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Area 9 Joint Heater Trials

Technical Report

Aggregate Industries · highways england · KIER · TARMAC A CRH COMPANY · THERMAL road repairs

Kier Services

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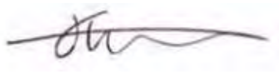			
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Executive Summary

The high level objectives of Highways England are safety, value for money, driving innovation and improving efficiency. The Strategic Road Network (SRN) plays a vital role in improving productivity and driving economic growth. Highways England aims to provide a safe and serviceable network with free flowing roads. As such, there is now greater emphasis on asphalt surfacings that are able to deliver whole life cost reductions as well as environmental benefits.

It is understood that construction factors have a significant impact on the durability of asphalt joints, in particular in relation to the potential for water ingress and asphalt density/air voids at the joint. Both these points are linked to potential relative reductions in durability and mechanical performance of the asphalt in the proximity of joints. As such, there has been significant focus on the optimisation and development of joint construction methods and techniques which aim to mitigate the potential maintenance risks associated with constructing an area of relative weakness in terms of durability and mechanical performance in an asphalt surfacing.

Advancements in joint heater technology have lead Highways England to engage with suppliers with a view to evaluating the potential benefits of using the technology on the SRN. Whilst there is good track record of use in other applications such as airfields, the effect on performance of asphalt joints constructed using joint heaters on the SRN was not well evidenced.

The aim of this project was to carry out a trial to investigate the performance of longitudinal joints installed using paver mounted joint heaters in comparison to conventional methods.

Key variables assessed:

1. Heated joints are constructed using a paver mounted joint heater (no joint sealant applied).
2. Painted joints are constructed using conventional paving methods (joint sealant is applied).

The testing methodology was developed to enable relative comparison of the joint types and is not intended for use as standardised testing. The assessment comprised:

- Visual assessment of joints and cores
- Density and air voids at and around the joints, compared with the central mat
- Permeability of the joint and surrounding material
- Indirect tensile strength test to provide a relative index of material integrity cohesion
- Direct tension test, which is a bespoke test developed for these trials which aims to provide an indication of the force required to pull the samples apart at the joint
- Recovered binder properties to assess the effect of joint heater technology on the binder

The trials demonstrate that paver mounted joint heaters can produce uniform bonded joints with good aggregate interlock. Temperature measurements taken during installation show that material is heated to an appropriate temperature above softening point and recovered binder testing suggests that this temperature increase does not adversely affecting properties of the bitumen after installation.

Findings highlighted some differences in relative performance of heated and painted joints, but relative performance depends on which parameter is being considered and should be viewed in context of how the joint is formed.

Findings suggest that painted joints may achieve slightly lower permeability than heated joints (however, this is unlikely to be significant in the context of the accuracy of the permeability test). ITS and DTT testing suggests that heated joints displayed slightly higher ITS and slightly higher peak stress than that of the painted joints.

A key area which isn’t directly impacted by heating or painting is compaction at the unconfined edge which is expected to have a significant influence on durability of material in the proximity of the joint. In addition, construction practice is highlighted as a key factor to the success of any joint, in particular the time before rolling which should be minimised to realise the benefits from joint heater technology.

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1. Introduction

Overview

Highways England 'Innovations designated funds' funded trials in Area 9 to evaluate the effectiveness of using asphalt joint heaters for longitudinal joint construction. AECOM were appointed by Keir Services (Area 9) to independently observe the installation trials and undertake coring and performance testing. The trials were designed to allow comparison in performance of longitudinal joints constructed using conventional methods (i.e. painted joints) and heated joints constructed using a paver mounted joint heater. The trials were carried out in the Area 9 depot which enabled safe access for inspection and coring. This report presents a record of the trial works and key findings.

Scope

Collaborative planning meetings were held between interested parties including Kier Services (Area 9), Highways England (including representatives from the Pavement Efficiency Group), Tarmac, Aggregate Industries and Thermal Road Repairs to agree the layout, logistics and the test plan for the trials.

Aim

The aim of this project was to *carry out a trial to investigate the construction and performance of longitudinal joints installed using paver mounted joint heaters in comparison to conventional methods.*

Objectives:

1. Assess the practical aspects of using paver mounted heaters for Highways operations.
2. Compare the performance of joints prepared using paver mounted heaters versus those formed using conventional methods.
3. Share findings from the trials with a view to determining the next steps and demonstrate that the proposal is consistent with Highways England relevant key performance indicators and efficiency targets.

This report addresses Objectives 1 and 2 and will be shared in order to inform the next steps for achieving Objective 3.

Background

The high level objectives of Highways England are safety, value for money, driving innovation and improving efficiency. The Motorway and All-Purpose Trunk Road Network (formerly known as the Strategic Road Network (SRN)) plays a vital role in improving productivity and driving economic growth. Highways England aim to provide a safe and serviceable network with free flowing roads. As such, there is now greater emphasis on asphalt surfacings that are able to deliver whole life cost reductions as well as environmental benefits.

It is widely recognised that joints are a point of weakness in asphalt pavements which often require maintenance in advance of the central asphalt mat. Common signs of distress at joints include loss of aggregate (fretting), ravelling and loss of bond between adjacent asphalt materials potentially associated with the ingress of water. In addition, it is not uncommon to observe reflective cracking from joints in underlying courses which subsequently can also be relatively prone to the same distress mechanisms associated with joints in the asphalt surface course.

