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Early life trafficking of overlaid concrete
Pavement Test Facility Trials

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Executive summary

Nationally, the cost of delays caused by utility and highway works, both in lost time and the additional vehicle operating costs are significant. Congestion costs are forecast to rise in Europe and the USA by 50% to $293.1b by 2030. Research suggests that utilities street works are responsible for about 5% of total congestion. The economic benefits to be gained from employing innovative methods that will reduce the impact of road works on traffic congestion are therefore substantial.

In June 2011, Transport for London (TfL) and the Department for Transport (DfT) jointly commissioned TRL to investigate the feasibility of increasing the use of three technologies that could be used to reduce road traffic congestion on the road network. These included the use of ‘faster cure and set’ materials for permanent reinstatement of the carriageway to shorten the duration of roadworks by opening of the carriageway to traffic earlier after the completion of the works.

This report covers trials of various strength concrete overlaid with 100mm of asphalt and trafficked 1 day, 2 days, and 3 days after construction of the concrete layer to establish what damage, if any, occurs during early life and whether the road could be opened earlier to trafficking thereby reducing occupation of the carriageway and reducing congestion on the network. This work was wholly funded by the TfL Lane Rental Technology fund. The conclusions from the trials are:

- No significant deterioration occurred in any of the concrete materials as a result of early life trafficking even at 1 day after construction. This included the weak C6/8 concrete included in the trials.

- Some very minor cracking was observed in a few of the cores but this was not restricted to the trafficked areas; one minor crack was observed in a control (un-trafficked) sample.

- The presence of any fine cracking had no apparent effect on the compressive strength.

- The compressive strength of trafficked cores was no different to the control (un-trafficked) cores.

- The C6/8 concrete proved successful in the trials which should provide confidence in the use of C16/20 and higher strength materials in practice.

It is recommended that trials of the higher strength materials should be undertaken on the TLRN, under controlled conditions, with early life trafficking applied. The trial sites should be monitored and their performance compared with similar strength concrete reinstatements that are allowed to cure for longer before trafficking.
Abstract
The time taken for concrete in reinstatements to cure and reach a suitable strength to allow trafficking and/or overlaying could be reduced as a measure to reduce congestion. General practice for reinstatement works is for concrete to be left for at least 3 days before being overlaid and opened to traffic. The programme investigating 3 strengths of concrete overlaid with 100 mm of asphalt and trafficked, using the TRL pavement test facility, 1 day, 2 days and 3 days after construction of the concrete. Cubes were taken to monitor the progression of strength gain over the first 28 days. Cores were taken from trafficked and control areas of the pavement and tested for compressive strength and compared with cubes.

1 Introduction
Nationally, the cost of delays caused by utility and highway works, both in lost time and the additional vehicle operating costs are significant. Congestion costs are forecast to rise in Europe and the USA by 50% to $293.1b by 2030 (CEBR, 2014). Research suggests that utilities street works are responsible for about 5% of total congestion (DfT, 2004). The economic benefits to be gained from employing innovative methods that will reduce the impact of road works on traffic congestion are therefore substantial. In June 2011, Transport for London (TfL) and the Department for Transport (DfT) jointly commissioned TRL to investigate the feasibility of increasing the use of three technologies that could be used to reduce road traffic congestion on the road network. TfL are continually looking at methods of working that lead to reduced occupancy of the road network, particularly at peak times and hence reduce congestion on the network. An overview summary report of this previous work is given in TRL Report PPR 658 (Carswell and Collis, 2013).

Occupation of the carriageway is often extended to include curing times for concrete of up to 7 days which affects the ability to re-open the road quickly and therefore increases congestion.

The work described in this report, wholly funded by the TfL Lane Rental Technology fund, investigates the early life trafficking of concrete bases overlaid with 100mm of asphalt using the TRL Pavement Test Facility (PTF) which can apply wheel loading representative of fully loaded HGVs. Three different strength concrete materials were trafficked 1 day, 2 days and 3 days after construction of the concrete layer.
2 Background

There are a number of different documents where the strength of concrete used in road pavements is specified. TRL undertook a brief review of the requirements for the minimum strength of concrete needed prior to being overlaid and/or trafficked.

The Specification for the Reinstatement of Openings in Highways (SROH) (HAUC, 2010) requires concrete (clause S7.3.6) to have a crushing (cube) strength of 25 N/mm². However, this is explicitly for the running surface of rigid roads with no alternative requirement provided for concrete that is to be overlaid. The running surface needs higher strength in order to ensure the brushed finish is not affected, so that skid resistance is maintained, as well as providing sufficient strength to carry traffic. However, the Specification for Highway Works (HA et al., 2011) allows concrete slabs to be opened to traffic once the cube compressive strength is assessed to have reached 25 N/mm² for pavement surface slabs or 20 N/mm² for bases with asphalt surfacing. Clause 1004.8 requires the time for use of a concrete slab by traffic to be assessed from the strength development rate predetermined by cubes stored at 20°C made from trial concrete mixtures and maturity meters placed in the pavement, which is impractical for most reinstatement openings.

The SROH specifies a strength for concrete of 25 N/mm² in line with surface slab requirements but does not have any other strength requirements for concrete used as a base below the surface course. However, the SROH specifies that a Cement Bound Granular Mixture (CBGM) ‘B’ (laid as the base) has to be overlaid within the following time limits:

- Type 0 and 1 roads (those carrying over 10 million standard axles [msa]), within 7 days of compaction;
- Type 2, 3 and 4 roads (those carrying up to 10 msa), within 3 days of compaction.

