HIGHWAYS DEPARTMENT

ROAD NOTE 9

PRECAST CONCRETE UNIT PAVING SYSTEM

Research & Development Division

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Road Note 9 - Precast Concrete Unit Paving System

List of the Latest Revisions (as at 22.12.2006)

No.	Issue Date	Purpose	Brief Description of Amendment
B	Nov 1999	-	-
C	22nd Dec 2006	To impose an additional limitation on the application of precast concrete unit paving.	Addition of the fourth bullet to para 4.1.2 (iv).

ROAD NOTE 9

PRECAST CONCRETE UNIT PAVING

1. INTRODUCTION

1.1 For many years, precast concrete unit paving has been adopted successfully in overseas countries for surfacing pedestrian areas, vehicular roads, container ports and airport runways. In Hong Kong, precast concrete unit paving was mainly adopted in surfacing pedestrian areas, however most of the paved areas were found unsatisfactory particularly those in the urban areas.

1.2 In July 1982, a Working Group was established within the then Highways Office to examine the quality and performance of precast concrete units paved in the territory and to review overseas experience and practice in precast concrete unit paving. A report namely "Pedestrian Paving in Urban Areas" was completed by the Working Group in April 1985. This report contains findings of the survey on a number of local areas and trial sites paved with precast concrete units, and gives recommendations on adoption of concrete unit paving in public works.

1.3 Because of the large volume of information contained in the report, it was considered desirable to extract only that part which would be essential to the practicing professionals involved in pedestrian pavement construction in the form of a Road Note. In November 1986, Road Note 9 was promulgated which gives guidelines on selection and design of concrete unit paving as well as the specification for its use in footway and carriageway pavement construction.

1.4 After about 8 years, in early 1995, the Maintenance Working Group of the Highways Department considered it necessary to review the contents of the Road Note 9. The review was finally completed in July 1995. In the new edition, some of the guidelines are modified with reference to the practical experience gained by the three Regions of Highways Department. Amendments are also made to take account of the General Specification for Civil Engineering Works, 1992 Edition (GS) and the Highways Department Standard Drawings, Jan. 1995 Edition.

2. PURPOSE OF ROAD NOTE

2.1 The purpose of this Road Note is :

(i) to publicise the availability and physical characteristics of the precast concrete units as an acceptable and often more desirable alternative paving material.

(ii) to supply essential technical information of concrete unit paving to the practicing professionals in a form which will facilitate its selection and design in pavement surfacing works.

(iii) to set a standard for selection, design and construction of the current range of precast concrete paving units.

3. PRECAST CONCRETE PAVING UNITS

3.1 General

3.1.1 Precast concrete paving units can be manufactured locally in a wide range of sizes, shapes, thickness, colours and surface textures. Quality of paving unit varies considerably among the manufacturers and compliance with the specification should be strictly observed.

3.1.2 To facilitate easy maintenance of public footpaths, designers are encouraged to use the more common paving units. The recommended types, shapes, sizes and basic bonding patterns of precast concrete paving units to be used in Hong Kong are included in Appendix A.

3.2 Size

3.2.1 Precast concrete paving units of varying size are available from the market and the combination of which gives many design opportunities.

3.2.2 Metric dimension of precast concrete paving units provides better dimensional co-ordination of paving works. It gives better design opportunities and facilitates easy setting out. Current productions of paving units by CSI are in metric dimensions though limited stock of non-metric paving units are available for localised maintenance and replacement. Non-metric units would only be produced upon special request.

3.2.3 Site experience revealed that paving units exceeding 300 mm are difficult to handle and resulted in unsatisfactory workmanship; therefore are normally discouraged to use.

3.3 Shape

3.3.1 Precast concrete paving units are generally patented and marketed commercially in a wide range of shapes that may range from simple square or rectangular to irregular complex units.

3.3.2 Not all shape of precast paving units can be laid in the designed bonding and this should be considered when selecting shape of the paving units in design.

