TripStop™ - physical and functional description

TripStop™ is a rigid µPVC profile that is used in concrete pavements to form transverse joints that are capable of transferring load while accommodating rotation and contraction or expansion. It is particularly suited to pavements designed for pedestrian or bicycle traffic. Pavements of this type are relatively lightly loaded but are often subject to relatively high levels of uplift from tree roots and subsidence and / or uplift from soil movement. They are subject to normal levels of expansion and contraction from temperature change and shrinkage.

TripStop™ accommodates significant upward or downward vertical movement at joints without the formation of trip hazards to pedestrians or damage to the concrete. It accommodates contraction without damage to the concrete. It is being increasingly used to eliminate the need for expansion joints, a common, if not inevitable source of trip hazards in pedestrian pavements.

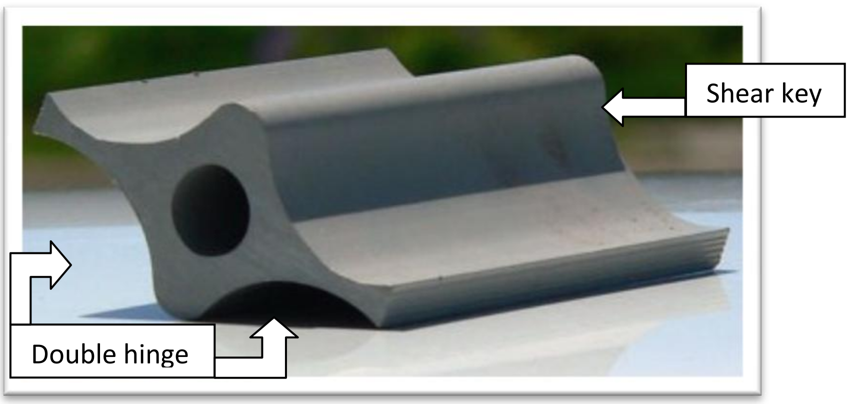
TripStop™ profiles are made to match common pavement thicknesses and are cut to match the width of the pavement. They are designed to be located at similar intervals to conventional contraction or dummy joints.

When a tree root grows under a slab in a pavement, it lifts and rotates the slab at the joint nearest to the point of uplift. If the joint is able to transfer load, the slab lifts and rotates the adjacent slab. As the two slabs rotate they lengthen in plan and thrust against each other at their lower edges and against the adjoining slabs at their upper edges, causing high localised stresses at these points. In plane-of-weakness joints this can cause spalling of the ends of the slabs. In continuously reinforced pavements rotations of the level often encountered in footpaths and cycleways can cause breakage of the reinforcing as well as spalling of the ends of the slabs. These effects reduce or destroy the shear capacity of either kind of joint and can lead to steps high enough to become trip hazards.

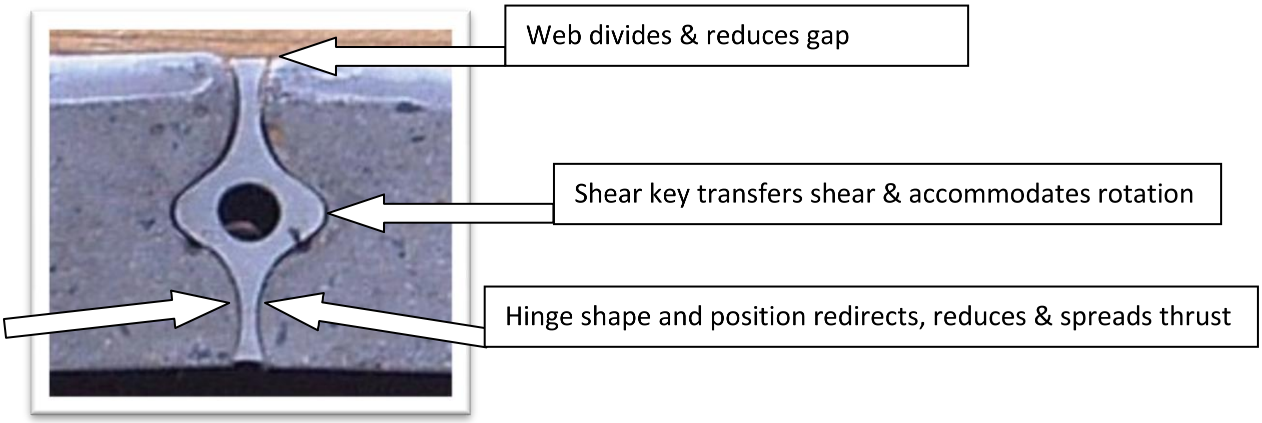
Note that movement caused by tree roots is permanent and happens gradually over time unlike that caused by traffic or temperature change. Soil movement can be of a permanent (e.g. subsidence) or fluctuating nature (e.g. reactive soils). Concrete shrinkage is predominantly of a permanent nature.