Highway Design note 27 (HD 27/15, HE et al., 2015) gives a reasonably comprehensive set of characteristic compressive strength requirements (although using old nomenclature) for concrete from each layer before being opened to traffic with:

- Pavement quality concrete surface slabs 25 N/mm²
- Pavement quality concrete road bases 20 N/mm²
- CBM 4 [CBGM] or C20 [C16/20] concrete 15 N/mm² (75 % of 28-day strength)
- CBM 3 [CBGM] or C15 [C12/15] concrete 10 N/mm² (67 % of 28-day strength)
- CBM 2 [CBGM] or C10 [C8/10] concrete 7 N/mm² (70 % of 28-day strength)
- CBM 1 [CBGM] or C7 [C6/8] concrete 4.5 N/mm² (64 % of 28-day strength)

However, further requirements for the concrete are given in Table 10/1 of clause 1001 of the SHW. This table is reproduced as Table 2-1. It is noted that there are very few concrete surface slabs, continuously reinforced concrete bases or continuously reinforced concrete pavements (CRCP) and continuously reinforced concrete beams (CRCB) ground beam anchorages on the TFL network. Therefore, it is the requirements for wet lean concrete that are the most relevant for concrete strengths used on the TFL network; the specific grades are left up to Appendix 7/1 with no advice in the Notes for Guidance (NG), Clause NG1001.
The review has confirmed that there a number of different guidance values or specifications for concrete available. It therefore supports the need to investigate the impact of strength on damage caused by early-age trafficking.

### Table 2-1 Pavement layers – Concrete strength classes

<table>
<thead>
<tr>
<th>Pavement Layer</th>
<th>BS EN 206 &amp; BS 8500</th>
<th>BS EN 13877-1 (At I/d = 1.0)</th>
<th>Concrete chloride class to BS 8500</th>
<th>SHW Clause</th>
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<tr>
<td></td>
<td>Designed Concrete</td>
<td>Standardised Prescribed Concrete*</td>
<td>Designated Concrete*</td>
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<tr>
<td>(i)</td>
<td></td>
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<td>Surface slabs:</td>
<td>C32/40</td>
<td>CC35</td>
<td>Cl 0,40</td>
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<tr>
<td>Unreinforced concrete (URC)</td>
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<td>Jointed reinforced concrete (JRC)</td>
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<td>Continuously reinforced concrete pavement (CRCP)</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>(ii)</td>
<td>C32/40</td>
<td>CC35</td>
<td>Cl 0,40</td>
<td>1001 to 1039 and 1044</td>
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<td>Continuously reinforced concrete base (CRCB)</td>
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<td>(iii)</td>
<td>C25/30</td>
<td>**</td>
<td>Cl 0,40</td>
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<tr>
<td>CRCP and CRCB ground beam anchorages</td>
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<td></td>
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<td>C40/50</td>
<td>CC40</td>
<td>Cl 1,0</td>
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<td>Roller compacted concrete</td>
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<td></td>
</tr>
<tr>
<td>(v)</td>
<td>C16/20</td>
<td>ST4</td>
<td>GEN 3</td>
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<tr>
<td>Concrete 4 )</td>
<td>For bases or sub-bases as required in contract specific</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>(vi)</td>
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<td>ST3</td>
<td>GEN 2</td>
<td>Cl 1,0</td>
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<tr>
<td>Concrete 3 )</td>
<td>Appendix 7/1</td>
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<td>GEN 1</td>
<td>Cl 1,0</td>
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<td>ST1</td>
<td>GEN 0</td>
<td>Cl 1,0</td>
</tr>
<tr>
<td>Concrete 1 )</td>
<td>C6/8</td>
<td>***</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* For small volumes, less than 100 m$^3$ per day and ground beam anchorages

** BS EN 206 & BS 8500 options preferred

*** There is no BS EN 13877-1 equivalent class to C6/8
3  Construction of PTF trial pavements

In order to assess the impact of early life trafficking of concrete road bases with various strength concretes three different strength concrete materials were used in the trials. Advice was sought from the Mineral Products Association (MPA) through TfL’s Congestion Reducing Steering Group Forum in the selection of materials and a low strength concrete (C6/8) together with two concrete materials regularly used in reinstatements works (C16/20 and C25/30) were selected for the trials. For the C6/8 and C16/20 concrete mixes a recipe was specified to avoid too high a strength material being delivered. The mixes were specified as follows:

C25/30 - (CEM I or II), S3 slump with target slump of 120 mm;
C16/20 - 200 kg of cement (CEM I or II), 2000 kg aggregate (30 to 45% sand), S3 slump with target slump of 120 mm; and
C6/8 - 100 kg of cement (CEM I or II), 2100 kg aggregate (30 to 45% sand), S3 slump with target slump of 120 mm.

Each slab was approximately 3.3m long and 2.4m wide and all concrete was overlaid with nominally 60mm thick asphalt concrete (AC) binder course (AC20 Dense Bin 100/150) and 40mm hot rolled asphalt (HRA) surfacing (HRA 30/14 Surf 40/60 Des). Pre-coated chippings were not applied to the HRA as no skid resistance requirement was needed for these trials.

The plan of the trial is shown in Figure 3-1. Shuttering was used between all segments, as shown in Figure 3-2, so that any slab being trafficked was isolated from the adjacent slab such that, if any damage did occur this would not be propagated across to adjacent slabs.