3.3.3 Irregular shape units tend to be incompatible with other paving units, hence unsuitable for use in combination with others.

3.4 Colour

3.4.1 A range of high quality concrete colour pigments currently available from the market means that virtually paving units of any colours can be produced.

3.4.2 There is no limit on choice of colour but consideration must be given to the market availability of the chosen paving units to facilitate easy maintenance and replacement. Currently grey, brown and red are the most common colours used as they can blend into the typical street scene and are sufficiently dark to reduce glare.

3.5 Finish

There is a wide range of finishes available from the market to suit different client requirements. The basic qualities required are durable, non-slip and consistent in colour.

3.6 Bonding & Pattern

3.6.1 Variety of paving pattern can be developed from the basic bonding patterns illustrated in Appendix A. However the adoption of which should relate to the site situation and the aesthetic and design considerations mentioned in Paragraph 5 below.

3.6.2 More sophisticated paving pattern for prestigious sites and large paved areas could be considered on individual basis.

4. GUIDELINES FOR DESIGN AND CONSTRUCTION

4.1 Suitability and Limitation of Precast Concrete Unit Paving

4.1.1 Suitability

From experience gained in overseas countries and from local site trials, it has been determined that precast concrete unit paving is suitable for a wide range of applications which include:-

(i) Areas where the aesthetic appearance of the paved surface is important. Precast concrete slabs or blocks offer unique aesthetic benefits by the introduction of special patterns, colours or markings which harmonize with the environment.

(ii) Reclamation areas or fills subjected to ongoing settlement or localised large uneven ground displacement. Failed areas can be readily rectified by lifting and replacing the paving units after levelling and strengthening the foundation. Examples of this type of application are in the Port of Rotterdam, Holland, and Dover, U.K.

(iii) Paved areas which are frequently disturbed by utility openings. Precast slabs or blocks can be lifted and re-laid at minimum cost. The use of jack hammer is not required and consequently reduces the noise nuisance associated with excavation of conventional pavements in urban or residential areas. The paving units can be trafficked immediately after reinstatement without any noticeable colour or texture difference between the original and the reinstated areas. Delays associated with the curing of conventional rigid pavements and the cooling of flexible pavements are avoided.

(iv) Remote areas such as outlying islands where access for conventional construction plant is limited or the use of normal materials is not feasible. Concrete paving slabs or blocks are designed to be laid by hand requiring only labour of skills and a minimum of very basic construction equipment.

4.1.2 Limitation

(i) For carriageway applications, the principal limitation on precast concrete unit paving is that the riding quality and the skid resistance of the finished surface are inappropriate for high speed traffic operation. Paving slabs are not recommended to be used on carriageway pavements. Only Type "A" paving blocks can be used on carriageway pavements in view of their higher load supporting and interlocking capacity, however their usage is confined to only pavements with operation speed not exceeding 50 km/h or vehicular run-ins.

(ii) For footway applications, the principal limitation on precast concrete unit paving is its higher initial cost when compared to that of conventional concrete or bituminous pavement construction. However, as the units if handled carefully can be repeatedly lifted and re-laid in pavement reinstatement works e.g. trench reinstatement, the high initial cost will be considerably offset by savings in future maintenance/reinstatement costs.

(iii) Industrial areas where concentrated heavy loads can cause severe deformation, surface scoring or punching shear failures, e.g. areas regularly used by cranes, fork lifts and straddle carriers in container stacking areas.

(iv) Based on past experience, precast concrete unit paving should not be used in various situations as listed below:

- Areas where the surfaces are likely to be stained by oil or fuel spillage which spoils the aesthetic appearance of precast unit paving. These areas include bus-bays, depots, lorry parks, petrol station forecourts, areas fronting car repair shops, markets, etc.

- Footways where there are considerable numbers of utility pits or street furniture which pose difficulties in achieving proper laying and compaction of the precast units around the pits or furniture.

- Footways where gradients are steep leading to possible washout of the joint-filling or bedding sand during rainstorms.

