# Mechanical Testing

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IN CONFIDENCE TO THE CLIENT

REPORT NO: MT-14/158

TESTING OF TRIPSTOP 100X AND SL72 MESH REINFORCED 100MM THICK CONCRETE PAVEMENT

CLIENT: TRIPSTOP Pty Ltd
PO Box 2438
ROWVILLE VIC 3178

DATE OF TEST: APRIL 4TH 2014

DATE OF REPORT: JUNE 2ND 2014

TEST SYNOPSIS:

Footpath pavement test slabs constructed from nominal 25MPa ready-mix concrete were fabricated by DAP Constructions and tested by MTS. The pavement slabs, constructed with two different jointing methods, were tested for comparative uplift performance in a manner that simulated heaving uplift from expansive soils and tree roots.

One of the slabs was cast using TripStop TS100X, which is a rigid PVC extrusion, also known as TripStop Double Hinge Joint, inserted at nominal 1.5m centres (see Fig.1). The second slab incorporated a piece of AS/NZS 4671 500SL72 fabric reinforcing mesh and saw cut joints at 1.5m intervals.

Specifically, the aim of the test was to determine if the variant slab designs could achieve a magnitude of 108mm uplift displacement (equivalent slope 1:14) without failure or excessive cracking.

PAVEMENT CONSTRUCTION DETAILS:

A nominal 8m length of pavement was constructed on top of a rigid structural test frame (see Fig.2). The slab mould was ≈1.5m wide and ≈100mm thick. One end of the slab was unreinforced and incorporated three TripStop joints. The opposite end was reinforced using a continuous length of AS/NZS 4671 SL72 steel reinforcing mesh positioned to provide a 50mm cover.
A nominal $F_c$ 25MPa, 80mm slump concrete was poured onto the formwork on the 5th of March, 2014. The concrete was placed by direct shutching from the truck and shovelling. Levelling was conducted by hand screeding without vibration and the pavement was finished by towelling, bull floating and brooming. Once the concrete had initially cured for 24 hours, three control joints were cut within the fabric reinforced section of the slab. The joints were cut to a depth of 20mm and spaced at nominal 1.5m centres (see Fig.3). The pavement test slab was then allowed to cure for 30 days before testing was conducted.

Concrete compression cylinders and samples of steel wire were procured from the slab materials for laboratory testing. Tests were conducted to determine the strength and ductility properties. Full details for the material properties are provided in Appendices A and B.

**Nominal Test Procedure:**

In accordance with the client’s instructions, control joints in the pavement slab were to be tested by jacking the slabs from the underside. For both tests, a 400mm long by 100mm wide loading bearer was positioned to react against the underside of the innermost slab. The bearer was offset to provide a 50mm edge distance between the bearer’s edge and the centre of the control joint. Clamping beams were fitted at each end of the test pavement to secure the slab ends to the testing frame. The beams were employed to provide an uplift reaction against the slab’s free end, simulating the continuous nature of an in-situ, linear run of footpath paving.

Loading was conducted by jacking the slabs in nominal uplift increments of 10mm. Upon achieving the target uplift positions the pavement was examined for cracking and signs of distress. This procedure was continued until the specified maximum rise/run ratio of 1:14 or 108mm was achieved. The test load was then released and the rebound performance of the pavement joint was monitored. The procedure was then repeated three times to assess the joint’s ability to perform under repeated uplift scenarios.

All testing was conducted using calibrated load and displacement measuring instruments. Test data was recorded using a computerised data acquisition system.
TRIPSTOP PAVEMENT TEST OBSERVATIONS:

Four draw string linear displacement transducers were connected to the upper surface of the pavement 50mm from the joint line and 25mm inboard from the pavement edge (see Fig.5). Under test, the TripStop joint was observed to act as a hinge point, allowing the adjacent slab to lift freely. The hinge mechanism facilitated both slabs to lift unheeded and there was no visible evidence of cracking in the concrete paving segments.

Upon achieving the target uplift deflection of 108mm (see Fig.6) the differential displacement across the joint was measured at 7.2mm. After completing three loading cycles the pavement returned to within 0.3mm of its pre-test position.

