Guidelines for Construction of Concrete Footpath Slabs

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1. Introduction
The purpose of this document is to provide guidance on constructing residential concrete footpaths complying with the Australian standards. The document combines the provisions in the Australian Standard: Guide to Residential Pavements[1] with those covered in the newly published "Guide to Residential Streets and Paths"[2] and presents information in a user friendly manner for practitioners for installation in the field. The document is structured into four main sections covering general information, un-reinforced pavements, reinforced pavements and correct construction procedures. In conclusion, the advantages offered by TripStop for all the stakeholders are summarized.

2. General Information
Design and construction of reinforced and un-reinforced concrete slabs on ground is a mature technology. The concepts of design and proper construction practices are well understood and documented. Concrete slabs used in residential footpaths transfer weight of pedestrian traffic and bicycle traffic to the ground. Slabs are relatively narrow (approximately 1.5 m) and the length of each panel is determined by the spacing of control joints. If the supporting sub-base is firm, the footpath slab is capable of resisting very large concentrated loads without failure. However, if the sub-base is not prepared and/or consists of a highly reactive soil, slabs can fail in bending under concentrated loads such as those of a wheel of a car. This is prevented by imposing a minimum breaking load of pavement units in a bending test for segmental pavements and specifying a minimum compressive strength for concrete pavements.

Shrinkage of concrete can cause failure of on-ground concrete slabs and is usually controlled by providing control joints (also known as contraction joints) and/or steel reinforcement. Reinforcement in on-ground slabs controls cracking due to concrete shrinkage and/or stresses induced due to soil movement.

3. Plain concrete footpaths used in residential streets
Plain concrete footpath slabs do not contain any steel reinforcement and are easy to construct. Provisions of table 2 of AS3727[1] summarized below in table 1, indicate that control joints should be spaced at least at 2 m intervals. The detail of a typical control joint in an un-reinforced slab is shown in Figure 1.

Reinforcement is required in some slab panels to control cracking as specified in Guide to Residential Streets and paths[2]:

- Slabs of irregular shape, or not square or near square (ie a slab with a width: length ratio exceeding 1:1.25)

[1] AS3727, Guide to Residential Pavements, Standards Australia, 1993
[2] Guide to Residential Streets and Paths, Cement and Concrete Association of Australia, 2004

- Slabs opposite a mismatched joint
- Slabs containing pits or access holes (wholly within the slab), slabs adjacent to rigid structures

These slabs should have SL72 mesh placed as shown in Figure 2.

Plain concrete footpath slab has the lowest initial cost, with the simplest construction method. These should not be used in areas where ground conditions are prone to large uneven settlements[1]. Large uneven settlements will cause cracking in the mid slab as well as uneven deformation of adjacent slabs at a control joint creating a tripping hazard. A shear connection such as that provided by TripStop will enhance the slab performance by providing an articulation mechanism if one panel is displaced.

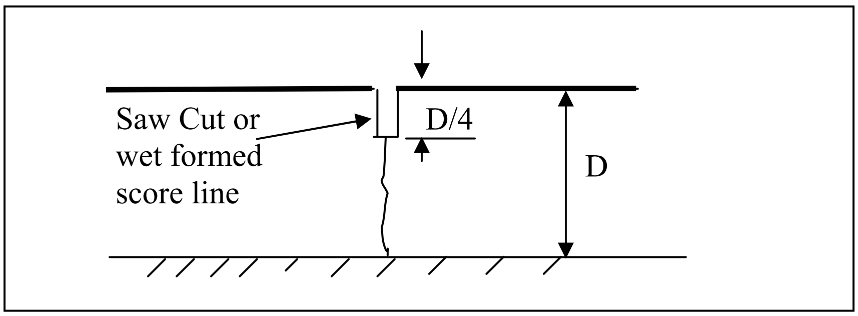

Figure 1: Control joint in an un-reinforced footpath slab

Table 1: Typical Concrete Pavement Specification for Residential Applications (AS3727, 1993)[1]