- Footways with gradient at or above 3% which are adjacent to high slopes unless there are justifications, and special treatments are given to the joint-filling sand to prevent sand erosion and dislocation of paving units by the action of runoff from the slopes during rainstorms. Engineering judgement shall be exercised to determine whether the adjacent slopes concerned will be of significant height to produce runoff that will cause such erosion and dislocation action during rainstorms.

- Footways where there are problems of underground seepage and where are always subject to water flowing or ponding such as wet food stalls in markets.

- Footways along which roadside slopes are present and the use of paving units are likely to give rise to seepage of surface runoff.

- Footways where frequent illegal parking is expected.

- Footways likely to be abused by cooked-food stalls or hawkers.

- Footways in the vicinity of KCR stations, ferry termini and airports in order to avoid uneven pavement surfaces causing inconvenience to passengers carrying trolleys.

- Other unsuitable areas like refuse collection points and legal hawkers areas.

- Areas where there will be less pedestrian usage and where likely to have weeding problem such as footways with high density of roadside tree planting.

4.2 Guidelines for Selection of Precast Concrete Units

4.2.1 The relative suitability of precast concrete unit paving under various local conditions is illustrated in Table 1 which is mainly based on the Report prepared by the Working Group on "Pedestrian Paving in Urban Areas" and experience gained in subsequent yeas of usage. The table gives general guidelines for selection of types of paving and is not exhaustive. The selection of a particular type of paving should be based on economics (both from the construction and maintenance point of view), the site conditions and its suitability for the particular application.

4.2.2 In the updated version of this Road Note, some of the guidelines given in Table 1 are modified based on the practical experience gained by professionals of the Highways Department.

Table 1 - Relative Suitability of Different Paving Types in Various Situations

Situation	Standard Paving Type				
	Conventional Surfacing		Paving Slabs	Type "A" Paving Blocks	Type "B" Paving Blocks
	Concrete	Bituminous			
Industrial Area	√	X	X	X	X
Housing Precinct	X	X	√	√	√
Prestige Area	X	X	√	0	√
Open Market Area	√	X	X	0	0
Narrow Bus Terminus Island	√	X	X	0	0
Irregular Area, Obstructions	√	√	X	0	0
Frequent Trench Opening	X	√	√	√	√
Wide Footway	X	X	√	0	√
Narrow Footway	√	√	0	√	√
Vehicular Road, Run-in	√	√	X	√	X

Note : (1) √ = preferable
X = not preferable
0 = no preference; depends on site

(2) See also para. 4.1.2 (iii) for some particular situations where precast concrete unit paving is not recommended to be used.

(3) For dimensional and constructional details of Type "A" and "B" paving blocks, refer to Highways Department Standard Drawings.

4.3 Thickness Design

The typical layer thickness of pavement materials in footways and carriageways using precast concrete unit paving are recommended in Table 2. Reference can also be made to Highways Department Standard Drawings for the relevant construction details.

Table 2 - Thickness Design for Precast Concrete Unit Paving

Layer	**Footway**	**Run-in**	**Carriageway** (≤ 5 msa) (Design Life = 15 Years)
Concrete Paving Unit	Paving Slabs or Blocks	Type 'A' Paving Blocks	
Thickness	60 mm	80 mm	
Sand Course	20 mm to 30 mm		
Bituminous Road Base	-	100 mm (see note 1)	100 mm
Sub-base	100 mm	225 mm	225 mm (For $E_{subgrade}$ > 50 MPa)

Note : (1) For industrial buildings and access with high volume of heavy commercial vehicles. Cross road ducts should be correspondingly lowered.

4.4 Carriageway Application

4.4.1 The shape of the block selected will influence the performance of the pavement under traffic. Generally, type 'A' blocks perform better than type 'B' blocks. (See Appendix A)

4.4.2 Appendix A illustrates the basic paving patterns which are commonly employed in laying concrete paving units. From laboratory researches and observations on actual block pavements, it has been found that there are two common modes of failure:

(i) the bond lines open under traffic thereby destroying interlock and the structural integrity of the pavement.