TripStop™ enables joints between slabs in a pavement to transfer load, while accommodating rotation, by providing a combined shear key and a double hinge. The shear key prevents steps of excessive size from forming as a slab is lifted or lowered at a joint by tree roots and / or ground movement. The key has a shape that enables it to accommodate rotation without reducing its ability to transfer load. The double hinge redirects the thrust induced by rotation, thus reducing both total thrust and local stress intensity, and spreads it, thus further reducing local stress intensity. TripStop™ enables a pavement to accommodate contraction by separating the slabs from which it is formed. Finally, the apparent reasons for TripStop's ability to accommodate expansion include;

- It provides no resistance to shrinkage at any stage during the setting and hardening of concrete. This facilitates the formation of gaps at joints of sufficient width to accommodate expansion (shrinkage strain is typically 2 -3 times that caused by expansion).
- Other than when there is significant uplift at a joint, the profile reduces the width of these gaps by dividing them, thus making them less susceptible to filling with debris.
- The top of the profile, being flush with the concrete, does not tend to capture debris, as does the groove in plane-of-weakness joints.
- The average size of the particles that enter the gaps is usually large relative to the width of the gaps, so that there is a substantial wall effect (ref 6.a, ch. 1). This prevents dense packing and creates a pseudo-compressible effect.
- Inevitable eccentricities in the expansion-induced thrust, acting upon the TripStop™ joints, which facilitate rotation, cause a self-limiting "concertina" effect in the slabs in a pavement, providing a means of progressive relief of expansion strain.
- These actions combine to ensure that there is sufficient space for expansion over time. This should not be taken to imply that TripStop™ has been used to replace expansion joints in conventional pavements; what is referred to here are "all-TripStop™" pavement systems.



TripStop™ profile



TripStop™ in partially uplifted slabs (In larger uplifts the web tends to move to one side rather than remain central as shown here)

TripStop™ specification

1. Appearance

TripStop™ is a rigid µPVC profile having a semi gloss surface and a light grey colour designed to blend with concrete. It is supplied in heights of 75, 100 and 125 mm, having weights per metre of 1.1, 1.7 and 2.3 kg respectively. The top surfaces of the webs are grooved for slip resistance. The profiles are cut to length to the customer's requirements and provided with vertical holes in the shear key so that they can be positioned using (supplied) galvanised steel pins.

2. Ease of Use

No special skills or tools are required for the installation of TripStop™ beyond those needed to construct conventional pavements. An installation video and downloadable guide are available. See our downloads page on our website at www.tripstop.net . We recommend that asset owners encourage first-time installers to study the provided information, understand how a TripStop™ pavement system works and undergo on site training. It is important that they know how to plan for and construct transitions, such as at driveways and dead-ends, so that the integrity of the total system is assured. While installation is essentially simple, much like installing metal key joints, there are many points of technique that can help installers increase productivity and quality. TripStop P/L is willing to provide on-site training when there is sufficient demand.