It is understood that construction factors have a significant impact on the durability of asphalt joints, in particular to the potential for water ingress and lower relative compaction at or near the joints. Both relatively low compaction and water ingress are linked to potential relative reductions in durability and mechanical performance of the asphalt in the proximity of joints. As such, there has been significant focus on the optimisation and development of joint construction methods and techniques which aim to mitigate liabilities associated with joints in asphalt pavements, constructing an area of relative weakness in terms of durability and mechanical performance in an asphalt surfacing.

Advancements in joint heater technology have lead Highways England to engage with suppliers with a view to evaluating the potential benefits of using the technology on the SRN. Whilst there is good track record of use in other applications such as airfields, the effect on performance of asphalt joints constructed using joint heaters on the SRN was not well evidenced.

It is important to recognise that joint heaters are one variable in the construction of longitudinal joints. Therefore, requirements for construction and factors that influence performance are detailed in the following section.

Requirements for longitudinal joint construction

A summary of some of the key specification requirements for joint construction are included below:

- BS 594987:2010+A1:2017, Clause 6.8 names the following methods which are permitted methods for preparation before the adjacent lane width is laid;
  - Echelon paving
  - Cutting back
  - Edge compaction
- Clause 903 requires the top surface of all binder and base course joints to be sealed such that there is not less than 0.50 kg/m^3 of residual bitumen 75 mm either side of the joint.
- There is no air void performance requirement for surface course materials in the mat or at joints for SRN. Cores are generally not taken from the surface course in the UK, with the exception of airfield asphalts, or where specifically required in the contract.
- Joints in binder and base courses have a maximum permitted air voids content measured from core pairs whose centres are not more than 100 mm from the final joint, not greater than 2% above the maximum limit for core pairs in the body of the mat.
- For AC dense base and binder course design mixtures (Clause 929), there are requirements for the air void content of cores adjacent to the joint to not exceed 9%.
- Clause 702.10 (rectification of surface courses and binder courses) permits the use of joint heaters, provided that the joint heater raises the temperature to the full depth of the course immediately before laying the new material, to a figure within the range of a minimum rolling temperature and maximum temperature at any stage specified for the material and for a width not less than 75 mm.

Factors which influence performance of longitudinal joints

There are a range of variables which are understood to have an effect on the performance of longitudinal joints. Key considerations are discussed to add context to the works described herein.

Achieving good compaction in order to produce a closed, uniform joint with minimal difference in air voids compared with the central mat is a key objective for construction of durable longitudinal joints in asphalt materials.

There are a range of factors which could influence compaction and performance at longitudinal joints, including:

1. Compaction and confinement – unconfined edges are generally less well compacted than confined edges. For this reason construction practices often cut back material to remove less well compacted material, or use methods such as edge compaction to provide confinement.
2. Material type – some materials are more easily compacted than others, depending on volumetrics, bitumen type and thickness.
3. Material aging – binder hardening and oxidation can lead to loss of cohesion and can result in fretting of the joint. Some materials types are more prone to fretting than others.
4. Temperature – asphalt materials have a recommended temperature range to achieve good compaction. Construction and compaction should be completed before the material temperature falls outside this range.

5. Weather conditions during installation - such as rain, wind and ambient temperature impact material temperature which has an effect on compaction.
6. Levels across the joint – Where surcharge is too high the roller may bridge the joint and not achieve optimum compaction. Conversely inadequate surcharge can result in low density if the thickness of material is insufficient at the joint.
7. Permeability – It is widely recognised that keeping water out of the pavement is a key objective in promoting durability. Therefore, construction practices aim to promote compaction and reduce the presence of interconnecting voids.
8. Use and trafficking – heavy trafficking can accelerate distress at joints. For this reason, longitudinal joints are positioned outside of the wheel tracks and are generally located under the white lines in the case of surface course materials.

Paver mounted thermal joint heaters and track record

Thermal joint heaters function by infrared heating, created by pre-mixed gas and air delivered under pressure to a series of energy converters, heating a layer of super conductive alloy, so no direct flame is imparted on the asphalt. They enable heating of the cold longitudinal joints to in theory simulate echelon paving, producing a seamless, thermally bonded joint.

The heating system's intention is to bring the already paved lane back up to a higher temperature before the second lane is installed; above the softening point of the bitumen so that a thermal bond and interlock is achieved. Ideally, the joint would be heated to such an extent that most of the layer is above softening point and compaction across the joint can be increased.

Thermal joint heating technology is available to be fully integrated with asphalt paving machines incorporating an intelligent control system and temperature display which provides continuous temperature monitoring to inform the operator of the optimum paving speed to achieve effective heating at the joint. The technology is also synchronised with the paver and is able to respond to reduced speed and breaks in paving operation to avoid overheating.

Application of joint heaters on the SRN is relatively new. Track record for use on airfields is more established. This is understood to be driven by air void requirements for airfield asphalt surfacing to mitigate the risk of foreign objects (e.g. fretted aggregate) along with the exposed nature of airfield work which is often carried out at night often with low temperatures and cross wind. AECOM's experience of the use of joint heaters on airfield projects has been positive in assisting in achieving visually well knitted longitudinal joints which meet the air void requirements.

Some example schemes where joint heater technologies have been applied on the SRN are summarised below. Please note that this list is not exhaustive.