(ii) horizontal creep of the blocks is mainly in the direction of the predominant traffic flow.

4.4.3 To overcome these failure modes, it has been found that herring-bone type of paving perform far better than other paving patterns. Thus the herring-bone bonds should be the preferred laying pattern for carriageways and this should be considered when selecting a block shape for use in a pavement.

4.5 Specification

The requirements for precast concrete paving construction are stated in Section 11, Part 7 of the General Specification for Civil Engineering Works.

4.6 Construction

In order to achieve the best possible pavement finish with a reasonable guarantee of a trouble free service life, the following important aspects should be closely observed during construction:

4.6.1 Delivery and Handling

Delivery, storage and subsequent handling of the paving units should be carried out with sufficient care to avoid damage. Any units found to be chipped or cracked should be removed from site unless the extent of damage allows their use along edges as specified in paragraph 4.6.7.

4.6.2 Edge Restraints

Edge restraints are vital for proper placing and full strength development of the paving units. Before commencement of the laying operation, all permanent edge restraints should be installed rigidly in position to resist possible displacement of the paving units induced by vibration of the plate compactor during construction or the subsequent traffic loads.

- Edge restraint should be parallel/right angle to the main direction of the laying pattern.
- Kerbs and edgings shall be completed before paving units are laid.
- Form edge restraints before compacting adjacent paving units.
- Do not vibrate paving units until edge restraint, with any concrete haunching, has gained sufficient strength.
- Make haunching to an edge restraint on the paving face vertical down to the level of the underside of the sand layer.
- Edge restraints should be adequate to support traffic loads and to prevent loss of sand layer from beneath paving units.

4.6.3 Tools and Equipment

A sufficient number of tools and equipment of the right type for the job should be available on site during the laying operations. Unless the correct tools are used, paving units are likely to be damaged unnecessarily. The minimum tools and equipment should include :

- Sand screed system,
- Large wooden paviour's maul,
- Spacer shims,

- Rotary cutter wheel as power hand tool or free-standing workstation for cutting units,
- Vibrating plate compactor,
- Set of screed boards,
- Brooms.

4.6.4 Setting Out

Accurate setting out of the paving pattern on site eliminates unnecessary cutting of paving units along edges and ensures a well finished job. Due regard should be paid on general direction of the site, size of paving units to be laid, and position of street furniture or trees if any.

A scaled layout plan showing a complete paving pattern of paving units within the paved area shall be prepared to determine the exact location of base lines for setting out on site

4.6.5 Sub-base and Road base

Before placing the sand bedding, the finished levels of the sub-base and road base should be checked against the tolerances permitted in Table 9.8 of the GS. The sand bedding material should not be used as a levelling material to compensate for any deviations in level from the permitted tolerances. The sand bedding should be of uniform thickness throughout to allow for even settlement and distribution of loads. Excessive building-up of the sand bedding layer is not an acceptable practice.

The sub-base should be consolidated and blinded where necessary to eliminate any voids which would allow the sand bedding to run out. This is particularly important at tight corners or narrow strips between edge restraints and fixtures such as manholes or street furniture where mechanical compactors are not able to operate effectively.

- The longitudinal falls and crossfall are such that no depression hold water.
- The surface is tight and dense enough to prevent the sand layer being lost into it during construction and use.
- Provision is required to drain water from the sand layer when the layer is on impermeable foundation, and prevent migration and loss of sand layer into drainage.
- The extent of the site prepared for block laying shall include enough room to provide adequate foundations and backing for any edge restraint.

4.6.6 Bedding and Joints

Consolidation of the sand bedding layer after laying of the units should be taken into account in achieving the design finished level of the pavement. Workmen should not be allowed to walk on the prepared sand bedding layer.