The concrete was laid onto a Type 1 sub-base over London Clay sub-grade. A cross-sectional view through the construction is shown in Figure 3-3.

Photographs showing the asphalt being laid, compacted and the final completed construction are shown in Figure 3-4, Figure 3-5, and Figure 3-6 respectively.

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1 CEM I  Portland cement: comprising Portland cement and up to 5% of minor additional constituents

CEM II  Portland composite cement: comprising Portland cement and up to 35% of certain other constituents (additional constituents are typically limestone, fly ash, and ground granulated blast-furnace slag).
Figure 3-1 Plan of trial in TRL’s Pavement Test Facility

Figure 3-2. Shuttering in place prior to concrete pour
Figure 3-3. Section through construction

Figure 3-4. Asphalt laying

Figure 3-5. Asphalt compaction

Figure 3-6. Completed pavement construction
The concrete slab construction took place on 19 April 2016 with the following times for each of the various strength concretes:

C6/8 11:48 start pour, 12:03 slabs completed
C16/20 14:19 start pour, 14:50 slabs completed
C25/30 12:39 start pour, 12:56 slabs completed

All slabs were hand tamped using a wooden board.

Cube samples of each concrete were taken to establish the cube strengths at 24h, 48h, 72h, 7 days, 14 days and 28 days after construction.

A tack coat was applied to the concrete surface prior to hand laying of the asphalt which took place on 20 April 2016. The asphalt was delivered from Conway’s Heathrow plant and laid by John Lee Construction Ltd. The timings of the construction were:

**Binder course**: Arrived at TRL at 12:50. Laying commenced at 13:15 using 4 barrows and spread using asphalt rakes. Area covered by 13:45. Compaction was started at 13:39 using a BW100 twin roller dead weight only and this was completed at 14:00. Initial material temperatures were measured around 135°C with subsequent measurements in the range 140-145°C.

**Surface course**: Arrived at TRL at 14:05 and laying started at 14:15 with the area covered by 14:40. Compaction was started at 14:30 and completed at 14:55. Initial material temperatures were measured around 135-138°C with subsequent measurements in the range 155-160°C.
4 Trafficking of pavement and materials testing

4.1 PTF trafficking

Each of the sections included one slab from each of the different strength concretes so that trafficking could be applied nominally 24h, 48h and 72h after construction of the concrete slabs. A dual tandem wheel was used with a load of 50kN (5 tonnes) to replicate a fully loaded HGV vehicle. A distribution was incorporated into the trafficking of ± 300mm from the centre line with 12 passes at each 30mm lateral steps, to represent the lateral variation that occurs with normal street traffic, with a total of 1512 wheel passes for each set of trafficking. This is representative of 1 day of trafficking on a Type 0/1 road. The test speed was 15 kph.

Small holes were drilled into the asphalt just after completion of compaction to monitor the pavement temperature at 50mm and 100mm depths and at the surface. The air temperature was also recorded. This was needed to check that the pavement had cooled sufficiently to allow trafficking and avoid any excessive deformation of the asphalt layer.

The pavement had cooled to about 39°C at 100mm depth by 19:56 on 20 April with ‘day 1’ trafficking commencing at 20:06, approx. 30h after completion of the concrete construction. Day 1 trafficking was completed by 22:30.

The asphalt and air temperatures recording during the trafficking on day 1 are shown in Figure 4-1. This shows that the asphalt temperature continues to fall during the trafficking.

![Figure 4-1. Asphalt temperatures during day 1 trafficking](image)

Day 2 trafficking was undertaken between 14:00 and 16:30 on 21 April, 48h after concrete construction. The temperatures recorded during day 2 trafficking were 22-23°C at 100mm depth; 19-20°C at 50mm and 19-20°C at the surface. The ambient air temperature was about 18-19°C.
Day 3 trafficking was undertaken between 14:40 and 17:00 on 22 April, 72h after concrete construction. The temperatures recorded during day 2 trafficking were 17-18°C at 100mm depth; 16-17°C at 50mm and 14-15°C at the surface. The ambient air temperature was about 13-14°C.

The trafficking of the pavement is shown in Figure 4-2.

4.2 Materials sampling and testing

4.2.1 Deformation

There were no visible signs of any deformation and no significant or discernible rutting was measured, using a straight edge and wedge, in any of the trafficked sections. There were minor variations in surface profile as would be expected for hand laid material, and this is typical of most trench or small opening reinstatements in practice.

4.2.2 Cubes

The concrete cubes were tested at various intervals after construction in order to assess the progress in strength gain. As the material was expected to be weak 3 samples of each concrete were made for testing at 24, 48 and 72 hours after construction with two further samples for testing at 7, 14 and 28 days.

4.2.3 Cores

Cores were taken from each of the trafficked areas and from a single control line (un-trafficked) as shown in Figure 4-3. The plan was to take pairs of cores along the centre line of each set of trafficking together with three more pairs from an un-trafficked control area. A further core was taken from each slab spanning the edge of the trafficking line. Figure 4-3 shows additional cores in sections 1C and 2A. These were taken as small cracks were noted near the surface of the initial core/s taken. All cores were logged for layer thickness and any damage and then the concrete was prepared and tested for compressive strength to BS1881 Part 120. These tests were all carried out together and at the same time as the 28 day cube.
samples. This was done to allow a direct comparison to be made between pavement and laboratory cured strengths and to determine whether trafficking of the sections had had a detrimental impact on the strength of the concrete.

Figure 4-3. Coring plan

4.2.4 Compressive strength

The gain in compressive strength (BS EN 12390) measured from cube samples tested at 1 day and at various intervals up to 28 days, is shown in Figure 4-4.

