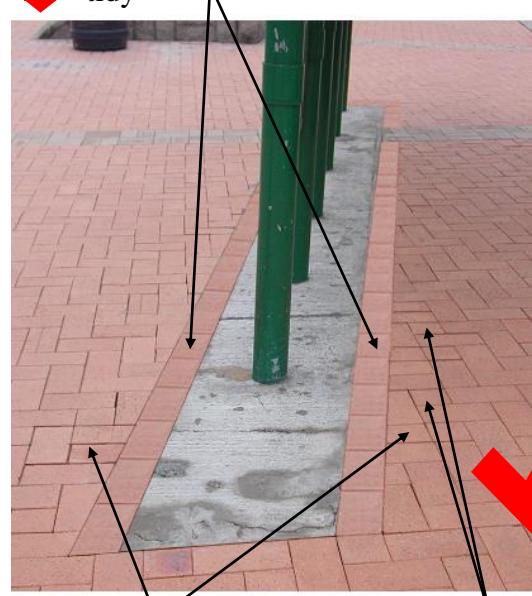


Appendix A3 – Examples for Cutting around Posts and Columns

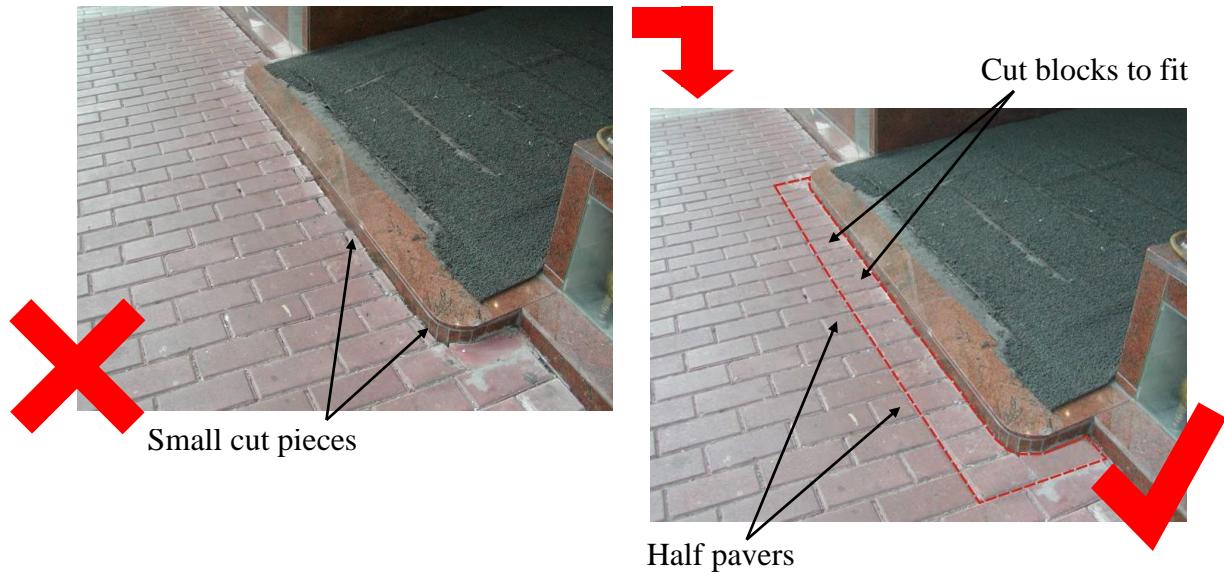
Untidy edge treatment around
footing of shelter



A row of full blocks on both
sides of footing to make it look
tidy



Appendix A4 – Examples for Cutting around Irregular Obstructions

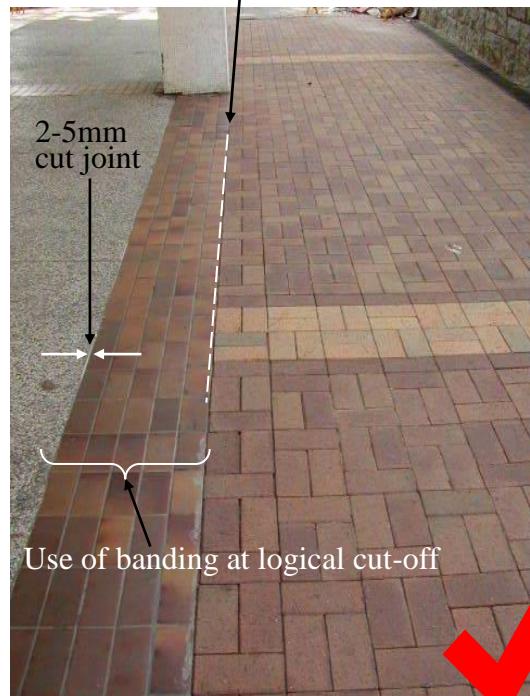


Appendix A5 – Examples for Interface with Other Paving Materials / Laying patterns

Use of banding at logical cut-off / change of materials



Setting out new paving directly abutting adjoining paving

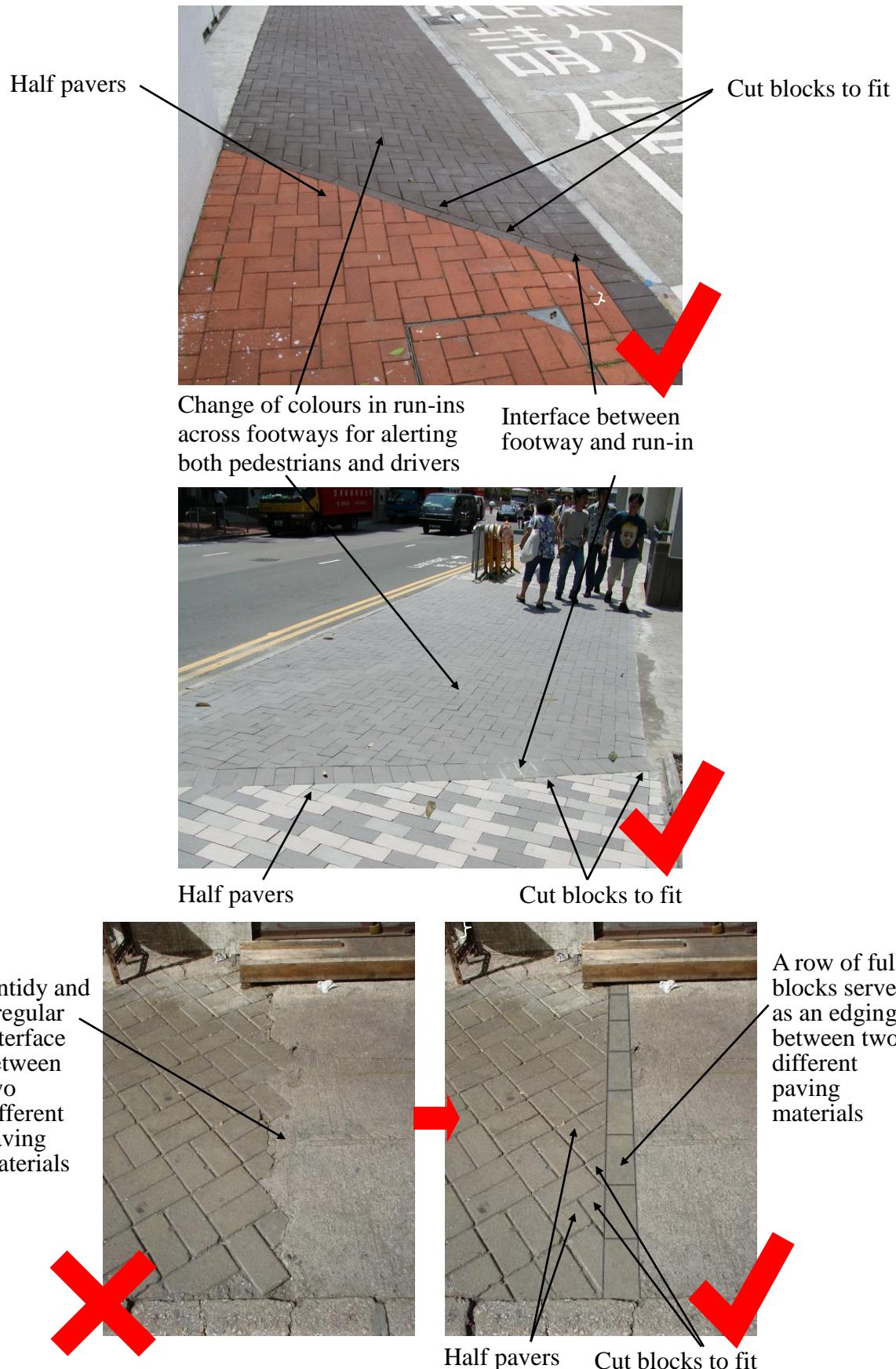


A dark brown band delineates ditch of stretcher bond on the left and footway of herringbone bond laying pattern on the right



Laying pattern changes after the feature band

Appendix A5 – Examples for Interface with Other Paving Materials / Laying patterns (Cont'd)



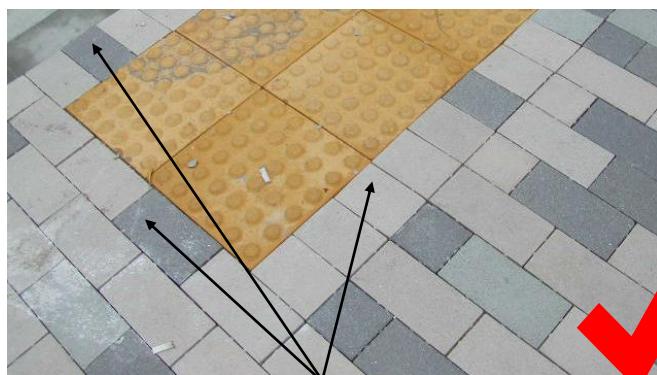
Appendix A5 – Examples for Interface with Other Paving Materials / Laying patterns (Cont'd)



Good visual contrast between dark color pavers and yellow tactile warning strip



Good visual contrast between pavers and tactile warning strip



Tidy paver edges are formed around a tactile warning strip

**Appendix B – Particular Specifications Published by the Highways Department
(2014 Edition)****Appendix B1 – General Requirements**

GS Clause 11.01 is renumbered as GS Clause 11.01.03 and the following sub-clauses are added before GS Clause 11.01.03:

11.01.01 GLOSSARY OF TERMS

Paver is a term used to described unit, clay paver, clay paving sett, artificial granite paver, natural granite paver, tactile paving block/slab/sett, tactile clay paver/paving sett, tactile artificial granite paving block/slab/sett, tactile natural granite paving block/slab/sett and tactile tile unless otherwise specified by the Engineer.

