



FLEXIBLE PAVEMENT INSTALLATION GUIDE

This guide aims to provide a basic background to the design and construction of flexible pavements using C&M Brick concrete pavers in commercial applications. Detailed guidelines are provided in documents from the Concrete Masonry Association of Australia (CMAA) listed below.

T44 Concrete Segmental Pavements - Guide to Specifying

T45 Concrete Segmental Pavements - Design Guide for Residential Accessways and Roads

T46 Concrete Segmental Pavements - Detailing Guide

MA44 Concrete Flag Pavements - Design and Construction Guide

The surface layer of a flexible concrete segmental pavement relies on the interlock between the paving units to gain its strength, as there are no binding materials, such as cement, in the bedding sand. When properly designed and constructed, particularly when placed on an unbound base course, the stiffness of the surface layer of paving units progressively increases under traffic. This makes flexible pavements ideal for most pavement applications from footpaths and malls to vehicular trafficked areas such as car parks, roads and heavy-duty industrial pavements.

Flexible segmental pavements consist of three basic layers:

Subgrade: The subgrade is the prepared and compacted in-situ soil or fill on which the pavement is constructed.

Base Course: The base course includes one or more layers of high quality unbound crushed rock or natural gravel, cement modified or cement-bound materials or lean-mix concrete.

Surface: The surface layer includes the concrete segmental paving units, a bedding course and edge restraints. Gaps, more commonly referred to as 'joints', between paving units are completely filled with a fine joint-filling material.

DESIGN CONSIDERATIONS

Subgrade

The strength of the subgrade, usually assessed in terms of the soaked California Bearing Ratio (CBR), will be needed to determine the thickness of the base course for each application. On low-strength subgrades of a sub-base layer, chemical stabilization or geotextile fabrics can be incorporated in the pavement to provide a firm and stable platform for further construction.

Base Course

The type of materials used and the thickness of the base course are determined by assessing the subgrade strength and the traffic loadings to which the pavement will be subjected. Design charts

for some common circumstances are available from the T45 Concrete Segmental Pavements - Design Guide for Residential Accessways and Roads (Figure 5) and MA44 Concrete Flag Pavements - Design and Construction Guide (Design Charts A, B & C). Pedestrian only pavements generally require a base course layer of between 75mm to 100mm thickness. A design engineer should be consulted to determine the base course requirements for commercial applications. Computer software for thickness design of concrete segmental pavers, Lockpave - Structural Design of Interlocking Concrete Segmental Pavements has been developed and is available from the CMAA.

To ensure good performance in a concrete segmental pavement it is essential to use materials of an appropriate quality. As a minimum unbound base course materials should comply with local requirements for an asphalt-surfaced pavement. Representative properties of unbound base course materials are provided in Table 4 of T45 Concrete Segmental Pavements - Design Guide for Residential Accessways and Roads.

Surface Layer

Paving Units:

Three factors are involved in the selection of the paving units: shape, thickness and laying pattern. For details on the minimum specifications required of the paving units for common applications, see Table 1 of T44 Concrete Segmental Pavements - Guide to Specifying, Table 1 of MA44 Concrete Flag Pavements - Design and Construction Guide and Table 3 of T45 Concrete Segmental Pavements - Design Guide for Residential Accessways and Roads. For pavements trafficked only by light vehicles a range of laying patterns can be used, but the most effective is herringbone bond. The direction of traffic has little effect on the performance of paving units laid in this bond, irrespective of the orientation of the rows of paving units. Other bonds can perform poorly if orientated incorrectly in relation to the traffic direction.

In C&M's extensive paving range you will find a paver for every application and your local C&M representative can assist the designer in choosing the correct paver.

The small gaps or joints between the pavers, nominally 2-5mm wide are filled with a fine material. The filling material should be washed free of soluble salts or contaminants that cause or contribute to efflorescence, and the use of cement is not recommended. To assist in the complete filling of the gaps, the joint filling material should be as dry as practicable when spread.