The mean results and ranges measured for compressive strength from cube samples are shown in Table 4-1. The ranges of test results for each concrete at each age is fairly small and is within the expected limits of test variability.
Table 4-1. Compressive strength of cube samples

<table>
<thead>
<tr>
<th>Age (days)</th>
<th>C6/8</th>
<th>C16/20</th>
<th>C25/30</th>
</tr>
</thead>
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<tr>
<td></td>
<td>Mean</td>
<td>Range</td>
<td>Mean</td>
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<td>1</td>
<td>1.9</td>
<td>1-8 - 2.0</td>
<td>2.2</td>
</tr>
<tr>
<td>2</td>
<td>4.3</td>
<td>3.9 - 4.6</td>
<td>6.1</td>
</tr>
<tr>
<td>3</td>
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<td>7</td>
<td>11.9</td>
<td>11.3 - 12.5</td>
<td>16.5</td>
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<td>14</td>
<td>17.8</td>
<td>16.8 - 18.7</td>
<td>23.0</td>
</tr>
<tr>
<td>28</td>
<td>20.5</td>
<td>20.1 - 20.9</td>
<td>27.2</td>
</tr>
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</table>

Figure 4-4. Strength gain measured from cube samples cured at 20°C

The core samples were trimmed to nominally 150mm in length to give a 1:1 testing ratio. This meant that some samples where cracking was observed over part of the length in the core logging (Appendix A) still contained a crack in the test sample. Examples of typical cores taken from the centreline after trafficking on day 1 for each of the different concrete materials are shown in Figure 4-5. Note the general level of voiding which is typical for tamped concrete. Some fine cracking was observed in a few cores (Figure 4-6) and these cracks were observed after coring when the moisture from the coring process is retained in the crack longer than on the surface of the core. However, it is interesting to also note that one of the most obvious cracks is observed in A/D3/C4 which is from a control area (that is, un-trafficked) and may indicate that some of the cracks may not be related to the action of trafficking and could possibly be shrinkage cracks.
The data from all of the cores tested is tabulated in Table 4-2 and cores with fine cracks observed are indicated. The mean equivalent cube results are represented graphically in Figure 4-7. This shows there has been no detrimental impact on the compressive strength of the concrete as a result of early life trafficking for any of the concrete types assessed.

**Figure 4-5.** Sound cores taken after Day 1 trafficking from (L-R) C6/8, C6/20 and C25/30 concretes

**Figure 4-6.** Examples of the fine cracking observed
<table>
<thead>
<tr>
<th>Material</th>
<th>Core Reference</th>
<th>Trafficking Age (days)</th>
<th>Compressive Strength (N/mm²)</th>
<th>Estimated Cube Strength (N/mm²)</th>
<th>Mean Est. Cube Str. (N/mm²) and (Variance)</th>
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<tr>
<td>C6/8</td>
<td>A/D1/C1</td>
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<td>15.6</td>
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<td></td>
<td>A/D1/C2</td>
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<td>20.4</td>
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<td>A/D1/C3</td>
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* Fine Cracking observed in top of core; # Very fine cracking observed in top of core
Figure 4-7. Mean compressive strength for each material trafficked at different ages after construction.

Comparing the 28 day laboratory cured cube results with the cored samples showed slightly higher values for the cubes (3-5N/mm² higher) compared with the measured strength from cores.

This would be expected as the measured densities for cubes were slightly higher than for the cores as shown by the average values for each concrete type in Table 4-3.

<table>
<thead>
<tr>
<th>Concrete</th>
<th>Average cube density (kg/m³)</th>
<th>Average core density (kg/m³)</th>
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<tr>
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<td>2230</td>
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<td>2250</td>
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<td>C25/30</td>
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In addition, the ambient temperature over the 28 day period was reasonably cool, particularly at night, so the variation in measured compressive strength between laboratory cured cubes and the in situ cores would be expected. The PTF is unheated and received little sunlight so temperatures generally resemble the prevailing air temperature. However, the early life curing may have been reasonably comparable given the application of a hot asphalt layer which would have aided curing of the concrete layer and kept this insulated from diurnal variations in the first 2 days after construction.
5 Discussion

The results from the trials are very promising and clearly indicate that reinstatement works could be overlaid within 24h and subjected to trafficking as soon as the asphalt layer has cooled sufficiently. It is also worth noting that generally trenching works would be narrower than the foot print of a heavily loaded HGV axle bogey and that the trench or opening would be supported by the existing surrounding material. In the trials there was no such support and the full loading was taken by the newly laid material.

The only cautionary note is that some minor cracking occurred in the C25/30 slab for the day 1 trafficking (measured mean cube strength at the time of trafficking was 5.1N/mm² – see Table 4-1) and in the C6/8 slab for the day 2 trafficking (measured mean cube strength at the time of trafficking was 5.1N/mm² – see Table 4-1).

It is interesting to note that the weaker C6/8 concrete materials did not show any major deterioration as a result of early life trafficking. It also suggests that deterioration of the concrete layer is not just related to the concrete strength. The results should provide greater confidence in the early life trafficking over the higher strength materials used in the trials.

It is recommended that the C16/20 to C25/30 type materials should be used on the TLRN and subjected to early life trafficking and monitored over a 1 year period. Similar materials that have been allowed to cure for longer prior to trafficking should also be included in any monitoring to provide a benchmark (control) for comparison.
6 Conclusions

From the trials undertaken in the PTF the following conclusions were made:

- No significant deterioration occurred in any of the concrete materials as a result of early life trafficking even at 1 day after construction. This included the weak C6/8 concrete included in the trials.