11.01.02 WORKERS ENGAGED IN LAYING PAVERS

- (1) Workers engaged in laying pavers shall have satisfactorily completed at least 14 hours of training in the past 3 years on laying of pavers conducted by the Construction Industry Council or other equivalent institution as approved by the Engineer.
- (2) In the event that such training courses are not readily available, the Contractor shall make their own arrangement with Construction Industry Council or other equivalent institutions as the case may be for the organisation of such courses.
- (3) The Contractor shall maintain the records of his workers who have attended the training courses pursuant to sub-clause (1) and produce the documentary proof of the training and identities of the trained workers for inspection upon request by the Engineer's site supervisory staff. If the Contractor fails to produce the evidence of such record for inspection, such worker shall be regarded as "helpers" and shall not be engaged in laying pavers.
- (4) In the event that the Contractor fails to comply with sub-clauses (1), (2) or (3), the Engineer shall determine the reduction of an amount in respect of any loss or damage suffered or likely to be suffered by the Employer or any saving in cost to the Contractor, whichever is the greater, as a result of such failure and deduct the same from the value of the work done as if the work has been executed in accordance with the Contract.

Appendix B2 – Precast Concrete Paving Units

Part 7 of Section 11 of the GS is supplemented by the following:

11.60 UNIT

Replace Item (2) of GS Clause 11.60 by the following:

- (2) Depending on their quality, units are classified as either Grade A or Grade B as follows:
 - Grade A units shall comply with GS Clauses 11.61 to 11.88.
 - Grade B units shall comply with GS Clauses 11.61 to 11.65, 11.67, 11.68, 11.70 and 11.72 to 11.85.

11.62 PRECAST CONCRETE PAVING SLABS

Replace Item (2) of GS Clause 11.62 by the following:

- (2) Paving slabs shall be 60 mm thick for footways and 80 mm thick for carriageways and vehicular accesses. Paving slabs of other thickness may be used if approved by the Engineer.

11.65 CONCRETE & USE OF RECYCLED AGGREGATES

Replace GS Clause 11.65 by the following:

- (1) Concrete for paving units in footways and cycle tracks shall be Grade 30; concrete for paving units in carriageways or areas to which vehicles will have access shall be Grade 45.
- (2) Aggregates for concrete shall comply with the following requirements:
 - (a) The aggregates shall contain not less than 70% by weight of recycled aggregates.
 - (b) The recycled fine aggregates shall constitute not less than 40% by weight of the total recycled aggregates. The recycled glass cullet shall be included as recycled fine aggregates and shall constitute 20% to 25% by weight of the total aggregates.
 - (c) The nominal maximum size of the aggregates shall be 10 mm.

- 11.65** (2) (d) The recycled coarse aggregates shall be retained on a 5 mm BS test sieve.
- (e) The recycled fine aggregates shall all pass a 5 mm BS test sieve.
- (f) The recycled glass cullet shall all pass a 3.35 mm BS test sieve and shall be integrated with other constituents in such a manner that there is no sharp edge nor burr exposed to put the pedestrians at risk when the paving unit surface is eroded.
- (g) The recycled aggregates shall contain not more than 0.5% of wood and other materials less dense than water by using the manual sorting test method in accordance with BRE Digest 433.
- (h) The recycled aggregates shall contain not more than 1% of other foreign materials (e.g. metals, plastics, clay lumps, asphalt and tar, glass, etc.) by using the manual sorting test method in accordance with BRE Digest 433.
- (i) The recycled aggregates, except recycled glass cullet, shall be recycled from inert construction and demolition materials sourced from the fill banks managed by the Civil Engineering and Development Department or other sources approved by the Engineer.
- (j) The recycled glass cullet shall be produced from glass waste generated from local sources approved by the Engineer.
- (3) Each paving unit shall bear an inscribed mark for the identification purpose that the unit contains recycled glass cullet of 20% to 25% by weight of the total aggregates.
- (4) Notwithstanding sub-clause (2) above,
- (a) the Contractor may propose for the Engineer's approval the use of recycled fine aggregates without recycled glass cullet in the concrete where there is a shortage of supply of recycled glass cullet; and/or

11.65 (4) (b) the Contractor may propose for the Engineer's approval the use of virgin aggregates in lieu of recycled aggregates in the concrete when there is a shortage of supply of recycled aggregates.

(5) Notwithstanding sub-clause (2) above, subject to the Engineer's agreement, the Contractor may use recycled fine aggregates without recycled glass cullet in the concrete for the minor repair works to existing concrete pavers.

11.66 ADDITIONAL REQUIREMENTS FOR GRADE A UNITS

Replace Item (2) of GS Clause 11.66 by the following:

(2) Colour Pigments for Grade A units shall comply with BS EN 12878:2005. They shall be UV-stable and shall be iron oxides, chrome oxide, titanium oxide or cobalt aluminium oxide unless otherwise approved by the Engineer.

11.68 PARTICULARS OF PAVING UNITS

Replace Item (1)(b) of GS Clause 11.68 by the following:

(1) (b) Certificates from the manufacturer showing the source and the particle size distribution of the virgin and recycled aggregates,

Add the following to the Item (1)(e) and (f) of GS Clause 11.68

(e) A statement of compliance from the manufacturer as follows showing that the manufacturer has put in place a system to assure that the paving units contain 20% to 25 % of recycled glass cullet by weight of the total aggregates:

- the statement of compliance shall be issued by an independent assessment body with recognized status (e.g. Hong Kong Productivity Council, Hong Kong Quality Assurance Agency, etc.) with a validity period of 6 months from the date of issue. The independent assessment body shall be approved by the Engineer.

11.68 (1) (f) Where the percentages of recycled aggregates, recycled fine aggregates and recycled glass as specified in PS Clauses 11.65(2) (a) and (b) cannot be fully complied with due to shortage in supply of the respective recycled materials in the market, the Contractor shall submit the following additional particulars to the Engineer:

- a written confirmation from the manufacturer confirming the shortage in supply of the respective recycled materials in the market; and
- the proposed quantities of paving units for which the recycled materials as specified in PS Clauses 11.65(2) (a) and (b) cannot be fully complied with.

11.69 PARTICULARS OF UNITS - ADDITIONAL REQUIREMENTS FOR GRADE A UNITS

Replace the 3rd and 4th Bullet Point of Item (1)(a) of GS Clause 11.69 by the

- Slip/skid resistance value of paving blocks and slabs to AS 4586:2013

Replace the 6th Bullet Point of Item (1)(a) of GS Clause 11.69 by the following:

- 24-hour cold water absorption value of paving slabs, blocks and setts to AS/NZS 4456.14:2003; and

11.74 LAYING UNITS

Add the following to GS Clause 11.74:

- (8) The units shall be laid to “Guidelines on Good Practice for Laying Unit Pavers” published by Highways Department.

- (9) Unless otherwise agreed by the Engineer, paving unit abutting traffic sign posts, traffic signal poles, lamp posts, or street name plate supports or the like shall be either prefabricated half-round units (where available) or cut in a circular manner to match with the diameter of the posts/poles and supports. The adjacent row/rows of paving units may need to be cut to match smoothly with the other paving units. Where such cutting will result in small units (any one dimension less than 1/3 of the original), at least two rows will need to be cut.
- (10) Where cutting of paving blocks is required at the edge of manholes or within recessed manhole covers for edge treatment, the size of the cut blocks shall not be less than 1/3 of the original size. If necessary, adjacent blocks shall also be cut to achieve the above requirement.

11.85 COMPRESSIVE STRENGTH TEST OF PAVING BLOCKS

Replace Item (1) of GS Clause 11.85 by the following:

- (1) One sample of units in a batch shall be provided from every 1000 m² of units or part thereof. A batch with units for area(s) less than 1000 m² may be added to the untested previous or following batch(es) as the case may be for testing purposes. The number of specimens in each sample shall be 8. For paving blocks of size 200 x 200 x 60mm or 80mm, specimens of size 200 x 100 x 60mm or 80mm shall be cut from these blocks in accordance with GS Clause 11.74 (6) to form samples.

11.87 ADDITIONAL TESTING FOR GRADE A UNITS : SLIP RESISTANCE OF PAVING SLABS AND BLOCKS

Replace Item (2), (3), (4) and (5) of GS Clause 11.87 by the following:

- (2) Each sample of paving slabs shall be tested to determine the slip resistance value by Wet Pendulum Test using slider 55 in accordance with AS 4586:2013.
- (3) Each sample of paving blocks shall be tested to determine the slip resistance value by Wet Pendulum Test using slider 55 in accordance with AS 4586:2013.