Examples of use of joint heaters on the Strategic Road Network include:

- Area 9 A45 (May 2016)
- Area 12 M62 Junction 32 W/B (May 2017)
- Area 7 M1 Junctions N/B and S/B Junctions 20 – 21 (May 2017)
- Area 10 M62 E/B and W/B Junctions 6 – 9 (Repair works, now overlaid)

Feedback from Area 9 and Tarmac were made available for the A54 trials and Area 7 trials respectively:

Area 9 A45 feedback: Trials were carried out on the Westbound A45 between A452 and M42. The existing HRA surfacing was replaced by Thin Surface Course and works were completed on a plane out and re-lay basis to 8no patches varying in length from 5m to 25m. Visual inspection suggested a well formed blended joint between new and existing surfacing. Laying speed was reduced to enable the heating operation to be effective.

Area 7 M1 J 20-21 feedback: Trials were carried out over 425 m length installation of 35 mm thick 14 mm thin surface course in Lanes 2 and 3 between marker posts 155750 and 1555325.Trials were undertaken at the paving speed recommended by the joint heater manufacturer (8m/min speed, heated joint), typical paving speed (10m/min speed, heated joint) and typical paving speed (10m/min speed, conventional bond coat joint). Visual assessment of the heated joint showed a seamless joint on the surface between the two lanes with aggregate interlock evident.

2. Joint Heater Trials

Trial philosophy

The trial aims to compare the performance of heated joints against painted joints for joints between newly installed thin surfacing and for joints between new and existing materials.

Key variables assessed:

1. Heated joints are constructed using a paver mounted joint heater (no joint sealant applied).
2. Painted joints are constructed using conventional paving methods (joint sealant is applied).

The testing methodology was developed to enable relative comparison of the joint types and is not intended for use as standardised testing. The assessment comprises:

- Visual assessment of joints and cores
- Density and air voids at and around the joints, compared with the central mat
- Permeability of the joint and surrounding material
- Indirect tensile strength test to provide a relative index of material integrity cohesion
- Direct tension test, which is a bespoke test developed for these trials which aims to provide an indication of the force required to pull the samples apart at the joint
- Recovered binder properties to assess the effect of joint heater technology on the binder

The following additional variables which could influence findings from these trials are noted:

- Paving speed varied throughout the trials, but targeted the optimum speed for the joint heating process.
- The amount of time between paving and first compaction was observed to be variable. This factor has an influence on material temperature at initial compaction.
- Material surcharge varied for each joint constructed.
- Joints were not cut back, with the exception of Painted Joint D.
- The type and condition of existing surface was observed to vary through the trial area.

The likely effects of the variables detailed above are further discussed in Section 7.

Trial location

Joint heater trials were carried out during the day on Monday 27th November at the Kier Area 9 depot at Stafford Park, Telford. The trial location is shown in Figure 1.

Figure 1: Trial location - Kier Services, Stafford Park 10, Stafford Park Area 9 Depot, Telford, TF3 3BU (Source: Google maps, 2018)

The trial location was selected to enable safe access, monitoring and a large number of cores to be taken. The trial location also provided multiple surfacing types.

The surfacing contractor and asphalt supplier was Tarmac and the joint heater was provided and installed by Thermal Road Repairs.

The trial was attended by members of Highways England, Kier (Area 9), Thermal Road Repairs (TRR), Tarmac, Aggregate Industries and AECOM.

Trial layout

The trial area was 40 m long by 12 m wide and comprised installation of four rips of Ultipave M 10 surf PMB 65 PSV thin surface course which included a range of longitudinal joint types as summarised in Table 1. A diagram showing the trial layout is presented in Figure 2 and Appendix B.