- Some very minor cracking was observed in a few of the cores but this was not restricted to trafficked areas with one minor crack being observed in a control (un-trafficked) sample.

- The presence of any fine cracking had no apparent effect on the compressive strength.

- The compressive strength of trafficked cores was no different to the control (un-trafficked) cores.

- The C6/8 concrete proved successful in the trials which should provide confidence in the use of C16/20 and higher strength materials in practice. The use of these higher strength materials in general works should be implemented on the TLRN, initially under controlled conditions, with early life trafficking applied. These sites should be monitored along with similar strength concrete reinstatements that are allowed to cure for longer before trafficking as a comparative control.
7 References


**Comité Européen de Normalisation (2012).** Testing hardened concrete. Shape, dimensions and other requirements for specimens and moulds. *BS EN 12390-1*. London, BSI.


8 Acknowledgements

The authors are grateful to the following for their support in this work.

Chris Clear from the MPA for advice on material mix designs to use in the trials.

Dave Gershkoff for Technically Reviewing this report.
Appendix A  Core Logs
### CORE LOG PAK test

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Cored at: A/D1/C1

Subbase type: Granular

Remarks: Intact, voids in CBM

**Time of coring:** n/a

**Hole depth:** 298mm

**Abbreviations:**
- TS = Thin Surfacing
- HRA = Hot Rolled Asphalt
- DBM = Dense Bituminous Macadam
- HBM = Hydraulically Bound Material
- GSB = Granular Sub-base
- GNT = Granite
- LST = Limestone
- GVL = Gravel
- PQC = Pavement Quality Concrete

Core Dia (mm): 150

Core Ref: 1

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### CORE LOG PAK test

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Subbase type: Granular

Remarks: Intact,
## CORE LOG PAK test

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Top of core

- Cored at: A/D1/C3
- Subbase type: Granular
- Remarks: Intact,

Hole depth: 308mm

Abbreviations: TSi=Thin Surfacing; HRA=Hot Rolled Asphalt; DBM=Dense Bituminous Macadam; HBM=Hydraulically Bound Material; GSB=Gravelite; GNT=Granite; LST=Limestone; GVL=Gravel; PQC=Pavement Quality Concrete, GSB=Granular Sub-base

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## CORE LOG PAK test

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Top of core

- Cored at: A/D2/C1
- Subbase type: Granular
- Remarks: Intact, Small cracks in CBM

Time of coring: n/a

Hole depth: 307mm

Abbreviations: TSi=Thin Surfacing; HRA=Hot Rolled Asphalt; DBM=Dense Bituminous Macadam; HBM=Hydraulically Bound Material; GSB=Gravelite; GNT=Granite; LST=Limestone; GVL=Gravel; PQC=Pavement Quality Concrete, GSB=Granular Sub-base

---

**Sampling and logging methods:** BS EN 12697-27:2001 Clause 4.1, BS EN 12697-36:2003 Clause 4.1, in-house procedure LP20

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Nine Mile Ride
Wokingham.
RG40 3GA

**Published** 21 PPR801
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**Cored at:** A/D2/C2

**Subbase type:** Granular

**Remarks:** Intact, Small cracks in CBM

**Hole depth:** 317mm

**Core Dia (mm):** 150

**Core Ref:** 5

**Location:** Centre line of Wheelpath

**Direction:** n/a

**FWD ch:** n/a

**Coring Date:** 12/05/2016

**Logged by:** JT

**Checked by:** JP

---

**Abbreviations:**
- TS=Thin Surfacing
- HRA=Hot Rolled Asphalt
- DBM=Dense Bituminous Macadam
- HBM=Hydraulically Bound Material
- GSB=Granular Sub-base
- GNT=Granite
- LST=Limestone
- GVL=Gravel
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**Cored at:** A/D2/C3

**Subbase type:** Granular

**Remarks:** Intact, voids in CBM

**Hole depth:** 304mm

**Core Dia (mm):** 150

**Core Ref:** 6
## CORE LOG PAK test

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### General Remarks
- Intact,
- Remarks: Intact,
- Remarks: Intact,
- Core Dia (mm): 150
- Core Ref: 7

---

**Abbreviations:**
- TS=Thin Surfacing;
- HRA=Hot Rolled Asphalt;
- DBM=Dense Bituminous Macadam;
- HBM=Hydraulically Bound Material;
- GS=Gritstone;
- GNT=Granite;
- LST=Limestone;
- GVL=Gravel;
- PQC=Pavement Quality Concrete;
- GSB=Granular Sub-base

---

## CORE LOG

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### General Remarks
- Intact,
- Remarks: Intact,
- Core Dia (mm): 150
- Core Ref: 8

---

**Abbreviations:**
- TS=Thin Surfacing;
- HRA=Hot Rolled Asphalt;
- DBM=Dense Bituminous Macadam;
- HBM=Hydraulically Bound Material;
- GS=Gritstone;
- GNT=Granite;
- LST=Limestone;
- GVL=Gravel;
- PQC=Pavement Quality Concrete;
- GSB=Granular Sub-base

---

**Sampling and logging methods:**

---

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---

**TRL Limited, Crowthorne House, Nine Mile Ride, Wokingham, RG40 3GA**
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Cored at: A/D3/C1
Subbase type: Granular
Remarks: Intact,