- (4) The sample shall have a slip resistance value not less than that required in the table below:

Gradient of Footways / Cycle Tracks	Minimum Slip Resistance Values Measured by Wet Pendulum Test Slider 55
$\leq 3\%$	45
$> 3\% \text{ and } \leq 7\%$	50
$> 7\% \text{ and } \leq 12\%$	55
$> 12\%$	60

11.88 ADDITIONAL TESTING FOR GRADE A UNITS : WATER ABSORPTION VALUE OF PAVING SLABS AND BLOCKS

Replace Item (2), (3) and (4) of GS Clause 11.88 by the following:

- (2) Each sample of paving slabs and blocks shall be tested to determine the 24-hour cold water absorption value to AS/NZS 4456.14: 2003.
- (3) The sample shall have a characteristic water absorption value not more than 6% by 24-hour cold immersion method to AS/NZS 4456.14: 2003.
- (4) The characteristic water absorption value (W_c) shall be calculated from the following equation:

$$W_c = W_m + 1.65 X_s \%$$

where:

- W_m is the average water absorption rate of the sample
- X_s is the unbiased standard deviation as stated in AS/NZS 4456.2: 2003.

Appendix B3 – Granite Paving Units

1. MATERIALS

- (a) 'Granite' referred to in this Appendix N to the PS shall mean natural granite unless otherwise specified.
- (b) Granite paving setts and blocks shall be of size 100 mm x 100 mm and 200 mm x 100 mm respectively as specified by the Engineer. Granite paving slabs shall be of size 200 mm x 200 mm, 200 mm x 300 mm, 300 mm x 300 mm, 300 mm x 400 mm, 300 mm x 600 mm, 400 mm x 400 mm, 400 mm x 600 mm or 500 mm x 500 mm as specified by the Engineer. The thickness of granite pavers shall be as specified by the Engineer.
- (c) Granite paving setts, blocks or slabs (collectively referred to "granite pavers" hereafter) shall be machine cut at 5 sides with a textured upper face unless otherwise stated in drawing. They shall be consistent in colour and finish, and shall be free from defects that will adversely affect strength or appearance.
- (d) Unless with prior approval of the Engineer, granite pavers shall not be used in carriageways, run-ins and other paved areas to which vehicles will have access.
- (e) Surface finish/textured of granite pavers shall be as specified on drawing or approved by the Engineer. Unless otherwise directed by the Engineer, the finish/textured to the upper face shall be:
 - (i) coarse textured upper face by hand (brush hammer, "Laichee", "Longan" etc.);
 - (ii) coarse textured upper face by machine (flamed, dolly pointed, tooled/routed, fine brush hammer and shot blasted etc.); or
 - (iii) fine textured upper face by machine (polished, honed or diamond sawn cut etc.);all as specified by the Engineer.
- (f) No granite pavers shall be supplied by quarries or fabricated in factories where excessive variety is expected or which deviated from the selected stone or dimensions.
- (g) Slabs for granite tree surrounds shall be in quadrant with machine cut sides and coarse textured upper face with 12 nos. drilled holes in 20 mm diameter to fit 1200 mm x 1200 mm or 1500 mm x 1500 mm tree pit with 600 mm diameter opening in the centre, colour to match pavement or as specified by the Engineer.
- (h) Machine cut granite kerbs shall be machine cut on all sides except the bottom. The colour, finish and texture of machine cut granite kerbs shall be as specified by the Engineer.
- (i) Granite stone grating cover shall have machine sawn cut sides, textured upper face with machine drilled drain holes in 20 mm or 25 mm diameter, of light or medium hue and fine/medium grain size stone. Granite stone grating cover shall conform to BS EN 124: 1994.

- (j) Colour and grain size of granite pavers shall be as specified on drawing or as approved by the Engineer.
- (k) Bedding sands and jointing sands shall be in accordance with BS 7533: Part 3:1997 or as specified by the Engineer.
- (l) All pavers shall have 2-5 mm edge chamfers unless otherwise stated in drawing or as instructed by the Engineer. Granite kerb shall be chamfered as standard drgs. H 1118 and H 1119 unless otherwise stated in drawing or as instructed.

2. SUBMISSIONS

- (a) The following particulars of the proposed materials and methods of construction for granite pavers shall be submitted to the Engineer:
 - (i) Name and address of manufacturer;
 - (ii) For granite paving slabs and blocks, a certificate from the manufacturer showing the manufacturer's name, the petrographical description of the stone, the name and the location of the quarry and test results for:
 - dimensional deviations to BS EN 1341: 2001;
 - flexural strengths of paving slabs to BS EN 1341: 2001 for specimens at different thickness of 40 mm, 50 mm, 60 mm, 70 mm and 80mm;
 - transverse breaking loads of paving blocks to BS EN 1344: 2002 for specimens at different thickness of 40 mm, 50 mm, 60 mm, 70 mm and 80 mm;
 - slip/skid resistance to BS EN 1341: 2001 or BS EN 1344: 2002;
 - 24-hour cold water absorption rate to AS/NZS 4456.14:2003.
 - (iii) For granite paving sets, a certificate from the manufacturer showing the manufacturer's name, the petrographical description of the stone, the name and the location of the quarry and test results for:
 - dimensional deviations to BS EN 1342: 2001;
 - slip/skid resistance to BS EN 1342: 2001;
 - 24-hour cold water absorption rate to AS/NZS 4456.14:2003.
 - (iv) Paving setting plans with method statements and shop drawings for the Works.
- (b) In the submission, the manufacturer/supplier shall also declare if the product has been subjected to a chemical surface treatment and the type of treatment.
- (c) The submission shall be made to the Engineer for approval of the source and type of granite pavers and for approval of the paving setting plans at least 14 days before laying of the pavers starts.
- (d) The Contractor shall supply sufficient reference samples each of at least 0.01m² in plan area indicating the appearance regarding colour, variation in colour, vein pattern, texture and other general characteristics.

- (e) Following acceptance of the approved granite samples and test results, the Contractor shall ensure that the granite is consistent in appearance regarding colour, variation in colour, vein pattern, texture and other general characteristics throughout the Works. If directed by the Engineer, the Contractor shall submit test specimens each of at least 0.01m² in plan area and of at least 50 mm thick for visual inspection against the reference sample(s) in accordance with BS EN 1341: 2001 or BS EN 1342: 2001. The number of test specimens shall be at least 5 for every 100m² paving area. All test specimens shall not display significant difference in appearance regarding colour and texture from the reference sample(s) when inspected in accordance with BS EN 1341: 2001 or BS EN 1342: 2001. The test specimens can be used for the subsequent compliance tests.

3. MOCK-UP PANEL

- (a) If directed by the Engineer, the Contractor shall construct a mock-up panel in a sufficient size to the satisfaction of the Engineer which will be a benchmark for both the aesthetics of the material and also the standards of laying.
- (b) Preferably the mock-up panel shall be constructed within the Site unless it is considered impractical by the Engineer due to site constraints or other site problems. A mock-up panel constructed within the Site shall form part of the Works if both the materials and workmanship are up to the satisfaction of the Engineer.
- (c) The cost of a mock-up panel constructed outside the Site, including the construction and demolition, shall be deemed to be included in the contract rates.

4. MARKING, LABELLING AND PACKAGING

- (a) Granite pavers and kerbs shall be packed in a manner to avoid damage in transit, and any metal banding used shall be corrosion resistant. Information on the packaging shall comply with BS EN 1341: 2001 & BS EN 1342: 2001.

5. HANDLING AND STORING

- (a) All granite material shall be carefully handled and stored on timbers to avoid damage to corners and chamfers. Damaged or defective units shall be rejected.
- (b) Sand for filling joints between granite pavers shall be stored in waterproof bags and shall be kept under cover until used.

6. CUTTING AND SHAPING

- (a) Cuts shall be made with a portable water cooled sliding bed bench saw or similar approved machinery to provide a 90 degree machine cut through the entire thickness of the paver.
- (b) Cuts necessary to be made on site shall be clean and true with protrusions no greater than 2 mm. Cuts shall be accurate to form a parallel line 2 mm of the adjacent paver or object. Any gap greater than 2 mm shall be rejected.
- (c) Wherever necessary, all other complex cuts requiring expert attention shall be made off site with dimensioned drawings or a template produced on site, referenced and delivered to the manufacturer for accurate factory cutting. Examples include circular cuts around fixtures and lights poles. Any cuts that do not conform to the specified requirements shall be rejected.
- (d) All cuts shall be finished with the chamfer reinstated to marry in with adjacent granite paving. Irregular or dissimilar chamfers shall be rejected and replaced at the Contractor's expense.

7. LAYING

- (a) The granite paving blocks/setts and slabs shall be laid to BS 7533: Part 3: 1997 and BS 7533: Part 4: 1998 respectively. All Pavers shall also be laid to "Guidelines on Good Practice for Laying Unit Pavers" published by Highways Department or as instructed by the Engineer.
- (b) Paving layout shall be carefully planned in advance to minimise the number of cuts. Particular attention shall be paid to accuracy of line. The pattern of laying and position of pavers shall be as shown in the Drawings. Paving lines shall be achieved with the use of string lines and a deviation of no more than 3 mm as measured with a 3 m straight edge shall be achieved.
- (c) Where unforeseen subsurface impediments do not allow the specified paving bedding method, the Contractor may be required to adjust materials and methods to suit. The Contractor shall inform the Engineer of changes to bedding methods for approval.
- (d) Levels and falls shall be established by the existing finished floor levels. Falls and levels shall be even, continuous, and free from depressions, humps and abrupt changes in level.