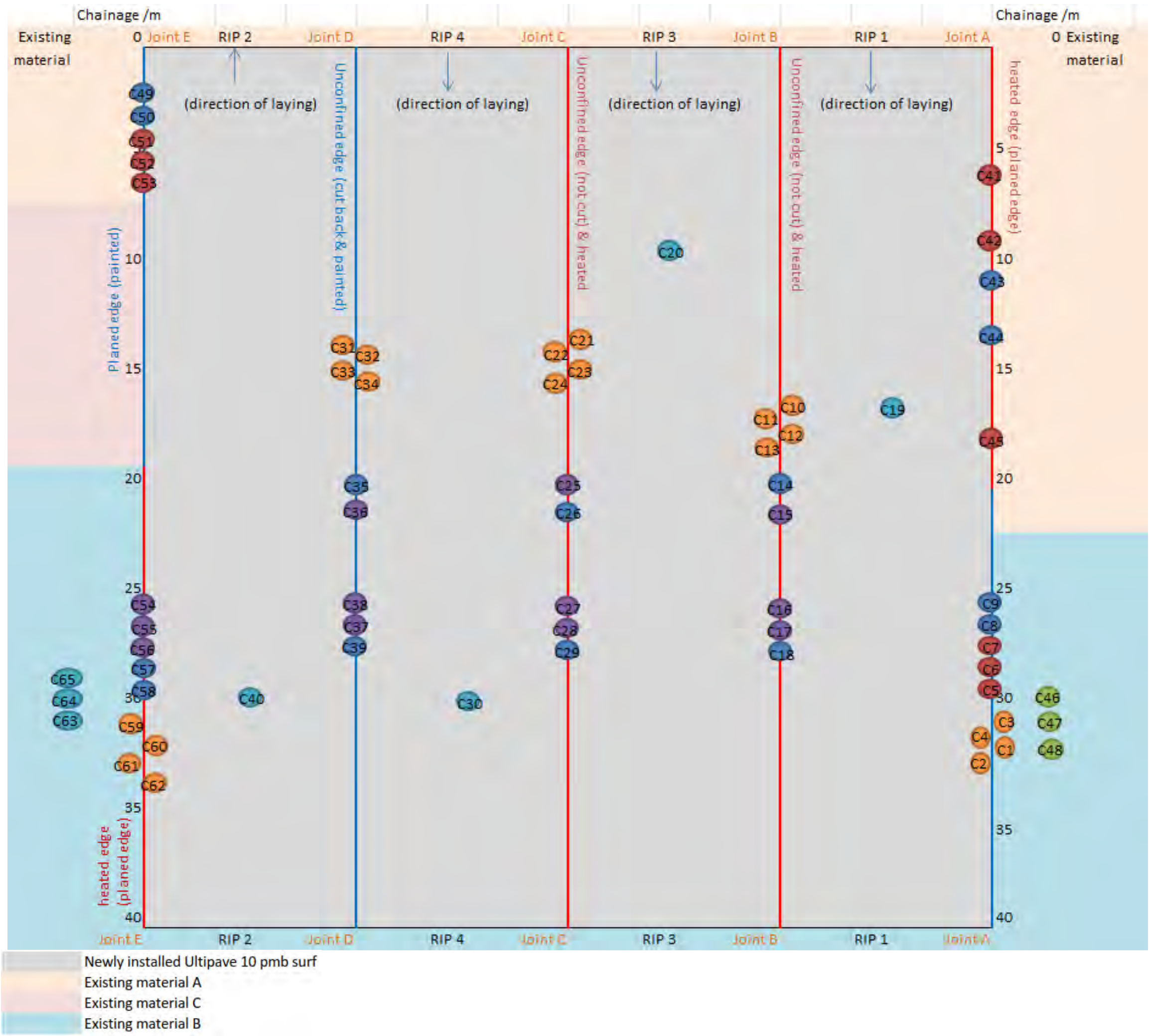


Figure 2: Trial layout and core locations

Diagram notes:

1. Red line denotes heated joint. Blue line denotes painted joint. Colour change of the 'existing material' signifies a change in surfacing type.

2. Rip number denotes the laying sequence.

Table 1: Summary of joint types

Joint Reference	Longitudinal Joint location	Chainage	Heated or painted	Comments
Joint A	Rip 1 | Existing	0-20 m	Heated	-
Joint A	Rip 1 | Existing	20-40 m	Painted	-
Joint B	Rip 1 | Rip 3	0-40 m	Heated	Target 30°C Rip 1 edge temperature. Thermocouples installed at chainage 34m
Joint C	Rip 4 | Rip 3	0-40 m	Heated	Target 'cooled' (<15°C) Rip 3 temperature.
Joint D	Rip 2 | Rip 4	0-40 m	Painted	-
Joint E	Existing | Rip 2	0-20 m	Painted	-
Joint E	Existing | Rip 2	20-40 m	Heated	-

The trial area included three types of existing (old) surfacing as summarised in Table 2.

Table 2: Summary of Existing material location and types

Material reference	Location	Chainage	Comments
Existing Material A	Adjacent to Rip 1	0-22 m	Assumed to be asphalt concrete
	Adjacent to Rip 2	0-8 m	
Existing Material B	Adjacent to Rip 1	22-40 m	Assumed to be SMA
	Adjacent to Rip 2	24-40 m	
Existing Material C	Adjacent to Rip 2	8-24m	Cracked and crazed – not tested

Existing material C was observed to be cracked and crazed in particular between chainage 15 and 22m and was excluded from joint testing.

Equipment and setup

Surfacing material:	Ultipave M 10 surf PMB 65 PSV supplied from Baston Hill (approximately 25 minutes from plant to site)
Joint sealant:	Hot Joint Paint (Bituchem Building Products Ltd). 50/70 penetration grade, 150^{o}C recommended application temperature.
Weather:	Heavy rain early morning before trials commenced. Dry throughout the day, except for one short very light rain shower 12:50pm to 1pm prior to installing the final rip.
Ambient temperature:	7^{o}C to 9^{o}C
Ground temperature:	5.6^{o}C
Paving machine:	Volvo P687 (high compaction screed not used, tampers only)
Joint Heater model:	GRR126 (new)
Joint heater height:	As per manufacturers recommendations, approximately 80 mm from the substrate surface
Rollers:	Bomag 135 HAM deadweight HW90 (8-10 tonnes)

The planing operation was carried out by Tarmac's subcontractor on Saturday 25th November 2017. The planing operation targeted 40 mm depth. Planed edges were not cut further.

Observations prior to overlay: Areas of crazed cracking were noted and cores targeted away from the worst affected areas where possible.

The heater was fitted to the side bar on the paver ahead of the augers. TRR fitted the heating equipment which took around 15 minutes to mount and appeared to be a simple well designed process. The equipment heated up at the same time as the paver screed and caused no delay to operations.

It was agreed that the paving speed should target the optimum required for the joint heater operation, based on the temperature displayed on the intelligent control system display unit monitored by TRR and fed back to the paver driver. For the trials the intelligent display unit was mounted above the paver heater at the screws, however, for more regular works the display unit is fitted with the paver driver.

The heater on the trial day came with a part full bottle of gas that was replaced during a break in the trial installation [actual figures advised by TRR from the Tarmac A52 (Area 7) contract shows an average use of 1.5 litres per hour, taken over 12500 linear meters of usage].