The maximum uplift load was recorded at ≈6kN (see Fig.7) and was considered to be primarily the result of self-weight from the pavement segments.
FIG. 6
TRIPSTOP SLAB AT 108MM (1:14) UPLIFT
The tests reported herein have been performed in accordance with approved MTS procedures. This document shall not be reproduced except in full.

**FIG.7**

**SINGLE CYCLE LOAD V LIFT CURVES FOR TRIPSTOP PAVEMENT TEST**

**MESH PAVEMENT TEST OBSERVATIONS:**

The mesh reinforced pavement slab was tested using the same procedure as adopted for the TripStop pavement. As can be seen from Figure 11, an uplift force of ≈15kN was achieved prior to the cracking moment of the joint. Further lifting resulted in a change of stiffness as cracking of the slab further developed.

At approximately **20mm** of uplift, severe cracking in the slab was observed ≈100mm to **150mm** offset from the control joint (see Fig.8a). The location of the crack nominally coincided with the position of the loading beam reaction against the soffit of the slab. Cracking was then observed in the free end portion of the slab, on the other side of the control joint (see Fig.8b).

As additional uplift was applied, cracking at the control joint began to dominate. Visibly wider cracks were observed (see Fig.9). Close examination of the cracking from the top of the slab revealed visible evidence of the steel mesh reinforcing wire spanning the cracked joint.

**FIG.8A**

**CRACKING IN MESH SLAB AT 20MM**
The peak test load coincided with and uplift displacement of **55mm**. Subsequent uplift resulted in tensile rupture of the longitudinal reinforcing wires at **≈60mm**. Fracture of the wires occurred in two stages with simultaneous audible reports and abrupt reductions in uplift force. As can be seen from Figure 11, rupture of some of the wires initially occurred, with the load dropping from **≈27kN** to **≈23kN**. With further uplift, the remainder of the wires fractured at approximately **67mm**, again coinciding with loud audible reports and an immediate reduction in force to **≈13kN**. Examination of the cracked joint revealed that the slabs had completely separated, with interaction between the slabs being solely reliant on shear force from aggregate interlock (see Fig.10).

Uplift testing was continued until the target **108mm** displacement was achieved with the differential displacement across the joint measured at **4.2mm**.

Post-test cyclic loading resulted in the pavement being raised and lowered multiple times. After each lifting cycle the differential displacement between the slabs increased due to failure of the aggregate interlock. The pavement returned to within **1.6mm** of its pre-test position.
The tests reported herein have been performed in accordance with approved MTS procedures. This document shall not be reproduced except in full.

**FIG. 11**

**SINGLE CYCLE LOAD v LIFT CURVES FOR SL72 MESH PAVEMENT TEST**

**TEST DATA:**

Test data for both TripStop and SL72 mesh pavement tests is provided in Table 1. The residual displacement values represent the settlement position of the slabs after being repeatedly raised to 108mm and lowered. The differential displacement represents the difference in step height between the slabs after being repeatedly raised to 108mm and lowered. As can be seen from the data in Table 1 and Figure 12, the TripStop slab performed with reasonable consistency between lifting cycles. In the case of the SL72 mesh slab, the magnitude of differential displacement amplified as the number of lift cycles increased. Loose cementitious grit deposited on the top flange of the support beams prevented the TripStop slabs returning to the precise starting position. In the case of the mesh slabs, the magnitude of post-test residual displacement was by and large due to compressive bearing and interference between the mating/exposed concrete interfaces.

<table>
<thead>
<tr>
<th>Lifting Cycle #</th>
<th>Test Date</th>
<th>Concrete Strength $F'_{c}$ (MPa)</th>
<th>Post-test Residual Displacement (mm)</th>
<th>Differential Displacement at Lift Height (mm)</th>
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<tr>
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<td>2</td>
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<td></td>
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**TABLE 1A.**

**TRIPSTOP TEST DATA**

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<tr>
<th>Lifting Cycle #</th>
<th>Test Date</th>
<th>Concrete Strength $F'_{c}$ (MPa)</th>
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**TABLE 1B.**

**MESH TEST DATA**
The tests reported herein have been performed in accordance with approved MTS procedures. This document shall not be reproduced except in full.