- (e) Wherever necessary, and especially along the edges of paving areas, tree grilles, manholes, drainage channel and light poles, the Contractor shall haunch the paving block into position with a 3:1 sand/cement mortar. Haunched pavers shall be laid to final falls and levels. Adjacent pavers laid on a dry sand/cement bed shall be laid to the final falls and levels plus 2 mm to allow for eventual settlement.
- (f) The Contractor shall ensure all necessary cuts have been made prior to uplifting all pavers to be haunched and shall remove sand/cement bedding under 150 mm edge of paver and replace with 50 mm layer of 3:1 sand cement mortar to final falls and levels.
- (g) The Contractor shall exercise caution around haunched pavers and especially during final machine compaction. Any pavers that have become dislodged or do not conform to specified falls and levels shall be lifted and reinstated.
- (h) Dry jointing sand shall be swept into joints prior to machine compaction.
- (i) Machine compaction shall be undertaken in such a way so as to ensure that pavers are not scratched, broken or become dislodged during compaction. This shall be achieved with a non-scratch material attached to the underside of the plate compactor and avoidance of haunched pavers with plate compactor.

8. TOLERANCES

- (a) The level of paved areas constructed using granite pavers shall be within 3 mm of the specified level. The difference in level of adjacent granite pavers shall not exceed 2 mm.

9. TESTING: GENERAL

- (a) A batch of granite pavers shall be any quantity of granite pavers of the same type, size, colour and finish, by the same manufacturer, from the same quarry, covered by the same certificates and delivered to the Site at any one time.
- (b) Sampling shall be carried out at random. The sample should comprise units that are distributed throughout the batch. The Contractor shall prepare specimens of the samples in accordance with relevant standards of testing as specified in the GS and this PS.

- (c) Unless otherwise directed by the Engineer, for minor works involving the use of granite pavers of any type for a total area(s) not greater than 100 m² under a Works Order, all testing requirements described in this Appendix will be waived.

10. TESTING: DIMENSIONAL DEVIATION

- (a) One sample of each type and size of granite pavers in a batch shall be provided from every 10,000 pieces of granite pavers or part thereof. A batch of granite pavers less than 10,000 pieces may be added to the previous batch(es) or the following batch(es) as the case may be for testing purposes. The number of specimens in each sample shall be 8. The sample can be used for the subsequent tests.
- (b) The dimensions of each sample of paving slabs and blocks shall be measured in accordance with BS EN 1341: 2001. The dimensions of each sample of paving setts shall be measured in accordance with BS EN 1342: 2001.
- (c) The tolerances for the dimensions of each individual granite paving slabs and blocks shall be:
- (i) within ± 2 mm for both length and width not more than 300 mm, and within ± 4 mm for both length and width more than 300 mm; and
 - (ii) within ± 3 mm for thickness not more than 60 mm, and ± 4 mm for thickness more than 60 mm.
- (d) The tolerance for the difference in diagonals of each individual granite paving slabs shall be 3 mm for diagonals less than 700 mm, and 6 mm for diagonals not less than 700 mm.
- (e) The tolerances for the dimensions of each individual granite paving setts shall be within ± 5 mm for length, width and thickness.

11. TESTING: SLIP/SKID RESISTANCE

- (a) One sample of each type and size of granite pavers in a batch shall be provided from every 10,000 pieces of granite pavers or part thereof. A batch of granite pavers less than 10,000 pieces may be added to the previous batch(es) or the following batch(es) as the case may be for testing purposes. The number of specimens in each sample shall be 5. The sample can be used for the subsequent tests.
- (b) Each sample of granite paving slabs and blocks shall be tested to determine the slip/skid resistance to BS EN 1344: 2002.

- (c) The mean slip/skid resistance of a sample shall not be less than:
 - (i) 45 Skid Resistance Value for granite paving slabs, blocks and setts in footways and cycle tracks, and
 - (ii) 60 Skid Resistance Value for granite blocks and setts in carriageways, run-ins and other paved areas to which vehicles will have access.
- (d) Notwithstanding the above (c), if considered appropriate by the Engineer for application on steep roads or other difficult site conditions, the required slip/skid resistance of granite paving slabs, blocks and setts in footways and cycle tracks may be increased up to 60 Skid Resistance Value and the required slip/skid resistance of granite blocks and setts in carriageways, run-ins and other paved areas to which vehicles will have access may be increased up to 65 Skid Resistance Value.

12. TESTING: WATER ABSORPTION VALUE

- (a) One sample of each type and size of granite pavers in a batch shall be provided from every 10,000 pieces of granite pavers or part thereof. A batch of granite pavers less than 10,000 pieces may be added to the previous batch(es) or the following batch(es) as the case may be for testing purposes. The number of specimens in each sample shall be 6. The sample can be used for the subsequent tests.
- (b) Each sample shall be tested to determine either the 24-hour cold water absorption value to AS/NZS 4456.14:2003.
- (c) Unless otherwise directed by the Engineer, the sample shall have a characteristic cold water absorption value not more than 1%.
- (d) The characteristic cold water absorption value (W_c) shall be calculated from the following equation:

$$W_c = W_m + 1.65 X_s \%$$

where W_m is the average cold water absorption rate of the sample

X_s is the unbiased standard deviation as stated in AS/NZS 4456.2:2003.

13. TESTING: FLEXURAL STRENGTHS AND BREAKING LOADS OF GRANITE PAVING SLABS

- (a) One sample of each type and size of granite pavers in a batch shall be provided from every 10,000 pieces of granite pavers or part thereof. A batch of granite pavers less than 10,000 pieces may be added to the previous batch(es) or the following batch(es) as the case may be for testing purposes. The number of specimens in each sample shall be 10.

- (b) Each specimen shall be tested to determine the flexural strength (Rtf) to BS EN 1341: 2001.

- (c) The characteristic flexural strength (Rtf_c) of a sample shall be calculated from the following equation:

$$Rtf_c = Rtf_m - 1.65 X_s \text{ MPa}$$

where Rtf_m = average flexural strength of the sample

$$X_s = \text{unbiased standard deviation} = \sqrt{\{(\sum Rtf^2 - 10Rtf_m^2)/9\}} \text{ MPa}$$

- (d) The breaking load shall be calculated from the characteristic flexural strength in accordance with Annex B of BS EN 1341: 2001. The breaking load shall not be less than the required breaking load of the appropriate class as specified in Table B.1 of BS EN 1341: 2001. The appropriate class should be determined by the Engineer based on the use of the pavement.

14. TESTING: TRANSVERSE BREAKING LOADS OF GRANITE PAVING BLOCKS

- (a) One sample of each type and size of granite pavers in a batch shall be provided from every 10,000 pieces of granite pavers or part thereof. A batch of granite pavers less than 10,000 pieces may be added to the previous batch(es) or the following batch(es) as the case may be for testing purposes. The number of specimens in each sample shall be 10.

- (b) Each sample of granite paving blocks shall be tested to determine the transverse breaking load to BS EN 1344: 2002.

- (c) The characteristic transverse breaking load (P_c) of a sample shall be calculated from the following equation:

$$P_c = P_m - 1.65 X_s \text{ kN}$$

where P_m = average transverse breaking load of the sample

$$X_s = \text{unbiased standard deviation} = \sqrt{\{(\sum P^2 - 10 P_m^2)/9\}} \text{ kN}$$

- (d) The characteristic transverse breaking load of a sample shall not be less than:

- (i) 4.8 kN for granite paving blocks in footways and cycle tracks, or granite paving blocks of Class 3 to Annex B of BS EN 1341: 2001; and

- (ii) 11.5 kN for granite paving blocks in carriageways, run-ins and other paved areas to which vehicles will have access, or granite paving blocks of Class 6 to Annex B of BS EN 1341: 2001.

Appendix B4 – Artificial Granite Paving Units

1. MATERIALS

- (a) Artificial granite paving slabs, blocks and setts (collectively referred to “artificial granite pavers” hereafter) are made of pulverized natural granite, feldspar, silica, clay, recycled glass and pigments etc., which are mechanically hard pressed to a high pressure and then subject to firing at a high temperature. The raw materials used for manufacturing artificial granite pavers shall be at the manufacturer’s discretion. Artificial granite pavers shall comply with this Appendix.
- (b) Unless with prior approval of the Engineer, artificial granite pavers shall not be used in carriageways, run-ins and other paved areas to which vehicles will have access.
- (c) Artificial granite paving setts and blocks shall be of size 100 mm x 100 mm or 200 mm x 100 mm respectively as specified by the Engineer. Artificial granite paving slabs shall be of size 200 mm x 200 mm, 200 mm x 300 mm and 300 mm x 300 mm as specified by the Engineer. The thickness of artificial granite pavers shall be as specified by the Engineer.
- (d) Artificial granite pavers shall be machine cut at 5 sides with a textured upper face unless otherwise stated in drawing. Surface finish/textured of artificial granite pavers shall be as specified on drawing or approved by the Engineer. Artificial granite pavers shall be consistent in colour and finish, and shall be free from defects that will adversely affect strength or appearance.
- (e) Bedding sands and jointing sands shall be in accordance with BS 7533: Part 3:1997 or as specified by the Engineer.
- (f) Unless otherwise stated in drawing or as instructed by the Engineer, artificial granite pavers shall have 2-5 mm edge chamfers or 2-5mm rounded edges.