Photographs of the equipment and set up for the trials are presented in Figure 3.

Figure 3: Photographs of the equipment; (clockwise) i) Joint heater equipment, ii) Paver side bar mount, iii) Joint heater technology fitted on the paving machine

Site Observations

The photographs and site observations detailed below were made by Jessica Tuck (AECOM) who was on site during the trials.

Figure 4: i) Planed surface prior to installation, ii) Joint heater in operation

Figure 5: Heated Joint A i) before compaction ii) after compaction

Figure 6: Heated joint B i) before compaction; ii) after compaction

Figure 7: i) Cutting back Rip 2 unconfined edge prior to painting and installing Rip 4; ii) Installing Rip 4

Figure 8: i) Heated Joint C (between Rips 3 and 4); ii) Painted joint D (between Rips 4 and 2)

Laying records

Laying records and temperatures were recorded by AECOM's technician and are presented in Appendix A.

Paving speed

'Normal' paving operation speed for highway works were reported to be around 8-9 m per minute (advised by Tarmac's paving supervisor). The paving speed during the joint heater trials was reduced to enable effective heating and the paving speed was controlled by TRR operatives who monitored the joint heater temperature display and communicated with the paver driver to proceed at the optimum speed for the heating operation.

The paving speed measured by AECOM ranged from 4.4 to 7.2 m/min.

The joint temperatures (for heated joints) and laying speeds were recorded and reported by TRR and are summarised in Table 3.

Table 3: Recorded joint temperatures and laying speeds - Data provided by TRR

Rip	Joint reference	Chainage (m)	Existing Joint Temp °C	Existing Joint Temp After Heating °C	Laying Speed Registered from Screwsman Screen m/min
Rip 1	Heated Joint A	2	5.6	165	4.1
		5	5.6	172	5.4
		10	5.1	167	6.9
		15	6.7	165	6.9
		20	8.9	168	6.9
		Average	**6.4**	**167**	**6.0**
Rip 2	Heated Joint E	40	5.8	165	4
		35	5.2	148	4.8
		30	6.9	155	6.9
		25	8.3	168	7.5

		20	5.9	172	7.5
		Average	**6.4**	**162**	**6.1**
Rip 3	Heated Joint B	2	28.8	176	4.7
		5	28.5	176	5.8
		10	23.4	175	7.3
		15	22.7	172	7.3
		20	25.8	174	7.3
		25	26.4	173	7.6
		30	27.1	161	7.6
		35	28.2	154	7.2
		40	27.6	144	6.1
		Average	**26.5**	**167**	**6.8**
Rip 4	Heated Joint C	2	10.8	176	4.1
		5	14.5	151	5.8
		10	13.2	137	6.4
		15	13.8	145	7.2
		20	18	148	7.8
		25	18	156	6.7
		30	15.8	134	7.6
		35	16.3	156	7.2
		40	14.2	146	6.1
		Average	**15.0**	**150**	**6.5**

It was noted by TRR that laying speeds during the trial were impacted by the length of the trial area. Paving speeds on current network operations are 8m - 10m per minute (Tarmac figures from the Area 7 contract January 2018/Associated Asphalt on Heathrow road network February 2018/ Colas M62 Area 12 contract May 2017).

Rolling pattern

The rolling pattern was varied slightly throughout laying. In general, the observed rolling sequence was:

- First pass by Bomag 135 roller (no vibration) over the joint, overlapping onto the heated 'existing' material by approx. 30 cm.
- Second & third pass with vibration straddling the joint (half and half)
- Fourth pass by HW90
- Subsequent passes over the joint with HW90

Observations during paving of Joint A (between Rip 1 and existing surfacing)

The joint was heated from chainage 0 to 20 m and the paving machine paused at chainage 20 m to lift the joint heater for the painted section at chainage 20 to 40 m. The rolling pattern was generally consistent for both heated and painted sections.

Existing material heated appeared dry and 'dull' in appearance at the surface after the heater pass.

The roller began the first pass over the joint >20 metres behind the paver and approximately 2 to 4 minutes after the paving machine had passed. TRR advised that roller should be right behind paver to realise maximum benefit from the joint heater.

The surcharge at joint appeared high (15 to 20 mm) and Rip 1 appeared to finish proud of the existing surface when finished. The surfacing thickness was dipped by a paving operative and recorded at 45 mm (central mat) compacted to target 40 mm thickness.

Observations during paving of Joint E (between Rip 2 and existing surfacing)

The observations were consistent with those noted above. The joint was heated from chainage 20 to 40 m and the joint heater was raised for the painted section at chainage 0 to 20 m.

The surface of the heated material at the joint measured 229°C using an infrared temperature gun immediately after the heater pass

Observations during paving of Joint B (between Rip 1 and Rip 3)

The joint was heated for the full length (chainage 0-40 m).

Thermocouples were fitted in the edge of Rip 1 (whilst still hot) at chainage 34 m, set at 10 mm and 20 mm depth from the surface prior to compaction. This was to enable temperature monitoring when laying Rip 3. The unconfined edge (of Rip 1) was not cut back prior to paving Rip 3.

Temperature of Rip 1 edge prior to laying against it was recorded at 27°C. The surface of the heated material at the joint measured 202°C using an infrared temperature gun immediately after the heater pass.

Paver started at CH0 at 11:10 am and reached CH40 at 11:16 am. Calculated mean paving speed on this basis = 6.6 m/min. Speed recorded by the TRR operator = 6.8 m/min.