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Bedding Course:

The quality and thickness of the bedding course have a significant influence on the performance of the pavement. The bedding course has a nominal compacted thickness of 25mm. The use of a bedding course thicker than 30mm is not recommended as it can result in differential compaction and will add unnecessary cost. Materials such as good quality concreting sands have given good performance provided that the following requirements are met. Single-sized, gap-graded or material containing an excessive amount of 'fines' will lead to reduced performance. The use of a cement-bound material is not recommended. When placed on the base course, the material should be washed and free of impurities and have a uniform moisture content. Saturated material should not be used, as it will not compact properly, resulting in an uneven paved surface. Moisture contents in the range 4-8% have been found to be suitable.

Edge Restraints:

An edge restraint is required at the perimeter of the pavement to maintain bond in the surface layer. Restraints can also be used to separate areas having different laying patterns. The function of the edge restraint is to prevent movement of paving units near the perimeter under the action of traffic and to limit any consequent opening of joints and spreading of paving units. Edge restraints are required to have sufficient stability to withstand occasional vehicle impact. Information on the selection and detailing of edge restraints is contained in Data Sheet 3 of T46 Concrete Segmental Pavements - Detailing Guide.

Surface Detailing

Special detailing around boundaries and penetrations such as drainage pits must be used, the use of full pavers around openings and boundaries prevent smaller cut pavers being exposed to the edge. Flexible pavements require good detailing at these points, should pavement failure occur, then it will generally start at these locations. Guidance on surface detailing is included in T46 Concrete Segmental Pavements - Detailing Guide.

Pavers abutting fixed objects such as light poles, seats, bins, kerbs, buildings etc require a 10mm control joint. The control joint must be filled with a propriety sealant and the application shall be in accordance with the manufacturer's specification.

Drainage

Good surface, sub-surface and subsoil drainage is essential for satisfactory pavement performance. Drainage needs to be considered during the design and construction phases of the project.

Requirements for surface profile, location and sizes of kerb gullies, surface inlets, and the provision of sub-surface and subsoil drainage are the same as for other pavements on the site. During its early life, some rainwater may penetrate the pavement via the filled joints. Experience indicates that as detritus is deposited in these joints, pavement permeability is substantially reduced. This process may take some time and the use of a bituminous prime coat on the base course before placing the bedding course can minimise early water penetration into the base course. Information on detailing of the drainage of the bedding course at pavement perimeters, especially important where heavy rainfall may occur or on wide pavements, is contained in Data Sheet 10 of T46 Concrete Segmental Pavements - Detailing Guide.

MATERIALS AND CONSTRUCTION SPECIFICATIONS FOR FLEXIBLE PAVEMENTS USING C&M BRICK PAVING UNITS

WARNING:

This model specification is only provided as an aid to design and for general guidance. They should not be used for contractual or costing purposes without being verified by a qualified Civil Engineer.

1. SPECIFICATIONS FOR CONCRETE PAVERS

1.1 Materials

1.1.1 Cement

Cement shall comply with AS 3972

1.1.2 Fly Ash

Fly Ash shall comply with AS 3582 Part 1

1.1.3 Aggregate

Aggregate shall comply with AS 2758 Part 1

1.1.4 Water

Water shall be free from matter in a quantity harmful to concrete.

1.1.5 Admixtures

Any chemical admixture used in the concrete shall comply with AS 1478.

1.2 Physical Properties

1.2.1 Paver Shape

Pavers shall be as shown in the drawings and laid in the bond shown on the drawings. Pavers shall incorporate chamfers between the upper (wearing) surface and the sides.

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1.2.2 Nett Area

The nett area of any paving unit shall not be less than 75% of the gross plan area. (The nett area is defined as the plan area of the top surface of the unit bounded by the chamfer).

1.2.3 Tolerance on Dimensions

The dimensions of any paver shall be such that it complies with Table 2.3 of AS 4455.