2. SUBMISSIONS

- (a) The following particulars of the proposed materials and methods of construction for artificial granite pavers shall be submitted to the Engineer:
 - (i) Name and address of manufacturer;
 - (ii) A brochure describing the raw materials used and the manufacture process;

- (iii) For artificial granite paving slabs, a certificate from the manufacturer showing the manufacturer's name, place of manufacture and test results for:
 - dimensional deviations to BS EN 1341: 2001;
 - bending strengths to BS 7263-1: 2001;
 - slip/skid resistance to BS EN 1341: 2001 or BS EN 1344: 2002;
 - 24-hour cold water absorption rate to AS/NZS 4456.14:2003.
 - (iv) For artificial granite paving blocks, a certificate from the manufacturer showing the manufacturer's name, place of manufacture and test results for:
 - dimensional deviations to BS 6717: 2001
 - transverse breaking loads to BS EN 1344: 2002;
 - slip/skid resistance to BS EN 1341: 2001 or BS EN 1344: 2002;
 - 24-hour cold water absorption rate to AS/NZS 4456.14:2003.
 - (v) For artificial granite paving setts, a certificate from the manufacturer showing the manufacturer's name, place of manufacture and test results for:
 - dimensional deviations to BS 6717: 2001;
 - slip/skid resistance to BS EN 1342: 2001;
 - 24-hour cold or 5-hour boiling water absorption rate to AS/NZS 4456.14:2003.
 - (vi) Paving setting plans with method statements and shop drawings for the Works.
- (b) The submission shall be made to the Engineer for approval of the source and type of artificial granite pavers and for approval of the paving setting plans at least 14 days before laying of the pavers starts.
- (c) The Contractor shall supply sufficient reference samples of actual sizes indicating the appearance regarding colour, variation in colour, texture and other general characteristics.

3. MOCK-UP PANEL

- (a) If directed by the Engineer, the Contractor shall construct a mock-up panel in a sufficient size to the satisfaction of the Engineer which will be a benchmark for both the aesthetics of the material and also the standards of laying.
- (b) Preferably the mock-up panel shall be constructed within the Site unless it is considered impractical by the Engineer due to site constraints or other site problems. A mock-up panel constructed within the Site shall form part of the Works if both the materials and workmanship are up to the satisfaction of the Engineer.
- (c) The cost of a mock-up panel constructed outside the Site, including the construction and demolition, shall be deemed to be included in the contract rates.

4. HANDLING AND STORING

- (a) All artificial granite material shall be carefully handled and stored on timbers to avoid damage to corners and chamfers. Damaged or defective units shall be rejected.

- (b) Sand for filling joints between artificial granite pavers shall be stored in waterproof bags and shall be kept under cover until used.

5. LAYING

- (a) The artificial granite paving blocks/setts and slabs shall be laid to BS 7533: Part 3: 1997 and BS 7533: Part 4: 1998 respectively. All pavers shall also be laid to “Guidelines on Good Practice for Laying Unit Pavers” published by Highways Department or as instructed by the Engineer.
- (b) Artificial granite pavers shall be laid to any design or pattern specified by the Engineer. The design or pattern may involve a single colour or a combination of different colours.

6. TOLERANCES

- (a) The level of paved areas constructed using artificial granite pavers shall be within 3 mm of the specified level. The difference in level of adjacent artificial granite pavers shall not exceed 2 mm.

7. TESTING: GENERAL

- (a) A batch of artificial granite pavers shall be any quantity of artificial granite pavers of the same type, size, colour and finish, manufactured in the same place, covered by the same certificates and delivered to the Site at any one time.
- (b) Sampling shall be carried out at random. The sample shall comprise units that are distributed throughout the batch. The Contractor shall prepare specimens of the samples in accordance with relevant standards of testing as specified in the GS and this PS.
- (c) Unless otherwise directed by the Engineer, for minor works involving the use of artificial granite pavers of any type for a total area(s) not greater than 100 m² under a Works Order, all testing requirements described in this Section will be waived.

8. TESTING: DIMENSIONAL DEVIATION

- (a) One sample of each type, size and colour of artificial granite pavers in a batch shall be provided from every 10,000 pieces of such pavers or part thereof. A batch of artificial granite pavers less than 10,000 pieces may be added to the previous batch(es) or the following batch(es) as the case may be for testing purposes. The number of specimens in each sample shall be 8. The sample can be used for the subsequent tests.
- (b) The dimensions of each sample of paving slabs shall be measured in accordance with BS EN 1341: 2001. The dimensions of each sample of paving blocks and setts shall be measured in accordance with BS 6717: 2001.
- (c) The tolerances for the dimensions of each individual artificial granite pavers shall be:
- (i) within ±2 mm for both length and width; and
 - (ii) within ±3 mm for thickness.

9. TESTING: SLIP/SKID RESISTANCE

- (a) One sample of each type, size and colour of artificial granite pavers in a batch shall be provided from every 10,000 pieces of such pavers or part thereof. A batch of artificial granite pavers less than 10,000 pieces may be added to the previous batch(es) or the following batch(es) as the case may be for testing purposes. The number of specimens in each sample shall be 5. The sample can be used for the subsequent tests.
- (b) Each sample of artificial granite paving slabs and blocks shall be tested to determine the slip/skid resistance to BS EN 1344: 2002.
- (c) The mean slip/skid resistance of a sample shall not be less than:
 - (i) 45 Skid Resistance Value for artificial granite paving slabs, blocks and setts in footways and cycle tracks, and
 - (ii) 60 Skid Resistance Value for artificial granite blocks and setts in carriageways, run-ins and other paved areas to which vehicles will have access.
- (d) Notwithstanding the sub-clause (c) above, if considered appropriate by the Engineer for application on steep roads or other difficult site conditions, the required slip/skid resistance of artificial granite paving slabs, blocks and setts in footways and cycle tracks may be increased up to 60 Skid Resistance Value and the required slip/skid resistance of artificial granite blocks and setts in carriageways, run-ins and other paved areas to which vehicles will have access may be increased up to 65 Skid Resistance Value.

10. TESTING: WATER ABSORPTION VALUE

- (a) One sample of each type, size and colour of artificial granite pavers in a batch shall be provided from every 10,000 pieces of such pavers or part thereof. A batch of artificial granite pavers less than 10,000 pieces may be added to the previous batch(es) or the following batch(es) as the case may be for testing purposes. The number of specimens in each sample shall be 6. The sample can be used for the subsequent tests.
- (b) Each sample shall be tested to determine the 24-hour cold water absorption value to AS/NZS 4456.14:2003.
- (c) The sample shall have a characteristic cold water absorption value not more than 1%.
- (d) The characteristic cold water absorption value (W_c) shall be calculated from the following equation:

$$W_c = W_m + 1.65 X_s \%$$

where W_m is the average cold water absorption rate of the sample

X_s is the unbiased standard deviation as stated in AS/NZS 4456.2:2003.

11. TESTING: BENDING STRENGTHS AND BREAKING LOADS OF ARTIFICIAL GRANITE PAVING SLABS

- (a) One sample of each type, size and colour of artificial granite pavers in a batch shall be provided from every 10,000 pieces of such pavers or part thereof. A batch of artificial granite pavers less than 10,000 pieces may be added to the previous batch(es) or the following batch(es) as the case may be for testing purposes. The number of specimens in each sample shall be 6.
- (b) Each specimen shall be tested to determine the bending strength (Rtf) to BS 7263-1: 2001.
- (c) The characteristic bending strength (Rtf_c) of a sample shall be calculated from the following equation:

$$Rtf_c = Rtf_m - 1.65 X_s \text{ MPa}$$

where Rtf_m = average bending strength of the sample

$$X_s = \text{unbiased standard deviation} = \sqrt{(\sum Rtf^2 - 6 Rtf_m^2)/5} \text{ MPa}$$

- (d) The breaking load shall be calculated from the characteristic bending strength in accordance with Annex B of BS EN 1341: 2001. The breaking load shall not be less than the required breaking load of the appropriate class as specified in Table B.1 of BS EN 1341: 2001. The appropriate class should be determined by the Engineer based on the use of the pavement.

12. TESTING: TRANSVERSE BREAKING LOADS OF ARTIFICIAL GRANITE PAVING BLOCKS

- (a) One sample of each type, size and colour of artificial granite pavers in a batch shall be provided from every 10,000 pieces of such pavers or part thereof. A batch of artificial granite pavers less than 10,000 pieces may be added to the previous batch(es) or the following batch(es) as the case may be for testing purposes. The number of specimens in each sample shall be 6.
- (b) Each sample of artificial granite paving blocks shall be tested to determine the transverse breaking load to BS EN 1344: 2002.
- (c) The characteristic transverse breaking load (P_c) of a sample shall be calculated from the following equation:

$$P_c = P_m - 1.65 X_s \text{ kN}$$

where P_m = average transverse breaking load of the sample

$$X_s = \text{unbiased standard deviation} = \sqrt{(\sum P^2 - 6 P_m^2)/5} \text{ kN}$$

- (d) The characteristic transverse breaking load of a sample shall not be less than:

- (i) 4.8 kN for artificial granite paving blocks in footways and cycle tracks, or artificial granite paving blocks of Class 3 to Annex B of BS EN 1341: 2001; and
- (ii) 11.5 kN for artificial granite paving blocks in carriageways, run-ins and other paved areas to which vehicles will have access, or artificial granite paving blocks of Class 6 to Annex B of BS EN 1341: 2001.