The surcharge of Rip 3 was observed to be slightly high and in general, Rip 3 material finished proud of Rip 1 material at the joint.

Observations during paving of Joint C (between Rip 3 and Rip 4)

The joint was heated for the full length (chainage 0-40 m).

The temperature of the edge of Rip 3 was measured at 15°C prior to installation of Rip 4.
The infrared temperature gun was held at a point close to the joint on the heated side to observe temperature change over time. The surface temperature was recorded at 200°C immediately out the back of the heater. After approximately 20 seconds the surface temperature read 100°C and after one minute the surface temperature recorded 65°C as the roller started the first pass. The new material (Rip 4) surface was recorded at 148°C close to the joint at this point.

The first pass of the roller at the joint followed was much quicker than in previous rips. Rolling commenced on heated the joint approximately 1 minute after the paving machine. The roller then switched over to the bonded joint shortly after.

Paving of Rip 4 commenced at 13:01 and finished paving 13:10. The calculated speed was 4.4 m/minute.

The surcharge appeared to be more appropriate than that for the other joints (approximately 10 mm) which resulted in a level joint which appeared to be well blended with interlock, based on visual assessment of the surface.

Observations during paving of Joint D (between Rip 2 and Rip 4)

The joint was painted for the full length (chainage 0-40 m). The edge of Rip 2 was cut to vertical using a roller mounted wheel [note this was to only unconfined edge which was cut back during the trial].

The temperature of the edge of Rip 2 was measured at 18°C prior to installation of Rip 4. This was possibly due to some heat from the bond coat operation. The surface of the heated material at the joint measured 200°C using an infrared temperature gun immediately after the heater pass.

Feedback from the installation supervisor

After the trials, AECOM requested feedback from the installation supervisor who advised that the equipment set up was simple and quick. The gang had commented that the joint heater obstructed the augers slightly and that TRR had advised that the positional could be adjusted along the mounting bar so this could be rectified. The gang commented that paving speed through the trial was significantly slower than normal operational speed and that a reduction in speed can result in an increase in material use and that around 6% more material was used than expected in the first two runs [due to lower paving speed].

3. Coring and Testing

Coring works

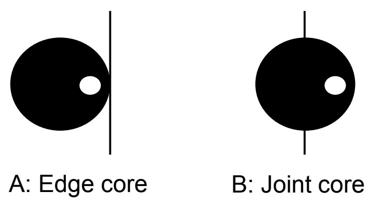
Coring works were undertaken by AECOM on 7th and 8th December 2017. 65no 150mm diameter cores were taken in locations presented in Figure 2 and Appendix B. Core locations were selected by AECOM to

i. be representative of each of the joints formed (based on visual assessment)
ii. avoid underlying cracked and crazed areas where possible
iii. avoid damaged 'existing' surfacing

A full core location diagram is presented in Appendix B which includes a key explaining the colour code for core testing.

The standard for taking edge cores (for highways binder courses) is to locate the core 100 mm from the joint. However for the purpose of assessing compaction of material at the joint for this specific project; edge cores were taken touching the joint. In addition; cores were spray painted to indicate which edge of the joint they were taken enable visual assessment of void distribution.

The schematic coring locations for the edge cores and joint cores are shown in Figure 9.



Notes:
A: White mark indicates edge closest to the joint
B: White mark indicates the heated and/or unconfined edge

Figure 9: Diagram showing core placement and marking relative to the joint

Cores were taken and logged by AECOM and core logs are presented in Appendix C.

Laboratory testing

Laboratory testing was undertaken at AECOM's accredited in house laboratory in Nottingham. A summary of testing undertaken is shown in Table 4. A detailed test instruction detailing the testing for each core is presented in Appendix D.

Table 4: Summary of testing carried out

Test	Test Method	Comments
In situ temperature monitoring (thermocouples in the joint)	Bespoke	Results provided by TRR
Binder content and grading	BS EN 12697-39 / BS EN 12697-2	Results provided by Tarmac
Bulk Density	BS EN 12697-6 Procedure B	Procedure C also used on some samples for comparison
Maximum density and air voids	BS EN 12697-5 Procedure A	Tested bulk material (Ultipave) & cores (existing surfacing)
Vertical Permeability	BS EN 12697-19	Constant head method
Indirect tensile strength test	BS EN 12697-23	20^{o}C test temperature
Direct tension test	Bespoke	Test and equipment designed and fabricated by AECOM
Bitumen testing: Dynamic Shear Rheometer	In house	Penetration grade and softening point (calculated)

Test methods are further detailed in Section 4.

4. Results

Results are presented for each set of testing carried out and a discussion of findings is detailed in Section 5.

Visual assessment of the joints

All of the joints appeared to be well compacted based on visual assessment.

Joints between newly installed materials

Photographs | Comments

Heated Joint B

Figure 10: i) Photograph of joint B ii) Close up of joint iii) Surface of core 18 iii) Profile of core 18

The joint appears to be uniform at the surface with good aggregate interlock. In general, Rip 3 finished slightly proud of Rip 1.

Material is uniform and well compacted with good interlock evident in all of the cores. It was difficult to visually determine the joint location based on the side profile of the joint cores.