---

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Cored at: A/D3/C2
Subbase type: Granular
Remarks: Intact,

---

Abbreviations: TSB=Thin Surfacing; HRA=Hot Rolled Asphalt; DBM=Dense Bituminous Macadam; HBM=Hydraulically Bound Material; GSB=Granular Sub-base

Core Dia (mm) 150
Core Ref: 9


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TRL Limited,
Crowthorne House
Nine Mile Ride
Wokingham.
RG40 3GA

TFL
TRL LMS Ref: 160790

Location: Centre line of Wheelpath
Coring Date: 12/05/2016
Logged by: JT
Checked by: JP

3 Days

Lane: n/a
Grid Ref X: n/a


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TRL Limited,
Crowthorne House
Nine Mile Ride
Wokingham.
RG40 3GA

TFL
TRL LMS Ref: 160791

Location: Centre line of Wheelpath
Coring Date: 12/05/2016
Logged by: JT
Checked by: JP

3 Days

Lane: n/a
Grid Ref X: n/a
## CORE LOG

### PAK test

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### General Remarks

- **Core Dia (mm):** 150
- **Core Ref:** 11
- **Location:** Edge of Wheelpath
- **Remarks:** Intact,

### Top of core

- **Core Dia (mm):** 150
- **Core Ref:** 12
- **Location:** Control
- **Remarks:** Intact, Small cracks in CBM

### Abbreviations:

- TS=Thin Surfacing
- HRA=Hot Rolled Asphalt
- DBM=Dense Bituminous Macadam
- HBM=Hydraulically Bound Material
- GSB=Granular Sub-base

---

Sampling and logging methods: BS EN 12697-27:2001 Clause 4.1.5.3 E N 12697-36:2003 Clause 4.1 in house procedure LP20

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## CORE LOG PAK test

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Cored at: A/D3/C5

Subbase type: Granular

Remarks: Intact,

Hole depth: 296mm

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## CORE LOG PAK test

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Cored at: B/D1/C1

Subbase type: Granular

Remarks: Intact, voids in CBM

Hole depth: 306mm

---

### Abbreviations:
- TS=Thin Surfacing
- HRA=Hot Rolled Asphalt
- DBM=Dense Bituminous Macadam
- HBM=Hydraulically Bound Material
- GS=Gritstone
- GNT=Granite
- LST=Limestone
- GVL=Gravel
- PQC=Pavement Quality Concrete
- GSB=Granular Sub-base

### Core Dia (mm)
- 150

### Core Ref:
- 13

### Core Dia (mm)
- 150

### Core Ref:
- 14
### CORE LOG PAK test

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Core Dia (mm) 150
Core Ref: 15

### General Remarks
- Remarks: Intact, Small cracks in CBM
- Time of coring: n/a
- Hole depth: 294mm

### Abbreviations:
- TS=Thin Surfacing
- HRA=Hot Rolled Asphalt
- DBM=Dense Bituminous Macadam
- HBM=Hydraulically Bound Material
- GSB=Granular Sub-base
- GNT=Granite
- LST=Limestone
- GVL=Gravel
- PQC=Pavement Quality Concrete

### Core Dia (mm) 150

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### CORE LOG PAK test

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Core Dia (mm) 150
Core Ref: 16

### General Remarks
- Remarks: Intact, Small cracks in CBM
- Time of coring: n/a
- Hole depth: 306mm

### Abbreviations:
- TS=Thin Surfacing
- HRA=Hot Rolled Asphalt
- DBM=Dense Bituminous Macadam
- HBM=Hydraulically Bound Material
- GSB=Granular Sub-base

### Core Dia (mm) 150

### CORE LOG

**Layer 17**

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**Layer 18**

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Cored at: B/D2/C3  
Subbase type: Granular  
Time of coring: n/a  
Hole depth: 296mm

Core Dia (mm): 150  
Core Ref: 20

---

### Core Dia (mm) 150

1. **Abbreviations:**  
   - TS=Thin Surfacing; HRA=Hot Rolled Asphalt; DBM=Dense Bituminous Macadam; HBM=Hydraulically Bound Material; GS=Gritstone;  
   - GNT=Granite; LST=Limestone; GVL=Gravel; PQC=Pavement Quality Concrete, GSB=Granular Sub-base

---

### CORE LOG PAK test

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Cored at: B/D3/C1  
Subbase type: Granular  
Time of coring: n/a  
Hole depth: 286mm

Core Dia (mm): 150  
Core Ref: 20

---

### Core Dia (mm) 150

1. **Abbreviations:**  
   - TS=Thin Surfacing; HRA=Hot Rolled Asphalt; DBM=Dense Bituminous Macadam; HBM=Hydraulically Bound Material; GS=Gritstone;  
   - GNT=Granite; LST=Limestone; GVL=Gravel; PQC=Pavement Quality Concrete, GSB=Granular Sub-base

---

### Sampling and logging methods:  

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Opinions and interpretations expressed herein are outside the scope of UKAS accreditation.
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Core Dia (mm): 150
Core Ref: 21

Cored at: B/D3/C2
Subbase type: Granular
Remarks: Intact,

Hole depth: 296mm

Abbreviations: TS=Thin Surfacing; HRA=Hot Rolled Asphalt; DBM =Dense Bituminous Macadam; HBM=Hydraulically Bound Material; GS=Gritstone; GNT=Granite; LST=Limestone; GVL=Gravel; PQC=Pavement Quality Concrete, GSB=Granular Sub-base

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Core Dia (mm): 150
Core Ref: 22