3. Performance

a. Speed of construction; naturally, this will be slower during an installer's learning period. Beyond that, our experience is that TripStop™ is not a cause of delay, and even, because it aids screeding (particularly where footpaths abut fences) and eliminates the need for edging or tooling at transverse joints, that speed is increased.

b. Safety-Critical

i. TripStop™ is made from virgin, UV and ozone stabilised μPVC and does not any contain lead, cadmium or any other heavy metals.

c. We strongly discourage the cutting of TripStop™ profiles using hand-held power tools; PVC is a thermoplastic that binds to blades when heated. The profiles can be readily cut using hand saws or bench mounted equipment. See our website www.tripstop.net downloads page.

d. Dimensional accuracy

i. TripStop™ profiles are supplied to the following tolerances;

- Cross-section; ± 0.5 mm laterally and ± 1 mm vertically (depending on size)
- Straightness; ± 25 mm / m horizontally (bow)) and ± 2 mm / m vertically (crown). Bow within the above tolerance can be straightened on site using the provided pins.
- Crowned profiles should be installed with the crown upwards.
- Twist; ± 1.0 mm /m from vertical.
- Length + 0 -10 mm relative to that specified by the customer.

Product outside these tolerances should not be installed.

ii. TripStop™ profiles should be installed to within 5 mm of vertical. In the horizontal direction they should be installed to ± 30 mm per metre of width from a right angle to the length of the pavement. In curved sections of pavement, where they may be installed radially, they should be installed to ± 30 mm per metre of width from a radial line.

e. Capacity

i. TripStop™ is designed, when installed as specified by TripStop P/L at intervals of up to 3500 mm in pavements constructed in accordance with AS3727-1993, to enable the slabs of which such pavements are comprised to rotate about the joints between them by up to 3.8^0 in either direction i.e. to a subtended angle of 176.2^0, while sustaining an imposed loading of 2.5 kPa (Light Vehicle Traffic as per AS1170.1:2002) on the slabs adjoining such joints, without the creation of steps exceeding 6 mm in height. This rotation may occur in any number of contiguous slabs so long as the rotation at the joint between any two slabs does not exceed 3.8^0 in either direction. This rotation limit is based on a projected safety margin of 33% before this step limit is exceeded. In terms of strength, TripStop™ is designed, when installed as above, to enable an imposed loading of 5 kPa (Medium Vehicle Traffic as per AS1170.1:2002) on the slabs adjacent to a TripStop™ profile, when these slabs are rotated as above, without damage to this TripStop™ profile or to the ends of these slabs. This loading limit is based on the combinations for stability and strength given in AS1170.0:2002 and assumes that the worst case support condition will be that of a tree root growing from one edge of and transversely to the length of one slab, adjacent to a joint, and exerting a maximum pressure of 1 MPa on that slab (this defines the area and shape of the contact zone).

Note that pairs of rotated slabs could be considered to act as a three-pin arch or, when the slabs against which they abut do not provide sufficient horizontal reaction to support arch action, to act as individual suspended slabs.

ii. TripStop™ has been shown by independent test to enable pavements of thicknesses of 75, 100 and 125 mm, comprised of contiguous slabs separated by TripStop™ joints at 1500 mm intervals and made from concrete having minimum strengths of 20and 25 MPa respectively, while carrying uniformly distributed loads of 200, 300 and 400 kg respectively, to accept vertical uplift at a joint sufficient to cause a rotation between the slabs adjacent to the joint of 3.8^0 (e.g. an uplift of 50 mm at one end of a slab 1500 mm long), without causing a vertical step in excess of 6 mm at this joint. Further testing on the 100 mm thick pavement showed that it was capable of carrying an a uniformly distributed load of 2000 kg without causing a vertical step in excess of 6 mm at this joint. Other tests demonstrated the ability of the same pavements to be supported at one corner of a slab adjacent to a joint, while carrying point loads of 200, 300 and 400 kg respectively on the adjacent corner of the non lifted slab, without causing a vertical step in excess of 6 mm on the joint. Sustained application of uniformly distributed loads of 200, 300 and 400 kg respectively showed that creep stabilised at less than 5% of the instantaneous deflection. Given that when slabs of typical configurations are subjected to the imposed loads recommended in AS1170.1:2002 for light or medium vehicle traffic, the calculated stresses in both the TripStop™ profile and in the concrete at the ends of the slabs joined by the profile are low, we interpret these results to mean that the failure criterion for the slab sizes indicated in 3.d (i) above is not strength but step size, and that so long as there is enough horizontal restraint to prevent significant sliding of such slabs, step size is mostly a function of profile geometry and rotation. We further interpret the results to indicate that there is significant safety margin in the level of rotation that such slabs will accept without the creation of steps exceeding the limits suggested in AS3727-1993. The design rotations and loads in 3.d (i) above are based on this interpretation.