1.2.4 Strength

The characteristic breaking load and flexural strength shall be determined in accordance with AS 4456.5

1.2.5 Appearance

All pavers shall be sound and free from major cracks or other defects, which would interfere with proper placing or impair the strength with proper construction. Minor cracks incidental to the usual method of manufacture or minor chipping resulting from the usual methods of handling, shipment and delivery shall not be deemed grounds for rejection.

The manufacturer and purchaser shall agree on the quality that is acceptable and on a reasonable means of inspection and assessment at the manufacturer's yard before delivery.

1.2.6 Abrasion Resistance

The 'mean abrasion index' shall be determined in accordance either AS 4456.9

1.3 Sampling and Testing

The engineer or his authorised representative shall be accorded proper facilities to inspect and sample the pavers at the place of manufacture from the lots ready for delivery. AS 4456.1 sets out the method of sampling segmental pavers for compliance testing of an identifiable lot.

1.4 Acceptance and Rejection

AS 4455 - Appendix A sets out the criteria for demonstrating compliance.

NOTE

The Concrete Masonry Association of Australia's publication T44 'Concrete Segmental Pavements - Guide to Specifying' sets out industry recommendations for the manufacture of concrete segmental pavers. T44 fully references AS 4455 and AS 4456.

2. SPECIFICATION FOR BEDDING AND JOINTING SANDS

2.1 Bedding Sand

The bedding sand shall comprise a clean well-graded sand passing a 4.75mm sieve and suitable to concrete manufacture. The sand shall comply with the following grading limits:

Sieve Size	% Passing
9.52mm	100
4.75mm	95 - 100
2.36mm	80 - 100
1.18mm	50 - 85
0.60mm	25 - 60
0.30mm	10 - 30
0.15mm	5 - 15
0.075mm	0 - 10

The bedding sand shall be free of deleterious soluble salts or other contaminants likely to cause efflorescence. No deviation from these specifications shall be permitted.

2.2 Jointing Sand

The jointing sand shall pass a 2.36mm sieve. The sand shall be free of soluble salts or contaminants likely to cause efflorescence. The sand shall comply with the following grading limits:

Sieve Size	% Passing
2.36mm	100
1.18mm	90-100
0.06mm	60-90
0.03mm	30-60
0.15mm	15-30
0.075mm	5-10

The sand shall be washed and free of salts or contaminants that can contribute to efflorescence. The use of cement in the jointing sand shall not be permitted.

3. SPECIFICATION FOR BASE MATERIAL

Minimum Marshall Stability (50 blow compactive effort) 6.0 kN

Minimum Marshall Flow 2mm

Maximum Marshall Flow 4mm

3.1 Unbound Granular Base

Unbound granular base material shall comprise either a graded crushed rock derived from the crushing of solid unweathered quarried rock or clean boulders or a graded crushed stone/soil mixture derived from crushing rock, boulders or coarse gravel which may contain natural 'fines' not derived from crushing the

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parent rock. The material shall generally comply with the requirements listed in Table 1.

4. PRIME (If Applicable)

The base shall be primed after compaction. The preferred primer shall comprise a medium-curing cut-back asphalt. Alternatively the use of a medium setting asphaltic emulsion diluted with water 2 to 1 by volume may be permitted.

A prime shall not be required where the base is asphalt.

5. SUBGRADE PREPARATION

The subgrade shall be compacted to a density not less than 100% of standard AASHTO maximum dry density using approved vibratory or impact rollers. Subgrade preparation shall extend to the rear face of all edge restraints. Where directed any unsuitable material shall be removed from the subgrade and replaced by approved fill or by sub-base material suitably compacted.

Drainage, construction and service trenches within the pavement area shall be backfilled to subgrade level with an approved granular material and compacted to not less than 100% of standard maximum density.

The subgrade shall be trimmed within +0, -25mm of nominated design levels. The surface of the prepared subgrade shall not deviate by more than 12mm from the bottom edge of a 2m straight edge laid in any direction.