Appendix B5 – Clay Paving Units

1. MATERIALS

- (a) Clay pavers and clay paving setts shall comply with BS EN 1344: 2002 and this PS.
- (b) Clay pavers shall be rectangular with the paver length approximately equals twice the paver width. Clay paving setts shall be square with the width/length equals to the width of the clay pavers to be used in conjunction, if any. Clay pavers and clay paving setts in footways and cycle tracks shall be minimum 50 mm thick and those in carriageways, run-ins and other paved areas to which vehicles will have access shall be minimum 65 mm thick.
- (c) Unless with prior approval of the Engineer, clay pavers and clay paving setts shall not be used in carriageways, run-ins and other paved areas to which vehicles will have access.
- (d) Unless otherwise directed by the Engineer or specified in this PS, clay pavers and clay paving setts in footways and cycle tracks should comply with the requirements for Class T2 to BS EN 1344: 2002, and clay pavers and clay paving setts in carriageways, run-ins and other paved areas to which vehicles will have access should comply with the requirements for Class T3 to BS EN 1344: 2002. The width and depth of the chamfer and round top edges as shown in Figure 2 of BS EN 1344: 2002 shall not be less than 2mm and not more than 5mm.
- (e) Unless otherwise directed by the Engineer, clay pavers in carriageways, run-ins and other paved areas shall have a 45° chamfered top edge or rounded top edges.
- (f) Clay pavers and clay paving setts may incorporate integral spacer nibs to aid the laying but shall not be included in the size of the unit.
- (g) The colours of clay pavers and clay paving setts shall be as specified by the Engineer.
- (h) Unless otherwise directed by the Engineer, clay pavers and clay paving setts shall be free from any surface sealant.
- (i) The bedding sands and jointing sands for clay pavers and clay paving setts shall be in accordance with BS 7533: Part 3: 1997.

2. SUBMISSIONS

- (a) The following particulars of the proposed materials and methods of construction for clay pavers and clay paving setts shall be submitted to the Engineer:
 - (i) Name and address of manufacturer;
 - (ii) A certificate from the manufacturer showing the manufacturer's name, place of manufacture and test results for:

- dimensional deviations to BS EN 1344: 2002;
 - transverse breaking load of clay pavers to BS EN 1344: 2002;
 - slip/skid resistance of clay pavers and clay paving setts to BS EN 1344: 2002 and BS EN 1342: 2001 respectively; and
 - 24-hour cold water absorption rate to AS/NZS 4456.14: 2003.
- (iii) Drawings showing the layout and setting out of the clay pavers and/or clay paving setts within the paved area.
- (b) The particulars shall be submitted to the Engineer for approval of the source and type of the clay pavers and clay paving setts, and for approval of the layout drawings at least 14 days before laying works starts.
- (c) Sufficient samples of each type of clay pavers and clay paving setts shall be submitted to the Engineer for approval of the source and type of clay pavers and clay paving setts at the same time as the particulars are submitted.

3. MOCK-UP PANEL

- (a) If directed by the Engineer, the Contractor shall construct a mock-up panel in a sufficient size to the satisfaction of the Engineer which will be a benchmark for both the aesthetics of the material and also the standards of laying.
- (b) Preferably the mock-up panel shall be constructed within the Site unless it is considered impractical by the Engineer due to site constraints or other site problems. A mock-up panel constructed within the Site shall form part of the Works if both the materials and workmanship are up to the satisfaction of the Engineer.
- (c) The cost of a mock-up panel constructed outside the Site, including the construction and demolition, shall be deemed to be included in the contract rates.

4. HANDLING AND STORING

- (a) Handling and storage of clay pavers and clay paving setts shall be in accordance with GS Clause 11.72. Storage of bedding sands and jointing sands shall be in accordance with GS Clause 11.73.

5. LAYING

- (a) Laying of clay pavers and clay paving setts shall be in accordance with “Guidelines on Good Practice for Laying Unit Pavers” published by Highways Department and BS 7533: Part 3: 1997 unless otherwise specified in this PS or as instructed by the Engineer.
- (b) Clay pavers shall be laid to any design or pattern specified by the Engineer. The design or pattern may involve a single colour or a combination of different colours.

6. TOLERANCES

- (a) The level of paved areas constructed using clay pavers and clay paving setts shall be within 3 mm of the specified level. The difference in level of adjacent pavers/paving

setts shall not exceed 2 mm.

7. TESTING: GENERAL

- (a) A batch of clay pavers / clay paving setts shall be any quantity of clay pavers / clay paving setts of the same type, size, colour and finish, manufactured in the same place, covered by the same certificates and delivered to the Site at any one time.
- (b) Sampling shall be in accordance with BS EN 1344: 2002.
- (c) Unless otherwise directed by the Engineer, for minor works involving the use of clay pavers / clay paving setts of any type for a total area(s) not greater than 100 m² under a Works Order, all testing requirements described in this Section will be waived.

8. TESTING: DIMENSIONAL DEVIATION

- (a) One sample of each type, size and colour of clay pavers / clay paving setts in a batch shall be provided from every 10,000 pieces of such pavers/setts or part thereof. A batch of clay pavers / clay paving setts less than 10,000 pieces may be added to the previous batch(es) or the following batch(es) as the case may be for testing purposes. The number of specimens in each sample shall be 10. The sample can be used for the subsequent tests.
- (b) The dimensions of each sample shall be measured in accordance with BS EN 1344: 2002.
- (c) The tolerances for the dimensions of each sample shall be within the limits set out for Class R1 in BS EN 1344: 2002.

9. TESTING: SLIP/SKID RESISTANCE

- (a) One sample of each type, size and colour of clay pavers / clay paving setts in a batch shall be provided from every 10,000 pieces of such pavers/setts or part thereof. A batch of clay pavers / clay paving setts less than 10,000 pieces may be added to the previous batch(es) or the following batch(es) as the case may be for testing purposes. The number of specimens in each sample shall be 5. The sample can be used for the subsequent tests.
- (b) Each sample of clay pavers shall be tested to determine the slip/skid resistance to BS EN 1344: 2002.
- (c) The mean slip/skid resistance of a sample shall not be less than:
 - (i) 45 Skid Resistance Value for clay pavers and clay paving setts in footways and cycle tracks, and
 - (ii) 60 Skid Resistance Value for clay pavers and clay paving setts in carriageways, run-ins and other paved areas to which vehicles will have access.
- (d) Notwithstanding the above (c), if considered appropriate by the Engineer for

application on steep roads or other difficult site conditions, the required slip/skid resistance of clay pavers and clay setts in footways and cycle tracks may be increased up to 60 Skid Resistance Value and the required slip/skid resistance of clay pavers and clay setts in carriageways, run-ins and other paved areas to which vehicles will have access may be increased up to 65 Skid Resistance Value.

10. TESTING: WATER ABSORPTION VALUE

- (a) One sample of each type, size and colour of clay pavers / clay paving setts in a batch shall be provided from every 10,000 pieces of such pavers/setts or part thereof. A batch of clay pavers / clay paving setts less than 10,000 pieces may be added to the previous batch(es) or the following batch(es) as the case may be for testing purposes. The number of specimens in each sample shall be 10.
- (b) Each sample shall be tested to determine either the 24-hour cold water absorption value to AS/NZS 4456.14: 2003.
- (c) The sample shall have a characteristic water absorption value not more than 6% by 24-hour cold immersion method to AS/NZS 4456.14: 2003.
- (d) Notwithstanding with the above (c), if considered appropriate by the Engineer, the required characteristic water absorption value of a sample may be increased by 1% for clay pavers and clay paving setts of dark colours. The definition of dark colours should be determined by the Engineer.
- (e) The characteristic cold water absorption value (W_c) shall be calculated from the following equation:

$$W_c = W_m + 1.65 X_s \%$$

where W_m is the average water absorption rate of the sample

X_s is the unbiased standard deviation as stated in AS/NZS 4456.2: 2003.

11. TESTING: TRANSVERSE BREAKING LOADS OF CLAY PAVERS

- (a) One sample of each type, size and colour of clay pavers / clay paving setts in a batch shall be provided from every 10,000 pieces of such pavers/setts or part thereof. A batch of clay pavers / clay paving setts less than 10,000 pieces may be added to the previous batch(es) or the following batch(es) as the case may be for testing purposes. The number of specimens in each sample shall be 10.
- (b) Each sample of clay pavers shall be tested to determine the transverse breaking load to BS EN 1344: 2002.
- (c) The mean transverse breaking load of a sample of clay pavers shall not be less than:
 - (i) 30N/mm with no individual result less than 24N/mm for clay pavers in footways and cycle tracks.
 - (ii) 80N/mm with no individual result less than 50N/mm for clay pavers in carriageways, run-ins and other paved areas to which vehicles will have access,

footways and cycle tracks where vehicular loads due to frequent illegal parking or other reasons are anticipated.

Appendix B6 – Tactile Pavers

GLOSSARY OF TERMS

Tactile Paver	11.110	(1) Tactile paver is a term used to describe a tactile tile, slab or block unless otherwise specified by the Engineer. (2) Depending on their usage, tactile pavers are classified as either hazard warning, positional or directional.
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MATERIALS

Tactile Pavers	11.111	(1) Tactile pavers shall be made of durable and non-slippery materials. They shall be precast concrete tactile tiles, slabs or blocks complying with Clause 11.112 to 11.114 of this Particular Specification. Tactile pavers of other materials, including dust ceramic, clay, and artificial granite tactile pavers shall be approved by and to the satisfaction of the Engineer. (2) Tactile pavers shall have patterns and details complying with HyD Standard Drawing No. H5118. For proprietary products having patterns and dimensions deviating from HyD Standard Drawing No. H5118, approval of the Road Safety and Standards Division of the Transport Department for the use of such products shall be sought. (3) Tactile pavers shall be within 3 mm of the specified dimensions. (4) Tactile pavers may incorporate integral spacer nibs to aid laying but these spacer nibs shall not be included in dimensions of the tactile pavers. (5) Tactile pavers shall come in a wide range of colours to facilitate pavement design by the Engineer. The colours shall be stable and fade resistant under any outdoor climate situations, consistent over the area to be laid and contrast visually with adjoining surfaces to provide clear indication of routes for people with low vision. (6) Tactile pavers shall not exhibit defects such as cracking or flaking, and shall be free of any surface sealant unless otherwise
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directed by the Engineer.