The test reports are available. See our website www.tripstop.net on the downloads page.

iii. TripStop™ has not been designed to resist horizontal forces transverse to the length of a pavement and has not been tested for performance when one slab within a pavement is displaced laterally relative to the adjacent slabs. However, given its ability to accept overload we expect that it will accept up to say 10% of the width of the pavement (i.e. 150 mm in a 1500 wide pavement) without reduction in performance. This does not apply when joints are radial to a curve in a pavement and are opened by the displacement e.g. where a pavement bends around a tree trunk and is laid so close to it that growth of the trunk causes both vertical and horizontal displacement. Our recommendation is that designers give thought to locating pavements far enough away from tree trunks to minimise the risk of transverse forces.

iv. TripStop™ has been used to replace expansion joints in residential pavements and cycle ways in many locations in Victoria, New South Wales and Queensland, with pavement lengths ranging from 10 to 200 metres, widths from 1.2 to 3 metres and joint spaces from 1.2 to 3 metres in 75, 100 and 125 mm thick pavements. Most have been subject to at least six cycles of seasonal temperature variation without visible buckling, random slab cracking, the formation of steps in excess of 6 mm or damage to the pavement or to driveways against which the pavements abut. Photographic evidence and map locations are available from TripStop P/L. The asset owners involved appear to have taken the view that expansion joints present a known hazard both in themselves and by undermining the ability of adjacent joints to work, and that there is sufficient field evidence of TripStop's ability to eliminate that hazard, to justify all-TripStop™ pavements.

f. Longevity: The grade of PVC from which TripStop™ profiles are made is similar to that used in structural products such as PVC pipes and the like. The service stresses in the profiles are low relative to the strength of the PVC. Little of the profile is exposed to UV radiation. Based on the foregoing, the life of the extrusion can be expected to match typical pavement design lives.

4. Operational and Environmental

a. Expected Physical Environment:

i. TripStop™ is designed to function in all the situations envisaged in AS3727-1993.

ii. All-TripStop™ pavements have been used in a limited number of situations susceptible to “sand-jacking,” without apparent signs of this phenomenon (TripStop P/L can provide photographic evidence and map locations), however at this point we recommend that asset owners design individual pavements for such situations.

b. Interfacing with adjacent systems: When a TripStop™ pavement interfaces with a dissimilar structure, the integrity of the total pavement system should be maintained.

i. Driveways; differential vertical movement frequently occurs between driveways and footpaths. In the case of all-new construction, a TripStop™ profile should be cast into the edge of the driveway and a transition slab constructed. In the case of an existing driveway and a new footpath, a transition stub should be constructed, connected to the driveway by deformed bar dowels. See our website www.tripstop.net on the downloads page. These details are not recommended for driveways less than 100 mm thick.

ii. Dead-ends; at any permanent termination of a pavement, enough longitudinal resistance should be provided to prevent “walking” of the terminal slabs. We recommend that consideration be given to providing this resistance via, for example, a buttress slab.

c. Release Requirements: There are no special requirements for the release of a TripStop™ pavement for public use other than an inspection to make sure that the concrete has been properly compacted around the joints and that the tops of the profiles are flush with the surface of the pavement.

d. Maintenance; There are no special maintenance requirements for TripStop™ pavements. If it is necessary to remove and replace pavement to accommodate utilities, care should be taken to maintain the integrity of the total pavement system.

e. Technical Support: TripStop P/L provides general technical support and design assistance for unusual situations, and for the testing of unusual designs.

5. Environmental

a. TripStop™ profiles are made in Australia from imported, recyclable PVC.

6. Standards/referenced documents

a. De Larrard, F. (1999) Concrete Mixture Proportioning. Spon, London.

b. AS3727-1993 Guide to Residential Pavements

c. ADA Standards for Accessible Design; 4.5 Ground and Floor Surfaces; www.ada.gov/stdspdf.htm

d. AS 1170.0:2002 Structural Design Actions; General principles

e. AS 1170.1:2002 Structural Design Actions; Permanent, imposed and other actions