Traffic	Minimum slab thickness mm	Minimum concrete grade MPa	Alternative 1 Un-reinforced		Alternative 2 Reinfroced		Alternative 3 Reinforced	
			Maximum control joint spacing	Minimum reinforcing fabric	Maximum control joint spacing	Minimum reinforcing fabric	Maximum control joint spacing	Minimum reinforcing fabric
Foot & bicycle	75	20	2	NA	NA	NA	NA	NA
Light Gross mass not exceeding 3 tonnes	100	20	2	NA	3	F52 (SL52)	6	F62 (SL62)
Medium Gross mass not exceeding 10 tonnes	150	25	2	NA	4	F72 (SL72)	6	F82 (SL82)

[1] AS3727, Guide to Residential Pavements, Standards Australia, 1993

3. Reinforced Concrete footpaths for residential streets

Use of reinforcement in on-ground slabs control cracking due to shrinkage of concrete and/or stresses induced due to soil movement. Reinforced slabs may have control joints at larger intervals (3-6 m) than the maximum spacing allowed in un-reinforced slabs. Since reinforcement is provided to control shrinkage and soil movement, they should be located closer to the upper surface of the slab. Table 1 given above, prescribes the reinforcement required in footpath slabs based on the type of traffic expected. The mesh identification numbers given in AS3727 have been superseded with new One Steel meshes numbered as "SL", which are given within brackets.

The detailing specified for control joints in AS3727[1] is shown in Figure 2. Reinforcement should be located with a minimum clear cover of 30 mm to the top surface of the slab and essentially above mid-depth of the slab. The saw cut (or wet formed score line) requires to have a width of 3 to 5 mm and a depth equal to at least one fourth of the slab depth.

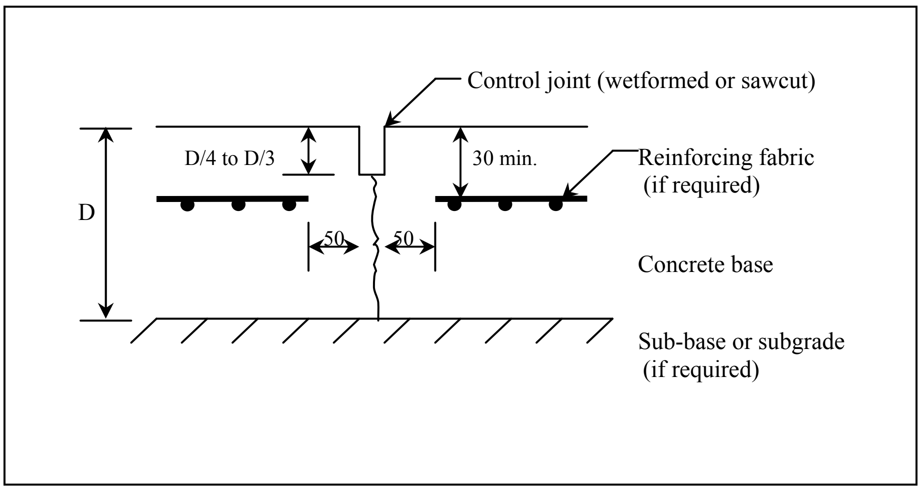

Figure 2: Control joint in a reinforced footpath slab

At a control joint, on either side, steel reinforcement should be discontinued at a minimum distance of 50 mm from the joint (Figure 2). In road pavements, these joints require 20 mm diameter dowel bars (Figure 3) of grade 250 steel placed at 300 mm intervals to ensure load transfer across the control joint. Whilst dowel bars are not essential for footpath slabs, the Guide to Residential Streets and Paths[2] mentions usage of dowel bars when step faulting (pavement shear) is likely to occur due to growth of tree roots and/or soil movement. The minimum size of dowel bars recommended is 20 mm diameter, placed at mid-depth of the slab. However, in situations where tree root invasion or soil movement causes step faulting at the joint causing a trip hazard, the thin concrete cover to dowel bars can fail at even small differential movements of the slabs.