Precast concrete tactile tiles	11.112	(1) Precast concrete tactile tiles shall be installed on highway structures unless otherwise directed by the Engineer. (2) Precast concrete tactile tiles shall be square of metric size 300 mm x 300 mm. (3) Precast concrete tactile tiles shall be 15 mm thick. Precast concrete tactile tiles of other thickness may be used if approved by the Engineer. (4) Chamfer not exceeding 3 mm shall be provided.
Precast concrete tactile slabs	11.113	(1) Precast concrete tactile slabs shall be square of metric size 300 mm x 300 mm. (2) Precast concrete tactile slabs shall be 60 mm thick. Precast concrete tactile slabs of other thickness may be used if approved by the Engineer. (3) Chamber not exceeding 3 mm shall be provided.
Precast concrete tactile blocks	11.114	(1) Precast concrete tactile blocks shall be square of metric size 200 mm x 100 mm. (2) Precast concrete tactile blocks shall be 60 mm thick. Precast concrete tactile slabs of other thickness may be used if approved by the Engineer.
Concrete	11.115	(1) Concrete for tactile pavers in footways shall be Grade 30. Concrete for tactile pavers in areas to which vehicles will have access shall be Grade 45. (2) The nominal maximum aggregate size for concrete shall be 10 mm.
Sand for tactile slabs / blocks	11.116	Sand for bedding tactile slabs / blocks shall comply with GS Clause 11.67.
Cement mortar for tactile tiles	11.117	(1) Cement, water and sand for mortar for bedding tactile tiles shall comply with GS Clause 24.65 unless otherwise approved by the Engineer. (2) Cement mortar shall consist of cement and sand in the proportions 1:3 by volume unless otherwise approved by the Engineer.

SUBMISSIONS

- Particulars of tactile pavers***
- 11.118 (1) The Contractor shall submit the following particulars of the proposed materials and methods of construction for tactile pavers to the Engineer:
- (a) Name and address of manufacturer;
 - (b) Catalogue, brand name / model name and job reference;
 - (c) A certificate from the manufacturer showing the source and particle size distribution of aggregates for precast concrete tactile pavers;
 - (d) Layout and method statement for installation of the tactile pavers;
 - (e) A certificate from the manufacturer showing the manufacturer's name, date and place of manufacture and results of tests for:
 - slip resistance value of tactile pavers calculated in accordance with Appendix A to AS 4586:2013;
 - compressive strength of concrete cubes at 28 days and precast concrete tactile blocks to GS Appendix 11.1;
 - 24-hour cold water absorption value of concrete tactile slabs and blocks to AS/NZS 4456.14;
 - bending strength and breaking loads of concrete tactile slabs to BS EN 1339;
 - bending strength of concrete tactile tiles to Appendix 11.2;
- (2) The particulars as required under sub-clause (1) shall be submitted to the Engineer for approval of the source, type and layout of tactile pavers at least 14 days before commencement of laying.

Particulars of sand and cement mortar 11.119 (1) The following particulars of the proposed materials for sand and cement shall be submitted to the Engineer:

For tactile slabs and blocks:

- (a) A certificate for cement mortar showing manufacturer's name, date and place of manufacture and compliance with requirements stated in the Contract;
- (b) Details of materials for cement mortar; and
- (c) Certificates for sand showing the sources of materials and compliance with requirements stated in the Contract, including results of particle size distribution tests.

For tactile tiles:

- (a) A certificate for cement mortar showing manufacturer's name, date and place of manufacture and compliance with requirements stated in the Contract; and
 - (b) Details of materials for cement mortar.
- (2) The particulars shall be submitted to the Engineer for approval at least 14 days before the first delivery of the material to the Site.

Samples of tactile pavers 11.120 (1) Samples of tactile pavers showing actual sizes, colours, textures, patterns and general characteristics of the appearances shall be submitted to the Engineer for approval at the same time as particulars of the tactile pavers are submitted.

(2) Samples submitted to the Engineer shall be subject to visual inspection and shall comply with the following requirements:

- (a) There shall not be significant visible differences in colour and texture between any samples of the same type;
- (b) Samples shall not exhibit defects such as cracking, flaking or dislodging of aggregates, etc.;
- (c) Fine materials shall not be easily dislodged from surfaces of any samples by gentle manual handling;

and

- (d) Edges of all samples, apart from round chamfers, shall be sharp and straight without any defects.
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HANDLING AND STORAGE OF MATERIALS

<i>Handling and storage of tactile pavers</i>	11.121	Tactile pavers shall be handled and stored on pallets to avoid damage to corners and chamfer edges. Pallets shall be stored on a levelled, well drained and maintained hard-standing ground and in a manner which shall not result in damage or contamination to the tactile pavers. Tactile pavers shall be protected from damages and damaged tactile pavers shall not be used unless permitted by the Engineer.
<i>Handling and storage of sand</i>	11.122	Sand for filling joints between tactile blocks and slabs shall be handled and stored in accordance with GS Clause 11.73.
<i>Handling and storage of cement</i>	11.123	Cement shall be delivered in sealed bags or containers bearing the manufacturer's name and type. The bags and containers shall be stored in a dry weatherproof store with a raised floor.

LAYING TACTILE PAVERS

<i>General</i>	11.124	<ul style="list-style-type: none"> (1) Tactile pavers shall not be laid until the layout of the tactile pavers has been approved by the Engineer. (2) Tactile pavers shall be laid according to the details shown in the HyD Standard Drawing Nos. H5119 to H5123. (3) Kerbs and edgings shall be completed before the tactile pavers are laid. (4) Measures shall be taken to prevent water draining across or through the area during laying, bedding and compaction of the tactile pavers. (5) Laying of tactile pavers shall be started as soon as practicable after the formation has been completed. The formation shall be protected as stated in GS Clause 6.55 until laying starts.
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		(6) Where cutting of tactile pavers is required at the edge of manholes or within recessed manhole covers for edge treatment, the size of the cut tactile pavers shall not be less than 1/3 of the original size. If necessary, adjacent tactile pavers shall also be cut to achieve this requirement. The cut made through raised portions of the tactile pavers should be avoided.
<i>Laying sand for tactile slabs / blocks</i>	11.125	<p>(1) A layer of sand shall be laid and shall be screeded and tamped to a uniform depth over the complete width of the area to be paved. The quantity and thickness of sand shall be appropriate to methods of preparation of the sand layer, and shall be sufficient to give the required nominal thickness of the sand layer after compaction of the sand and tactile slabs / blocks.</p> <p>(2) The sand layer shall not be disturbed by additional compaction, footmarks or other damage after the layer has been screeded and tamped to the required level and before the tactile slabs / blocks are laid.</p>
<i>Bedding tactile slabs / blocks</i>	11.126	<p>(1) Tactile slabs / blocks shall be laid on the prepared sand layer immediately after screeding and tamping in such a manner that the sand is not disturbed.</p> <p>(2) Tactile slabs / blocks shall be adjusted to form uniform joints between 2 and 3 mm wide and shall be bedded into the final position using a wooden mallet or a plate vibrator fitted with a rubber base-pad for tactile slabs, or a heavy-duty plate compactor fitted with a rubber base-pad for at least two passes for tactile blocks.</p> <p>(3) Tactile slabs / blocks shall not be bedded within 1 m of an unrestrained edge of a screeded sand layer.</p> <p>(4) Final levelling of tactile slabs / blocks shall be carried out as soon as practicable after bedding and before changes in moisture content of the prepared sand layer.</p> <p>(5) Damaged tactile slabs / blocks shall be immediately removed and replaced.</p>
<i>Filling joints and compaction of tactile slabs / blocks</i>	11.127	(1) After tactile slabs / blocks were bedded, sand for filling joints shall be spread over surfaces of the slabs / blocks and brushed into the joints in such a manner until all joints are

completely filled.

(2) Joints shall be filled as soon as practicable after bedding and on the day the slabs / blocks are laid and bedded.

(3) After all joints are completely filled with sand, the slabs / blocks shall be fully compacted by using a plate compactor fitted with a rubber base-pad. Additional sand shall be added to refill the joints as required and compacted into the joints by using the plate compactor with two or more passes.

(4) Areas with vehicular or regular heavy pedestrian traffic shall be compacted by at least ten evenly-spaced passes of a pneumatic tyred roller having a gross weight of between 10 t and 12 t, or by a plate compactor which shall have the following capacity:

- Minimum plate area of 0.25 m²;
- Minimum effective force per unit area of plate of 75 kN/m²;
- Frequency of 65 –100 Hz; and
- Minimum mass of 200 kg.

Other suitable compacting equipment to approval of the Engineer can be used. Sand shall be added as required, and brushed and compacted into the joints.

(5) Excessive sand shall be removed after completion of compaction.

(6) Damaged tactile slabs / blocks shall be immediately removed and replaced.

(7) Pigmented cement and sand in a proportion 1:3 by volume with minimum amount of water necessary to achieve the required workability shall be placed to full depth of the slabs / blocks to fill up the gaps with adjacent kerbs, edgings, quadrants, covers, frames and other hardware. Colour of the pigment shall match the adjacent hardware or paving units or otherwise instructed by the Engineer. This sealing works shall only be carried out upon approval by the Engineer.

Bedding tactile tiles

11.128 (1) Unless, otherwise approved by the Engineer, tactile tiles shall be laid on a bed of cement mortar. Thickness and details of

the bed shall comply with the HyD Standard Drawing No. H5123. The screed shall be dampened with clean water to prevent water being absorbed from the bed.

(2) Before laying, tactile tiles shall be immersed in water for 30 minutes, allowed to drain and back of the tiles shall be coated with a slurry of cement mortar together with the minimum amount of water necessary to achieve a creamy consistency, unless otherwise approved by the Engineer. Tactile tiles shall be firmly tamped into the bed to leave straight and even joints.