6. BASE AND SUB-BASE CONSTRUCTION

The base and sub-base shall nowhere be of lesser thickness than that shown in the drawings and shall be of sufficient width to extend to the rear face of all edge restraints. Materials shall be spread and brought to optimum moisture content and specified density in layers each not exceeding 150mm loose depth.

The base shall be trimmed to within +0, -10mm of nominated design levels. The surface of the prepared base shall not deviate by more than 10mm from the bottom edge of a 2m straight edge laid in any direction.

The upper layer of the base shall be sufficiently well graded and compacted to prevent infiltration of the bedding sand into its surface both during construction and throughout the life of the pavement. If the available base materials are unsuited to this requirement then the upper surface shall either be blinded by the application of crushed 'fines', which shall then be watered and compacted into the surface prior to being sealed with an asphaltic primer as specified in Clause 4 of this specification.

6.1 Unbound Granular Base

Base material shall be spread in uniform layers not exceeding

150mm in thickness using methods that will ensure that segregation does not occur. Where required for compaction purposes water shall be added and mixed uniformly with the pavement material by approved mechanical means. If there exists excess moisture in the material it shall be dried to the required moisture content by loosening and aerating the material.

Base material shall not be spread upon a waterlogged subgrade. If at any time the subgrade or sub-base material becomes rutted or mixed together the contractor shall at his own expense remove the material, reshape and re-compact the subgrade and replace the base with fresh material.

After spreading, the base shall be brought to a suitable moisture content for compaction. For crushed rock base the material shall be placed near saturation moisture content and shall be slushed to increase the compacted density. For crushed stone/soil bases the material shall be placed at optimum moisture content for the compaction equipment. Compaction shall proceed until the base achieves a minimum dry density not less than 98% of modified maximum density to AS 1289.

Any irregularities in excess of the surface tolerances stated above shall be corrected by trimming the surface to correspond to the designed cross section and grade. Under no circumstances shall quarry dust or bedding sand be used to fill up depressions. After compaction and trimming the base shall be primed in accordance with Clause 7 of these specifications.

7. PRIMING (If Applicable)

After the base has been compacted and trimmed to final level it shall be primed using a binder approved by the engineer and meeting the requirements of Part 4 of these specifications. In the case of a cement treated base the prime shall be applied as soon as possible and not later than sixteen hours after completing finishing operations. For crushed rock or crushed stone/soil bases the prime shall be applied as soon as possible after completion unless the base is very moist when priming shall be delayed until the top 10mm to 25mm has partially dried out.

Unless approved by the engineer priming shall not be carried out when the spraying performance of the distributor is likely to be affected by wind or when rain is threatening. Before priming the pavement shall be swept with a mechanical broom to remove loose particles and extraneous matter. The prime shall be sprayed with a binder distributor calibrated to give an accurate rate of application and tested for satisfactory transverse distribution. The rate of application of residual bitumen shall be 0.6 l/sq m. Traffic shall be kept off the pavement until the prime has dried

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sufficiently to avoid being picked by the tyres of vehicles. If so directed by the engineer the contractor shall bind the primer by a light application of sand meeting the requirements laid down in Clause 2 of these specifications.

8. CONSTRUCTION OF THE SAND BEDDING COURSE

8.1 Material

Bedding and jointing sand shall comply in all respects with the requirements of Clauses 2.1 and 2.2 of these specifications. No deviation from these specifications shall be permitted without the approval of the engineer.

8.2 Moisture Content

The sand shall be of uniform moisture content when spread and shall be protected against rain when stockpiled on site prior to spreading.

8.3 Spreading

The bedding sand shall be spread loose in a uniform layer whose thickness shall be chosen on the basis of field trials to give a depth after compaction of the pavers of between 20mm and 30mm.

8.4 Screeding

The spread sand shall be carefully maintained in a loose condition and protected against pre-compaction both prior to and following screeding. Any pre-compacted sand or screeded sand left overnight shall be loosened before further pavers are placed. Sand shall be lightly screeded in a loose condition to the pre-determined depth only slightly ahead of the laying of the pavers. Under no circumstances shall the sand be screeded in advance of the laying face to an extent to which paving will not be completed on that day.