**FIG. 12**

**DIFFERENTIAL DISPLACEMENT FOR TRIPSTOP AND SL72 MESH PAVEMENT TEST**

**FIG. 13**

**1ST CYCLE DIFFERENTIAL (STEPPING) DISPLACEMENT FOR TRIPSTOP AND SL72 MESH PAVEMENT TEST SLABS**
The tests reported herein have been performed in accordance with approved MTS procedures. This document shall not be reproduced except in full.

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**FIG. 14**

**CYCLIC DIFFERENTIAL (STEPPING) DISPLACEMENT FOR TRIPSTOP AND SL72 MESH PAVEMENT TEST SLABS**

**SUMMARY:**
Comparative uplift tests on the concrete paving slabs as reported herein confirm that the TripStop 100X joints were able to heave to a 108mm (1:14) slope by raising one segment of the paving slab. The TripStop control joint had sufficient keying action to maintain connection with the abutting free end slab. The adjoining slab was lifted to the full height without cracking or excessive differential slip. The freedom of rotation created by the TripStop insert facilitated a hinge mechanism allowing both the reaction and slave slabs to be lifted in relative unison and rebound to their nominal original position upon release of the uplift load. After completing three lift cycles, post-test examination of the slabs did not reveal any evidence of cracking or other forms of failure in the test slabs or adjoining pavement segments.

Testing of the continuously reinforced SL72 mesh slab resulted in the concrete slab cracking after approximately 20mm of uplift. Cracking was initially observed adjacent the control joint on both slabs. Following this, a dominant crack developed in-line with the control joint which eventually became the governing/controlling flexural crack. From the chart provided in Figure 11, plastic deformation (yielding) of the steel mesh wire was well developed after an uplift displacement of 10mm. Further uplift displacement caused the steel reo mesh to rupture due to excessive tensile stress and elongation. From approximately 60mm of uplift, the mesh slab was effectively separated at the joint with mechanical interlock being provided by shear interaction between the exposed, aggregate, fracture faces. From approximately 60mm to 108mm (1:14) the SL72 mesh slabs were effectively segregated. Upon release of the uplift load the slabs rebounded to approximately 2mm of the starting position.
**COMMENTS:**
At the request of the client, MTS was asked to provide comment regarding the possibility of water ingress and the possibility of oxidisation (corrosion) related degradation of the steel reinforcing mesh. MTS advises the reader that speculation regarding the rate of corrosion and possible consequences of corrosion is outside the scope of work as requested for this report. Furthermore, we advise the reader that MTS has no specific expertise regarding corrosion related decay of concrete structures. This being said, in the opinion of the authors of this report we consider it likely that steel reinforcing mesh contained within cracked concrete elements which are exposed to outdoor environmental conditions would be subject to water ingress. Under this scenario the exposure is likely to precipitate oxidisation of the steel. MTS offers no comment on the rate of oxidisation or effect on the pavement’s performance or life span under such a scenario.

MTS advises that concrete pavements constructed in accordance with AS 3727 GUIDE TO RESIDENTIAL PAVEMENTS should not contain reinforcing across the control joints. This advice is provided in AS 3727 Clause 8.3(e) which states that “reinforcement should not be continuous through control joints”.

**APPENDICES:**
Mechanical properties for the SL72 Mesh material are provided in Appendix A. Concrete material sampling and strength properties are provided in Appendix B. Photographs showing the differential displacement between abutting TripStop slabs and SL72 mesh slabs at full lift height are provided in Appendix C. Photographs showing spalled concrete at the soffit of the SL72 mesh slab are provided in Appendix D. Photographs showing the fracture face and exposed reinforcing wires from the mesh test are provided in Appendix E.

**Notes:**
1. Melbourne Testing Services (MTS) Pty Ltd shall not be liable for loss, cost, damages or expenses incurred by the client or any other person or company, resulting from the use of any information or interpretation given in this report. In no case shall MTS be liable for consequential damages including, but not limited to, lost profit, damages for failure to meet deadlines and lost production arising from this report. This document shall not be reproduced except in full and relates only to the items tested.
2. It remains the responsibility of the client to ensure that the samples tested are representative of the entire product batch.
3. MTS shall take no responsibility for the procurement and authenticity of the test product as described herein.
4. This report is specific to the test items in their state at the time of testing. It should not be taken as a statement that all products in all states of repair, would also perform in the same manner.
5. MTS shall take no responsibility for the installation procedures used for the test items as described herein.
6. MTS shall take no responsibility for the interpretation or misinterpretation of the procedures or calculation methods as provided herein or for the appropriateness or validity of the test procedures for the test items described and reported herein.
7. The tests as reported herein are considered Experimental Type Tests and therefore do not validate or certify the products with any Australian or International standards that may apply.