(3) After the bed set, unless otherwise approved by the Engineer, tactile tiles shall be grouted with a mix of cement and sand in a proportion 1:1 by volume together with the minimum amount of water necessary to achieve the required workability. Surplus grout shall be cleaned from face of the tiles as work proceeds.

REINSTATEMENT OF TACTILE PAVERS

***Reinstatement of tactile
pavers***

11.129

(1) If excavation is to be carried out in areas laid with tactile pavers, the tactile pavers shall be extracted by manual methods for a distance of at least 300 mm beyond the limit of the excavation or twice the largest lateral dimension of the tactile pavers, whichever is greater.

(2) Unbroken tactile pavers shall be thoroughly cleaned to remove all sand and deleterious material. The tactile pavers shall be stacked on pallets for re-use.

(3) Tactile pavers to be re-used shall be re-laid in accordance with Clauses 11.124 to 11.127.

TOLERANCES

- Levels**
- 11.130 (1) For tactile slabs / blocks, the level of paved areas constructed using tactile pavers shall be within 3 mm of the specified level. The difference in level with adjacent paving units shall not exceed 2 mm.
- (2) For tactile tiles, there shall be no abrupt irregularities and no gradual irregularities exceeding 5mm in a 2m length.
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TESTING

- Batching**
- 11.131 (1) A batch of tactile pavers shall be any quantity of tactile tiles, slabs or blocks of the same type, size, finish, manufactured in the same place, covered by the same certificates and delivered to the Site at any one time.
- (2) Tactile pavers of different colours can be grouped together to form their respective batches provided that they comply with sub-clause (1) and with the same production methods.
- (3) Sampling shall be carried out in random. The sample shall comprise tactile pavers that are distributed throughout the batch.
- Testing requirements for tactile pavers**
- 11.132 (1) All tactile pavers shall be tested for slip resistance according to Clause 11.133, and tactile slabs / blocks shall be tested for 24-hour cold water absorption values according to Clause 11.134.
- (2) Tactile slabs shall be tested for bending strength according to Clause 11.135.
- (3) Tactile blocks other than precast concrete shall be tested for transverse breaking loads according to Clause 11.136, and precast concrete tactile blocks shall be tested for compressive strength according to Clause 11.137.
- (4) If required by the Engineer, tactile tiles shall be tested for bending strength according to Clause 11.138.

Slip resistance test

- 11.133 (1) One sample of tactile pavers in a batch shall be provided from every 10 m² of tactile pavers or part thereof. A batch of tactile pavers with areas less than 10 m² may be added to the untested previous or following batches for testing purposes. Number of specimens in each sample shall be 3. The sample can be used for the subsequent tests.
- (2) Each sample shall be tested to determine the slip resistance value by Wet Pendulum Test using slider 55 in accordance with AS 4586:2013.
- (3) The sample shall have a slip resistance not less than that required in Table 11.3:

Table 11.3: Required wet pendulum slip resistance

Gradient of Footways	Minimum Slip Resistance Values Measured By Wet Pendulum Test
=< 3%	45
> 3% and =< 7%	50
> 7% and =< 12%	55
> 12%	60

Water absorption test

- 11.134 (1) One sample of tactile pavers in a batch shall be provided from every 10 m² of tactile pavers or part thereof. A batch of tactile pavers with areas less than 10 m² may be added to the untested previous or following batches for testing purposes. Number of specimens in each sample shall be 3. The sample can be used for the subsequent tests.
- (2) Each sample shall be tested to determine the 24-hour cold water absorption value to AS/NZS 4456.14.
- (3) The sample shall have a characteristic water absorption value not more than the following by the 24-hour cold immersion method to AS/NZS 4456.14:
- 6% for precast concrete tactile slabs / blocks;
 - 3% for dust pressed unglazed ceramic tactile tiles;
 - 6% for clay tactile blocks but may increase to 7% for blocks of dark colours subject to approval by the

Engineer; and

- 1% for artificial granite tactile slabs / blocks

(4) The characteristic water absorption value (W_c) shall be calculated from the following equation:

$$W_c = W_m + 1.65 X_s \%$$

where: W_m is the average water absorption rate of the sample

X_s is the unbiased standard deviation as stated in AS/NZS 4456.2

Bending strength test for tactile slabs 11.135 (1) One sample of tactile slabs in a batch shall be provided from every 10 m² of the slabs or part thereof. A batch of tactile slabs with areas less than 10 m² may be added to the untested previous or following batches for testing purposes. Number of specimens in each sample shall be 6.

(2) Each sample shall be tested to determine the bending strength to BS EN 1339.

(3) For tactile slabs made of precast concrete, the mean bending strength of a sample shall not be less than 3.7 MPa with individual bending strength not less than 3.0 MPa.

(4) For tactile slabs made of artificial granite, the characteristic bending strength (Rtf_c) of a sample shall be calculated from the following equation:

$$Rtf_c = Rtf_m - 1.65 X_s \text{ MPa}$$

where: Rtf_m is the average bending strength of the sample

X_s is the unbiased standard deviation:

$$\sqrt{\{(\Sigma Rtf^2 - 6 Rtf_m^2)/5\}} \text{ MPa}$$

The characteristic bending strength shall be used to calculate the breaking load of the sample in accordance with Annex B of BS EN 1341. The breaking load shall not be less than the required breaking load of the appropriate class, which should be determined by the Engineer based on the use of the pavement, as specified in Table B.1 of BS EN 1341.

<i>Transverse breaking load test for tactile blocks</i>	11.136	<p>(1) One sample of tactile blocks in a batch shall be provided from every 10 m² of the blocks or part thereof. A batch of tactile blocks less than 10m² may be added to the untested previous or following batches for testing purposes. Number of specimens in each sample shall be 10.</p> <p>(2) Each sample shall be tested to determine the transverse breaking load to BS EN 1344.</p> <p>(3) For tactile blocks made of clay,</p> <ul style="list-style-type: none"> - the mean transverse breaking load of a sample shall not be less than 30 N/mm with individual test results not less than 24 N/mm for tactile blocks laid on footway, - the mean transverse breaking load of a sample shall not be less than 80 N/mm with individual test results not less than 50 N/mm for tactile blocks laid on run-ins or other areas subject to vehicular access. <p>(4) For tactile blocks made of artificial granite, the characteristic transverse breaking load (P_c) of a sample shall be calculated from the following equation:</p> $P_c = P_m - 1.65 X_s \text{ kN}$ <p>where: P_m is the average transverse breaking load of the sample</p> <p>X_s is the unbiased standard deviation:</p> $\sqrt{\{(\sum P^2 - 6P_m^2)/5\}} \text{ kN}$ <p>The characteristic transverse breaking load of a sample shall not be less than 4.8 kN for tactile blocks laid on footway or of Class 3 to Annex B of BS EN 1341, and 11.5 kN for tactile blocks laid on run-ins or other areas subject to vehicular access or of Class 6 to Annex B of BS EN 1341.</p>
<i>Compressive strength test for tactile blocks</i>	11.137	<p>(1) One sample of tactile blocks in a batch shall be provided from every 10 m² of the tactile blocks or part thereof. A batch of tactile blocks with areas less than 10 m² may be added to the untested previous or following batches for testing purposes. Number of specimens in each sample shall be 8.</p>

- (2) Each sample of tactile blocks shall be tested to determine the characteristic compressive strength at 28 days.
- (3) The method of testing shall be as stated in GS Appendix 11.1.
- (4) The characteristic compressive strength of a sample shall not be less than 30 MPa for tactile blocks laid on footway and 45 MPa for tactile blocks laid on run-ins or other areas subject to vehicular access.
- Bending strength test for concrete tactile tiles** 11.138 (1) One sample of tactile tiles in a batch shall be provided from every 10 m² of the tactile tiles or part thereof. A batch of tactile tiles with areas less than 10 m² may be added to the untested previous or following batches for testing purposes. Number of specimens in each sample shall be 6.
- (2) Each sample of tactile tiles shall be tested to determine the bending strength in accordance with Appendix 11.2.
- (3) The mean bending strength of a sample shall not be less than 3.7 MPa with individual bending strength not less than 3.0 MPa.

APPENDIX 11.2**DETERMINATION OF BENDING STRENGTH OF
CONCRETE TACTILE TILES FOR HIGHWAY STRUCTURES**

- Scope** 11.1.6 This method covers determination of bending strength at 28 days of precast concrete tactile slabs using three-point loading method.
- Apparatus** 11.1.7 A flexural strength testing machine complying with BS EN 12390 is required.
- Procedure** 11.1.8 The procedure shall be as follows:
 - Place the specimen in the apparatus with one side face on the supporting rollers with centre-to-centre distance 150mm apart and with its longitudinal axis normal to the supports.
 - Apply the load vertically in the middle of the specimen by means of the loading roller to the opposite side face of the specimen and increase it smoothly at the rate of (50±5) N/s until failure.
 - Calculate the bending strength, T, in megapascals (MPa) of the specimen tested from the following equation:
$$T = \frac{3 \times P \times L}{2 \times b \times t^2}$$

where:

 - P is the failure load, in newtons (N);
 - L is the distance apart of the supports, in millimetres (mm);
 - b is the width of the specimen at the failure plane, in millimetres (mm);
 - t is the thickness of the specimen at the failure plane, in millimetres (mm).
- Reporting of Results** 11.1.9 The following shall be reported:
 - Source, name of manufacturer and type of tactile slabs;
 - Nominal dimension of each specimen to the nearest mm;
 - Bending strength of each specimen to the nearest 0.1 MPa;
 - Mean bending strength of the sample tested;
 - The test method used was in accordance with this Specification.