Joints between units should be completely filled with joint-filling sand without undue delay before the pavement is open to traffic. This prevents possible displacement of the units and collection of deleterious materials in the joints.

- The moisture content of the sand bedding layer should be as uniform as possible and the material should be moist without being saturated.

- Spread the sand in a loose uncompacted layer to approximately the required final depth below the surface profile. Compact the layer using a vibrating plate compactor. Spread a further layer of material about 15 mm thick and screed it to create a loose surface on which paving units can be placed.

- The object of screeding the sand layer is to produce a uniform surface to the specified design profiles and falls.

- If any disturbance of the prepared sand layer by pedestrian or wheeled traffic occurs, prior to placing paving units, re-screed the areas of the sand layer.

4.6.7 Paving Units

If necessary, paving units should only be cut once for fitting along edges or around an obstruction unless the second cutting removes the first cut line totally.

Where it is impracticable to cut units to fit neatly around an obstruction, the latter can be surrounded with pigmented mortar or concrete in advance of the paving operation and the paving units, cut if necessary, laid to fit along edges of the mortar or concrete. The pigment should match with the colour of the adjacent units.

Very often, cut units may not be suitable or practicable for fitting the gaps between units and obstructions such as street furniture and manholes. Therefore pigmented mortar should be available on site during the laying operation for filling up the gaps where necessary. However, the pattern of paving units should be arranged so as to avoid leaving a narrow gap between the roadside kerbs and the units, and the subsequent filling the gap by mortar. A long strip of mortar next to the kerbs is not pleasing to the public, as shown in **Plate 14**.

- Measures shall be taken to prevent water draining across or through the paving area during laying, bedding and compaction of the units.

- Lay paving units so that the surface levels are within tolerances.

- Make minor adjustments to maintain the bond pattern and ensure that the joints remain wide enough for sand filling if required.

- The first row of units should be aligned against the edge restraints or by using a straightedge or string line. Check the alignment of units periodically and make adjustments where necessary.

- Trim paving units to shape and size to form boundaries. Do not insert pieces of a size less than one-third of a full unit as far as possible.

- To work round any obstructions such as tree planting pits, surround the obstruction with concrete strips to form a more regular shape first, and then cut paving units to abut the surround.

4.6.8 Compaction and Joint Filling of Paving Units

- Fully compact paving units using a plate compactor with a plate area of not less than 0.25 m^2.

- After compaction of the paving units, spread sand over the surface and brush it into the joints.

- Vibrate paving units to ensure complete filling of the unit-to-unit joints by the surface-applied sand. Where necessary, add further sand and re-vibrate the paving units.

5. AESTHETICS AND DESIGN CONSIDERATIONS

5.1 Colour

5.1.1 Colour of the precast concrete paving units is an important design tool in achieving both functional and environmental enhancement of the local character of a district and the local environment. It could reduce glare, and to stimulate interest as illustrated in **Plate 1**.

5.1.2 To choose a right colour for a paving, chromatic composition and chromatic "mood" of the district should be analysed to enhance the local environment.

5.2 Texture

5.2.1 Texture is one of the merits of precast concrete unit paving. Different textures could be achieved by sizes, shapes and bonding; which would have a significant effect on appearance.

5.2.2 Different textures may be used in combination on large areas in order to modify apparent proportions and to provide contrast and interest. However, it is advisable to keep a simple texture created by a uniform bonding and pattern along a localised strip of pavement. As a rule of thumb, narrower footpath seems to be more conforming to

uniform paving patterns and wider footpaths tend to allow more complex patterns to break the monotony. **Plate 2** illustrates this point.

5.3 Proportion and Scale

Proportion and scale may be defined as the scheme of dimensional ratios and size relationship to the surrounding respectively. It appears that certain dimensional ratios and scale are widely accepted as being more pleasing and desirable than others.

5.3.1 Relation with the Width of Footpath

The proportion and scale of the precast concrete paving units to the width of the pavement strongly influence the character of the local environment and does create a particular visual experience to the pedestrians. Generally speaking, smaller precast concrete paving units should be used in narrow pavements while bigger units in wide pavements. **Plate 3** & **4** illustrate these points.