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[1] AS3727, Guide to Residential Pavements, Standards Australia, 1993

[2] Guide to Residential Streets and Paths, Cement and Concrete Association of Australia, 2004

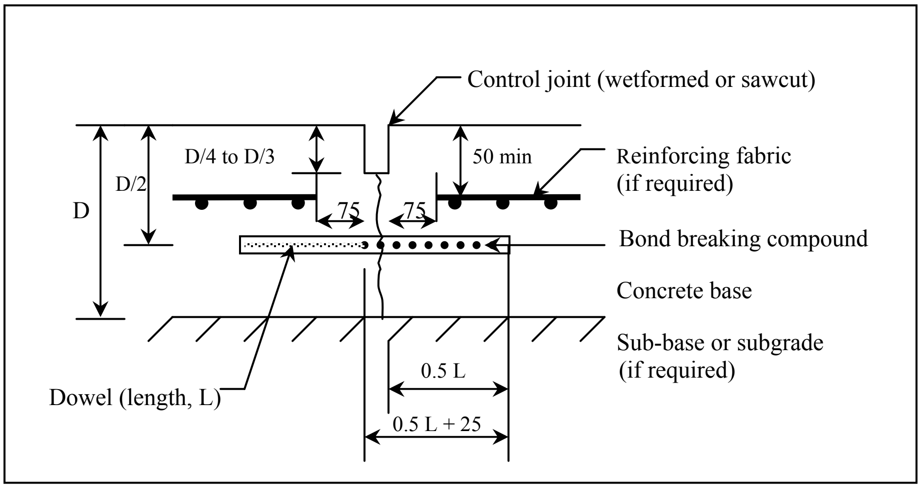

Figure 3: Dowelled Control Joint[2]

Shear connecting devices such as keyed joints are recommended as a precaution against step faulting[2]. Effectiveness of keyed joints can be limited by the capacity of very thin concrete elements of a footpath slab.

4. Construction Issues in Residential Footpath Slabs

4.1 Plain concrete footpath slabs

As clearly specified in the Guide to Residential Streets and Paths[2], the placing compacting, finishing and curing of concrete have a major influence on its strength and durability. Compaction using surface or immersion vibrators is recommended. For example, a 5% increase in voids can reduce the compressive strength of concrete by 30% below that of fully compacted concrete[2]. Low compressive strength will have a corresponding reduction in bending strength of the footpath slabs and even a small movement can cause failure of the slabs. Curing of concrete by covering of concrete or continuous wetting during the initial period is recommended with a minimum three day curing period for mild exposure conditions and seven day curing period for severe exposure conditions[3].

The joint detail shown in Figure 1 can be achieved by saw cutting or wet forming. Wet forming is more common in footpaths.

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[2] Guide to Residential Streets and paths, Cement and Concrete Association of Australia, 2004
[3] Guide to Concrete Construction, Standards Australia, Cement and Concrete Association of Australia, 2002

4.2 Steel-Reinforced Concrete Footpath Slabs

Reinforced footpath slabs will have reinforcing as per table 1 or SL62 fabric with joints spaced at 20 times slab depth (which agrees with provisions in Table 1)[2]. Proper placing and compaction of concrete becomes vital in reinforced footpaths due to the necessity of protecting reinforcing steel from corrosion. Permeable concrete will lead to rapid deterioration of the slabs through corrosion of steel.

In order to perform as intended, the steel reinforcement should be:

- in the form of a single sheet located in the upper half of the pavement base, subject to a minimum top cover of 30 mm according to AS3727[1]. This is increased in the newly published Guide to residential streets and paths to 50 mm;
- terminated 50 mm from transverse contraction joints and isolation joints (the distance is increased to 75 mm in reference 2);
- handled so that sheets are free from undue distortions or kinks;
- free from material which may affect bond with the concrete (a light coating of rust on the reinforcement will not impair its performance);
- supported on bar chairs in a regular grid not exceeding 1 m (it should neither be stamped down into the concrete nor laid on the ground and raised into the concrete);
- secured to the sub-base in such a way as to resist displacement during concrete placing.