Heated Joint C

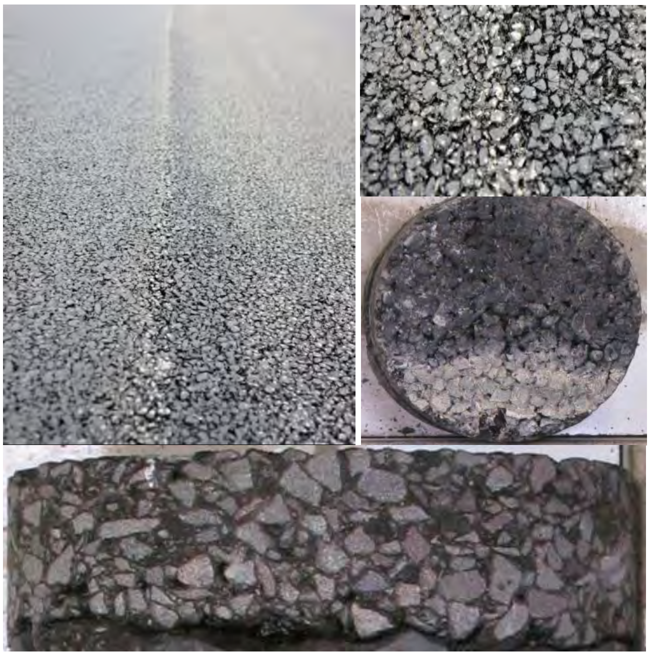


Figure 11: i) Photograph of joint C ii) Close up of joint iii) Surface of core 26 iii) Profile of core 26

The surface of the joint appears to be level, consistent and well formed with aggregate interlock evident. Heated Joint C appeared to be the most well-formed and uniform of the heated joints based on visual assessment of the surface.

From inspection of the cores, there is minor voiding visible in the unconfined edge side of the joint in four of the Joint C cores, with the confined edge appearing dense and well compacted in all but one core.

Photographs

Comments

Painted Joint D

Figure 12: i) Photograph of joint D ii) Close up of joint iii) Surface of core 35 iii) Profile of core 35

The surface of the joint appears to be level, consistent and well formed. Some bond coat is visible at the surface.

From inspection of the cores, there is a visible difference in voids between the unconfined edge and the confined edge in all of the Joint D cores, with the unconfined edge showing voids. The confined edge appears to be dense and very well compacted. It was noted during the trials that the edge of the Rip 2 material was cut back to vertical using a roller mounted cutting wheel. The amount of material cut back was estimated to be around 25 mm.

Joints between new and existing materials

Photographs

Comments

Painted Joint A

Figure 13: Painted Joint A; i) Photograph of the joint, ii) Core 8

Bituminous sealant was applied to the edge of the existing material ahead of the paving operation.

Thin Surface Course appeared to finish proud of the existing surface with some minor overlap.

The joint is observed to be at a slight angle on all of the cores taken.

In general, the newly installed surfacing appears to be uniform and well compacted at the joint. Some voiding is visible where the new thin surfacing overlaps the existing materials in one of the cores.

Painted Joint E

Figure 14: i) Photograph of the joint ii) Core 52 surface iii) Core 52 profile iv) Core 50 profile

Bituminous joint sealant was applied to the edge of the existing surfacing and spilled over to the surface.

The existing surfacing was cracked in some places. Coring was targeted to avoid any cracks.

The newly installed surfacing thickness was 50 mm in this location, based on the core logs.

Some loss of aggregate at the edge of the new surfacing was noted on three of the joint cores which is expected to have been caused by the coring operation. In addition, visible voiding was observed in the thin surfacing of two of the cores. The remaining cores appeared to produce a well compacted tight joint.

The newly installed surfacing generally finished flush with the existing surfacing and was slightly high of the existing surfacing locally.

Core 53 separated along the joint during core transit.

Photographs **Comments**

Heated Joint A

Figure 15: i) Photograph of the joint ii) Core 43 surface iii) Core 43 profile

Thin Surface Course appeared to finish proud of the existing surface with some overlap.

The joint is observed to be at an angle in all of the cores taken.

The cores suggest that in general, some voids are visible in the newly installed surfacing close to the joint. This may be due to the time delay between the paving machine and commencement of compaction at the joint.

Heated Joint E

Figure 16: i) Photograph of the joint ii) Core 56 surface iii) Core 56 profile

The newly installed surfacing was generally slightly high of the existing surfacing (to a lesser degree than was observed in Heated joint A).

The cores suggest that in general, the newly installed surfacing appears to be well compacted forming a tight joint. Slight voiding is visible in the thin surfacing in one of the cores only.

The joint is at an angle which may be due to the planning operation.

In situ temperature monitoring

In situ temperature monitoring was carried out at one location of a heated joint, comprising thermocouples installed at the joint. The aim was to record temperature rise of material at the joint through the depth of the layer. Thermocouples were placed in surfacing material in Rip 1 at chainage 34 m prior to compaction of the surfacing. The thermocouples were placed at the joint targeting 10 mm and 20 mm depth.

Equipment, installation and results were provided by TRR.

Figure 17: Installation of thermocouples at Rip 1 joint (chainage 34 m)

Figure 18: Installed thermocouples and data logger

Figure 19 and Figure 20 (provided by TRR) present temperature data for thermocouple 4 (installed at 10 mm depth, with end of probe 10 mm in the material) and thermocouple 3 (installed at 20 mm depth, with end of probe exposed) respectively.