Cored at: B/D3/C3
Subbase type: Granular
Remarks: Intact,

Hole depth: 295mm

Abbreviations: TS=Thin Surfacing; HRA=Hot Rolled Asphalt; DBM =Dense Bituminous Macadam; HBM=Hydraulically Bound Material; GS=Gritstone; GNT=Granite; LST=Limestone; GVL=Gravel; PQC=Pavement Quality Concrete, GSB=Granular Sub-base
# CORE LOG

## PAK test

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### Abbreviations:
- TS=Thin Surfacing; HRA=Hot Rolled Asphalt; DBM=Dense Bituminous Macadam; HBM=Hydraulically Bound Material; GS=Gritstone; GNT=Granite; LST=Limestone; GVL=Gravel; PQC=Pavement Quality Concrete; GSB=Granular Sub-base

### General Remarks
- Remarks: Intact,
- Time of coring: n/a
- Hole depth: 297mm

### Project
- Location: Control
- Direction: n/a
- FWD ch: n/a
- Coring Date: 12/05/2016
- Logged by: JT
- Checked by: JP

### PAK test

## CORE LOG

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### Abbreviations:
- TS=Thin Surfacing; HRA=Hot Rolled Asphalt; DBM=Dense Bituminous Macadam; HBM=Hydraulically Bound Material; GS=Gritstone; GNT=Granite; LST=Limestone; GVL=Gravel; PQC=Pavement Quality Concrete; GSB=Granular Sub-base

### General Remarks
- Remarks: Intact,
- Time of coring: n/a
- Hole depth: 296mm

### Project
- Location: Control
- Direction: n/a
- FWD ch: n/a
- Coring Date: 12/05/2016
- Logged by: JT
- Checked by: JP
### CORE LOG PAK test

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**Remarks:** Intact, Small cracks in CBM

**Time of coring:** n/a

**Hole depth:** 304mm

### Abbreviations:
- **TS** = Thin Surfacing
- **HRA** = Hot Rolled Asphalt
- **DBM** = Dense Bituminous Macadam
- **HBM** = Hydraulically Bound Material
- **GS** = Gritstone
- **GNT** = Granite
- **LST** = Limestone
- **GVL** = Gravel
- **PQC** = Pavement Quality Concrete
- **GSB** = Granular Sub-base

---

### CORE LOG 25

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**Remarks:** Intact, Small cracks in CBM

**Time of coring:** n/a

**Hole depth:** 304mm

### Abbreviations:
- **TS** = Thin Surfacing
- **HRA** = Hot Rolled Asphalt
- **DBM** = Dense Bituminous Macadam
- **HBM** = Hydraulically Bound Material
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- **LST** = Limestone
- **GVL** = Gravel
- **PQC** = Pavement Quality Concrete
- **GSB** = Granular Sub-base

---

### CORE LOG 26

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**Remarks:** Intact, Small cracks in CBM

**Time of coring:** n/a

**Hole depth:** 304mm

### Abbreviations:
- **TS** = Thin Surfacing
- **HRA** = Hot Rolled Asphalt
- **DBM** = Dense Bituminous Macadam
- **HBM** = Hydraulically Bound Material
- **GS** = Gritstone
- **GNT** = Granite
- **LST** = Limestone
- **GVL** = Gravel
- **PQC** = Pavement Quality Concrete
- **GSB** = Granular Sub-base

---

### Core Ref: 25

**Location:** Centre line of Wheelpath

**Direction:** n/a

**Coring Date:** 12/05/2016

**Core Dia (mm):** 150

**Core Ref:** 25

**Checked by:** JP

### Core Ref: 26

**Location:** Centre line of Wheelpath

**Direction:** n/a

**Coring Date:** 12/05/2016

**Core Dia (mm):** 150

**Core Ref:** 26

**Checked by:** JP
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**Core Dia:** 150

**Core Ref:** 27

**Location:** Edge of Wheelpath

**Coring Date:** 12/05/2016

**Abbreviations:**
- TS=Thin Surfacing; HRA=Hot Rolled Asphalt; DBM=Dense Bituminous Macadam; HBDM=Hydraulically Bound Material; GSB=Gravel; GNT=Granite; LST=Limestone; GVL=Gravel; PQC=Pavement Quality Concrete; GSB=Granular Sub-base

**Time of coring:** n/a

**Hole depth:** 321mm

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**Core Dia:** 150

**Core Ref:** 28

**Location:** Edge of Wheelpath

**Coring Date:** 12/05/2016

**Abbreviations:**
- TS=Thin Surfacing; HRA=Hot Rolled Asphalt; DBM=Dense Bituminous Macadam; HBDM=Hydraulically Bound Material; GSB=Gravel; GNT=Granite; LST=Limestone; GVL=Gravel; PQC=Pavement Quality Concrete; GSB=Granular Sub-base

**Time of coring:** n/a

**Hole depth:** 301mm
### Core Log PAK Test

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**Core Dia (mm):** 150

**Core Ref:** 29

**Client:** TFL

**Location:** Centre line of Wheelpath

**Direction:** n/a

**FWD ch:** n/a

**Coring Date:** 12/05/2016

**Remarks:** Intact,

**Hole depth:** 315mm

**Abbreviations:**

- TS = Thin Surfacing
- HRA = Hot Rolled Asphalt
- DBM = Dense Bituminous Macadam
- HBM = Hydraulically Bound Material
- GB = Gritstone
- GNT = Granite
- LST = Limestone
- GVL = Gravel
- PQC = Pavement Quality Concrete
- GSB = Granular Sub-base