**Rod Wilkie**
Authorised Signatory

**Roger Doulis**
Laboratory Test Engineer
APPENDIX A:

CONCRETE TEST REPORT

CLIENT: VICMIX (for DAP CONSTRUCTION)

PROJECT: TRIAL SLAB

JOB LOCATION: 429 HAMMOND RD DANDENONG SOUTH

Worksheet No. / Sample No. | F1591/1
---|---
Date of Sampling | 05/03/14
Batch | 10:39
Time | 11:00

Supplier / Plant | VIMIX / DANDENONG

Delivery Docket No. | Truck No. | Load Size (m³)
---|---|---
1383/2 | 622 | 1.6

Concrete Grade (MPa) / Agg. Size (mm): N25/20

Mix Code: N252SL

Location (in structure): Trip-Stop Test Slab

Sample Procedure (Discharge Type): 7.2.1

Slump Ordered (mm) / Measured (mm): 80 / 95

Compaction Method: Rodding

Air Temp. | Concrete Temp. | 20°C | 24°C
---|---|---|---

Specimen ID. | A | B | C | D | E | F

Cylinder Type (mm): 100

Initial Curing (hours): 27

Standard Curing (days): 6

Concrete Density (kg/m³): 2280

Type of Cap Used: R

Age at Test (days): 7

Compressive Strength (MPa): 18.0

Unles otherwise noted:
Sampling to AS 1012.1
Slump Test to AS 1012.3.1
Cylinder Compression to AS 1012.8.1
Initial Curing to AS 1912.8.1, Clause 9.2.2
Standard Curing to AS 1012.8.1, Clause 9.8(a)
Capping: R = Rubber, S = Sulfur
Concrete Density to AS 1012.12.1

NATA Accredited for compliance with ISO/IEC 17025
Accreditation No. 1879

Approved Signature: G.R. Lecmes

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# Mesh Test Report

## SPECIMEN DETAILS

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<th>Delivery Date</th>
<th>Test Date</th>
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<th>Proof Stress $R_{p0.2}$ (MPa)</th>
<th>Tensile Strength $R_m$ (MPa)</th>
<th>Ratio $R_m/R_p$</th>
<th>Uniform Elongation $\Delta_l$ (%)</th>
<th>0.5% Drop (%)</th>
<th>Rib Height (mm)</th>
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**Report No:** MT-14/158  
**Test Method:** Tensile  
**Report Date:** 20/03/2014  
**Standard Ref:** AS 1391, AS/NZS 4671  
**Wire Type:** SL72  
**Wire Diameter:** 6.75 mm  
**Area:** 35.78 mm$^2$  
**Test Machine ID:** TE  
**Extensometer GL:** 50 mm  

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**Authorised Signatory:**

Rod Wilkie  
Page 1 of 1

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APPENDIX C:

**FIG.C1**
TRIPSTOP SLAB HEIGHT DIFFERENTIAL 1ST CYCLE

**FIG.C2**
TRIPSTOP SLAB HEIGHT DIFFERENTIAL 2ND CYCLE

**FIG.C3**
TRIPSTOP SLAB HEIGHT DIFFERENTIAL 3RD CYCLE
APPENDIX C:

FIG.C4
MESH SLAB HEIGHT DIFFERENTIAL 1\textsuperscript{ST} CYCLE

FIG.C5
MESH SLAB HEIGHT DIFFERENTIAL 2\textsuperscript{ND} CYCLE

FIG.C6
MESH SLAB HEIGHT DIFFERENTIAL 3\textsuperscript{RD} CYCLE
APPENDIX D:

**Fig.D1**
SPALLED CONCRETE IN SOFFIT OF MESH SLAB

**Fig.D2**
SPALLED CONCRETE IN SOFFIT OF MESH SLAB AFTER 3RD CYCLE
APPENDIX E:

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