5.3.2 Relation with the Openness of the Footpath

Smaller units should be used on footpath enclosed by tall buildings while larger paving units could be used on footpath in open areas.

5.4 Visual Rhythm and Rhyme

Rhythm is concerned with the organisation of repetitive features, which shall as far as possible be both uniform and simple. Rhyme, or "likeness tempered with difference" gives variation without breaking the rhythm, as illustrated in **Plate 5**.

5.4.1 Laying Pattern

The laying pattern should be carefully designed taking into account the overall configuration and general direction of the areas to be paved so as to minimise on-site cutting of precast concrete paving units at edges and facilitate major changes in direction without loss of bonding. As a rule of thumb, it is advised to use right-angled type of paving pattern for straight footpath, as illustrated in **Plate 6**.

5.4.2 Treatment round Footpath Corners

Very often different paving designs meet at the corner of footpaths. For easier construction and clear demarcation, it is advised to extend the paving of the footpath along the more primary road across the corner.

5.4.3 Paving for Curving Footpath

Due care should be given to adopt an appropriate pattern conforming to the curving character of the footpath. **Plate 7** illustrates one of the desirable treatments around corners. **Plate 8** shows a poor practice in an abrupt change in direction of paving patterns.

5.5 Harmony and Coherence

A harmonious relationship exists between a number of things when they complement each other so that their combined effect is more pleasing than their separate contributions. There must be no discordant features.

5.5.1 Treatment where Different Paving Meet

It is advised to keep a uniform character of paving design along a localised strip of pavement. Where this cannot be avoided, careful consideration must be given to treat the boundary for harmony and coherence of character as shown in **Plate 9**. **Plate 10 & 11** show a poor laying pattern. Edging units or a concrete margin should be used whenever there is a change either in direction or paving pattern, that will involve a number of cut paving units.

5.5.2 Treatment of Structure Footings

In many cases the exposed footings of structures is in plain concrete that is obviously not visually pleasing; in particular when the surrounding paving is having a strong character. It is therefore more desirable to recess these footings into the ground as illustrated in **Plates 12** and **Plate 13**. If this is not feasible, colour mortar should be considered to match with the surrounding paving units. **Plate 14** shows a footing of a railing without recess nor coloured mortar.

5.5.3 Relationship with Utility Covers

In selecting paving units and pattern, due consideration should be given to the character and presence of utility covers on the footpaths. The selected type of paving should relate and conform to the orientation of the utility covers. As a good practice, the utility covers should be constructed to align with the kerb line for better integration of the paving design as illustrated in **Plates 15 & 16**. Where paving units are used as infill for manhole/utility cover, an attempt should be made to orient the infill units to align with adjacent paving blocks. **Plates 17 & 18** are perfect examples while **Plates 19, 20 & 21** show poor practices. Due attention should also be given to backfilling around manhole covers. Concrete should be avoided if possible as illustrated in **Plate 22** which is in sharp contrast to **Plates 23 & 24**. Otherwise, pigment concrete of matching colour should preferably be used.

5.6 Expression of Function

Function of the paving could be clearly expressed and defined by using colour, texture and pattern.

5.6.1 Treatment of Run-in and Level Crossing

For run-ins across footpaths, it is advised to adopt a paving design contrasting to that of the adjacent footpath. Change of colour of the precast concrete paving units of the run-in and for the area in front of level crossing can alert both the pedestrians and the drivers, as illustrated in **Plate 25**.

5.6.2 Treatment around Street Trees

Precast concrete paving units can be placed around street trees as a protective measure. It has the advantage of integrating tree pits into the paving design as illustrated in **Plate 26.**

5.7 Consultation

The Landscape Unit of Highways department should be consulted regarding the selection of colour and pattern of precast concrete paving units, and any other associated landscape provisions such as tree planting.

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