Screeded sand shall be fully protected against accidental precompaction including compaction by rain. Any screeded sand that is pre-compacted prior to the laying of pavers shall be removed and brought back to profile in a loose condition. Neither pedestrian nor vehicular traffic shall be permitted on the screeded sand.

The contractor shall screed the bedding sand using either an approved mechanical spreader (e.g. an asphalt paver) or by the use of screed rails and boards.

9. LAYING CONCRETE SEGMENTAL PAVING UNITS

9.1 Materials

The shape, thickness and quality of the pavers shall comply in all respects with Clause 1.3 of this specification.

9.2 Laying Pattern

Pavers shall be laid in the designated laying pattern throughout the pavement. Once the laying pattern has been established it shall continue without interruption over the entire pavement surface. Cutting of pavers, the use of infill concrete or discontinuities in laying pattern will not be permitted except along the outer pavement boundaries, and adjacent to drains and man-holes.

9.3 Laying Pavers

Pavers shall be placed on the uncompacted, screeded sand bed to the nominated laying pattern, care being taken to maintain the specified bond throughout the job. Pavers shall be placed to achieve joints nominally 2mm to 5mm wide between adjacent pavers such that all joints are correctly aligned.

The first row shall abut an edge restraint with a gap of 2mm to 3mm and shall be laid at a suitable angle to the edge restraint to achieve the required visual orientation of paving units in the completed pavement.

In each row all full units shall be laid first. Closure units shall be cut and fitted subsequently. Such closure units shall consist of not less than 25% of a full unit. Units may be cut using a mechanical or hydraulic guillotine, bolster, or by power sawing. To infill spaces between 25mm and 50mm wide it is recommended that a concrete having a 1:2:4 cement: sand: coarse aggregate mix be used. Within the concrete mix the nominal aggregate size should not exceed one third of the smallest dimension of the infill space. For smaller spaces dry packed mortar may be used. Except where it is necessary to correct any minor variations occurring in the laying bond the paving units shall not be hammered into position. Where adjustment of position is necessary care shall be taken to avoid premature compaction of the sand bedding.

9.4 Initial Compaction

After laying the paving units they shall be compacted to achieve consolidation of the sand bedding and brought to design levels and profiles by not less than three passes of a suitable plate compactor. The compactor shall be a high frequency, low-amplitude mechanical flat plate vibrator having a plate area sufficient to cover a minimum of twelve paving units.

Compaction shall proceed as closely as possible following laying and prior to the acceptance of any traffic.

Compaction should not be attempted, however, within one metre (yard) of the laying face. Compaction shall continue until lipping has been eliminated between adjoining units. Joints shall then be filled and compacted as hereinafter described.

All work to within 1 metre of the laying face must be left fully

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compacted at the completion of each day's laying. The pavement surface shall not deviate by more than 12mm from a 2m straight edge laid in any direction.

10. EDGE RESTRAINTS

Adequate edge restraint shall be provided along the perimeter of all paving in the form of integral kerb and gutter, concrete kerb or edge strip or established structure. The face of the edge restraint, where it abuts paving units, shall be vertical down to the base. All edge restraints shall be constructed to the dimensions and levels as shown on the drawings and shall be supported on a compacted sub-base not less than 100mm thick.

TABLE 1 SPECIFICATION FOR UNBOUND GRANULAR BASE

Particle Size Distribution

Sieve Size (mm)	(%)	or	(%)
53	100		100
37.5	100		100
26.5	84 - 94		100
19.0	71 - 84		85 - 95
13.2	59 - 75		71 - 84
4.57	36 - 53		42 - 60
2.00	23 - 40		27 - 45
0.423	11 - 24		13 - 27
0.075	4 - 12		5 - 12

Plasticity

Liquid Limit (max)	25	25
Plasticity Index (max)	6	6
Linear Shrinkage (max)	3	3

Strength

Min. Soaked CBR (%)	80	80
Max. Swell (%)	0.5	0.5