---

### Core Log PAK Test

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**Core Dia (mm):** 150

**Core Ref:** 30

**Client:** TFL

**Location:** Centre line of Wheelpath

**Direction:** n/a

**FWD ch:** n/a

**Coring Date:** 12/05/2016

**Remarks:** Intact,

**Hole depth:** 296mm

**Abbreviations:**

- TS = Thin Surfacing
- HRA = Hot Rolled Asphalt
- DBM = Dense Bituminous Macadam
- HBM = Hydraulically Bound Material
- GB = Gritstone
- GNT = Granite
- LST = Limestone
- GVL = Gravel
- PQC = Pavement Quality Concrete
- GSB = Granular Sub-base

---

**Sampling and logging methods:**

- BSEN 12697-27:2001 Clause 4.1
- BS EN 12697-36:2003 Clause 4.1
- In-house procedure LP20

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### CORE LOG

#### 31

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Cored at: C/D2/C3

Subbase type: Granular

Remarks: Intact, Small cracks in CBM

Core Dia (mm): 150

Core Ref: 31

Client: TFL

TRL LMS Ref: 160765 1

Location: Edge of Wheelpath

Direction: n/a

FWD ch: n/a

Coring Date: 12/05/2016

Logged by: JT

Traffic after: 2 Days

#### 32

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Cored at: C/D3/C1

Subbase type: Granular

Remarks: Intact,

Core Dia (mm): 150

Core Ref: 32

Client: TFL

TRL LMS Ref: 160766 1

Location: Centre line of Wheelpath

Direction: n/a

FWD ch: n/a

Coring Date: 12/05/2016

Logged by: JT

Traffic after: 3 Days

### Abbreviations:
- TS = Thin Surfacing
- HRA = Hot Rolled Asphalt
- DBM = Dense Bituminous Macadam
- HBM = Hydraulically Bound Material
- GS = Gritstone
- GNT = Granite
- LST = Limestone
- GVL = Gravel
- PQC = Pavement Quality Concrete
- GSB = Granular Sub-base

### General Remarks
- Intact
- Small cracks in CBM

### Core Dia (mm)
- 150

### Core Ref
- 31

### Location
- Edge of Wheelpath

### Direction
- n/a

### FWD ch
- n/a

### Coring Date
- 12/05/2016

### Logged by
- JT

### Traffic after
- 2 Days

### Checked by
- JP
### CORE LOG 33

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- **Core Dia (mm):** 150
- **Core Ref:** 33

**Client:** TFL

**Location:** Centre line of Wheelpath

**Section:** 1C

**Logged by:** JT

**Cored at:** C/D3/C2

**Subbase type:** Granular

**Remarks:** Intact,

**Time of coring:** n/a

**Hole depth:** 310mm

**Abbreviations:**
- TS = Thin Surfacing
- HRA = Hot Rolled Asphalt
- DBM = Dense Bituminous Macadam
- HBM = Hydraulically Bound Material
- GSB = Gravel
- GNT = Granite
- LST = Limestone
- GVL = Gravel
- PQC = Pavement Quality Concrete
- GSB = Granular Sub-base

**Sampling and logging methods:** BSEN 12697-27:2001 Clause 4.1, BS EN 12697-36:2003 Clause 4.1, in-house procedure LP20

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---

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- **Core Dia (mm):** 150
- **Core Ref:** 34

**Client:** TFL

**Location:** Edge of Wheelpath

**Section:** 1C

**Logged by:** JT

**Cored at:** C/D3/C3

**Subbase type:** Granular

**Remarks:** Intact,

**Time of coring:** n/a

**Hole depth:** 312mm

**Abbreviations:**
- TS = Thin Surfacing
- HRA = Hot Rolled Asphalt
- DBM = Dense Bituminous Macadam
- HBM = Hydraulically Bound Material
- GSB = Gravel
- GNT = Granite
- LST = Limestone
- GVL = Gravel
- PQC = Pavement Quality Concrete
- GSB = Granular Sub-base

**Sampling and logging methods:** BSEN 12697-27:2001 Clause 4.1, BS EN 12697-36:2003 Clause 4.1, in-house procedure LP20

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### CORE LOG 35

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Cored at: C/D3/C4
Subbase type: Granular
Remarks: Intact,

Time of coring: n/a
Hole depth: 316mm

**Abbreviations:**
TS=Thin Surfacing; HRA=Hot Rolled Asphalt; DBM= Dense Bituminous Macadam; HBM=Hydraulically Bound Material; GS=Gritstone; GNT=Granite; LST=Limestone; GVL=Gravel; PQC=Pavement Quality Concrete, GSB=Granular Sub-base

**Core Dia (mm):** 150
**Core Ref:** 35

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### CORE LOG 36

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Cored at: C/D3/C5
Subbase type: Granular
Remarks: Intact,

Time of coring: n/a
Hole depth: 305mm

**Abbreviations:**
TS=Thin Surfacing; HRA=Hot Rolled Asphalt; DBM= Dense Bituminous Macadam; HBM=Hydraulically Bound Material; GS=Gritstone; GNT=Granite; LST=Limestone; GVL=Gravel; PQC=Pavement Quality Concrete, GSB=Granular Sub-base

**Core Dia (mm):** 150
**Core Ref:** 36

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**Sampling and logging methods:** DOH (M) 12697-27:2001 Clause 4.1.5 EN 12697-36:2003 Clause 4.1.5. In-house procedure LP20

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