4.3 Steel Fibre Reinforced Pavements

Use of steel or polypropylene fibre reinforcement is an extremely effective way of increasing the resistance of cracking of concrete due to shrinkage and also small bending stresses. Whilst these are not covered in AS3727, the Guide to Residential Streets and Paths[2] mentions use of steel fibre in irregular shaped slabs. Following note is extracted from the above publication, which further refers to Fibres in Concrete – Current Practices Note 35, Concrete Institute of Australia.

When using steel fibres manufacturers' specifications need to be carefully observed. Steel fibres are generally between 15 and 50 mm in length with either an enlarged end that acts as anchorage and/or crimping to improve bond. Typically, fibres 15 to 50 mm in length are added to the concrete at a rate of approximately 75 to 45 kg/m^3 respectively (referred to as 'fibre loading'). The fibre supplier's recommendations on concrete strengths, thickness and joint design should be obtained.

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[1] AS3727, Guide to Residential Pavements, Standards Australia, 1993

[2] Guide to Residential Streets and paths, Cement and Concrete Association of Australia, 2004

5. Trip Stop

Trip stop is a shear connector which can be easily installed in between reinforced or un-reinforced concrete footpath panels (Figure 4).

In un-reinforced slabs TripStop can be extremely valuable in eliminating the need for saw cutting or wet forming of contraction joints. A control joint formed using a saw cur or wet forming may fail to initiate a crack going through the depth of the slab as intended, if concrete at the joint is stronger (due to better vibration etc) than mid-slab concrete. TripStop can ensure provision of a proper contraction joint at the required location. The additional benefit of reducing the effect of step-faulting and resulting tripping hazard makes use of TripStop in un-reinforced footpath panels extremely attractive.

In reinforced slabs, TripStop will eliminate the expensive and unreliable use of dowel bars to reduce tripping hazard caused by step-faulting of adjoining footpath slabs. A reinforced footpath slab constructed complying with the provisions of AS3727, can easily accommodate TripStop as shown in figure 4.

A footpath slab constructed of steel fibre reinforced concrete with control joints made of TripStop would eliminate numerous problems causing failure of thin residential footpath slabs, such as corrosion of steel reinforcement, movement of sub grade soil and tree root invasion. Combining the two innovative solutions developed independently will offer advantages to all the stakeholders.

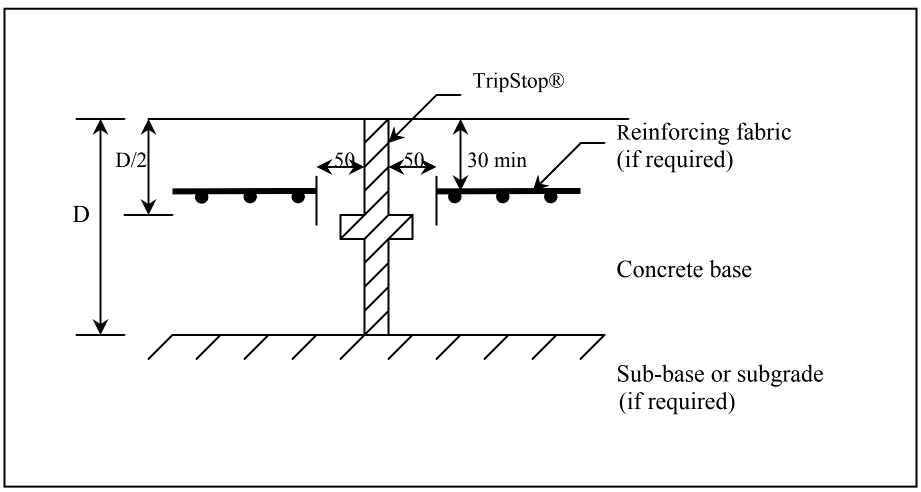

Figure 4: TripStop® joint