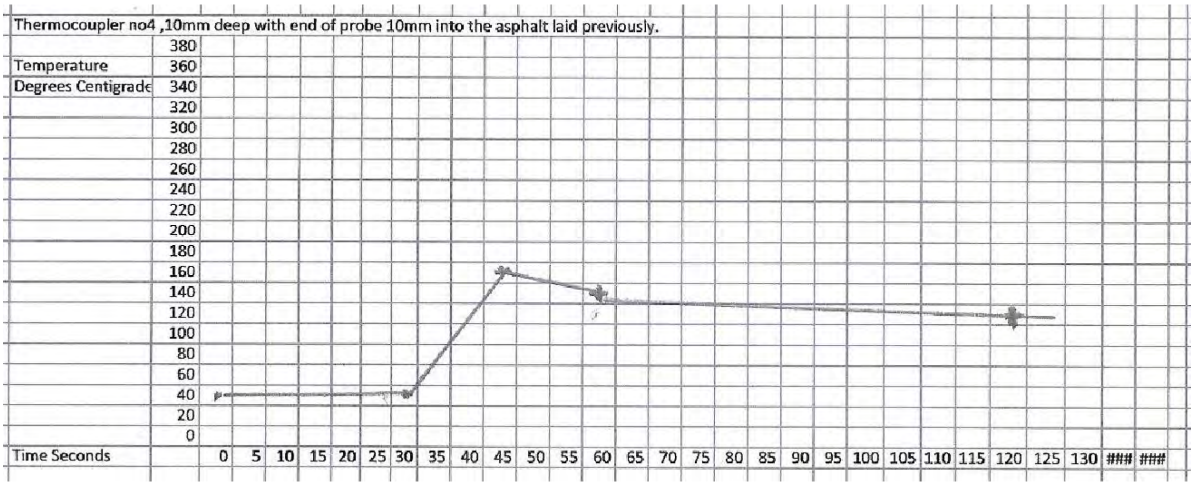


Figure 19: Thermocouple graphical data (Probe 4)

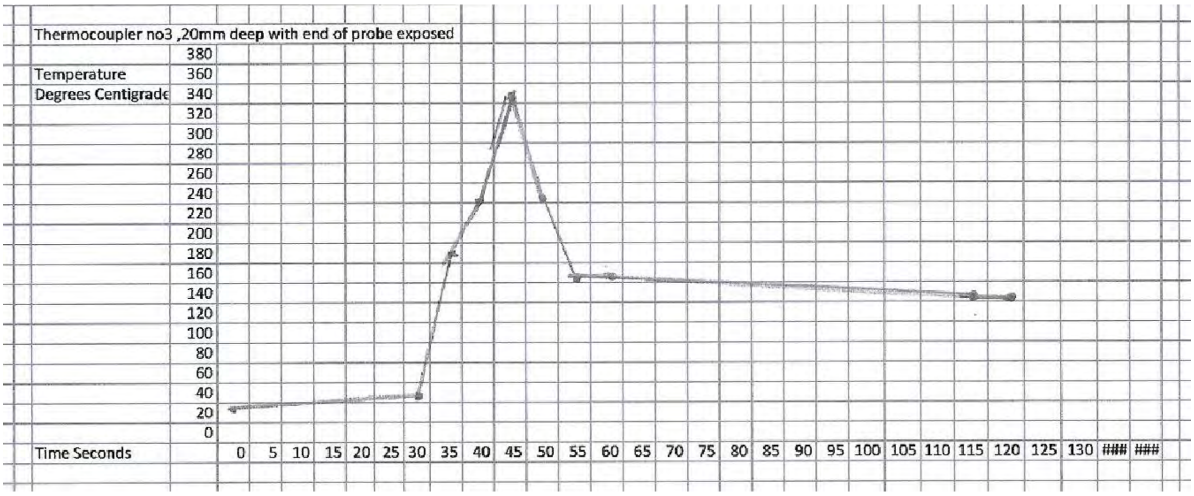


Figure 20: Thermocouple graphical data (Probe 3)

Thermocouple 4 data indicates a steady rise in temperature over approximately 15 seconds, peaking at 160°C followed by a slow reduction in temperature which remains above 120°C for at least a minute.

Thermocouple 3 indicates a rise in temperature to around 340°C, which is expected to be due to the thermocouple being exposed to direct heat from the joint heater. Over approximately 10 seconds the temperature steadily reduces from 160°C to 140°C which is in the expected temperature range of temperature of new material being installed and is reasonably consistent with thermocouple 4.

Thermocouple data indicates a steady increase in temperature which peaks at around 160°C

Binder content and grading

Three samples of Ultipave 10 thin surface course were taken (one sample from each load supplied) at the asphalt plant and tested by Tarmac for binder content and grading. All results were found to be compliant, within the target range and consistent.

All binder content and grading results were within the target range

Mixture Volumetrics

All cores were tested for bulk density to BS EN 12697-6, Procedure B (saturated surface dry).

A bulk sample of Ultipave 10 material was collected from Baston Hill asphalt plant which was sampled by Tarmac from the final load of material delivered to the trials. The maximum density for Ultipave 10 thin surfacing was determined from the bulk sample and this value was used to calculate the air voids of cores from newly laid materials.

At each joint, two edge cores were taken from each side of the joint and the unconfined edge and the confined edge are reported separately. In addition, six cores were taken directly over each joint and the bulk density measured and air voids calculated based on the maximum density for Ultipave 10.

Figure 21 presents the average air voids for cores taken over / next to joints between newly installed materials.

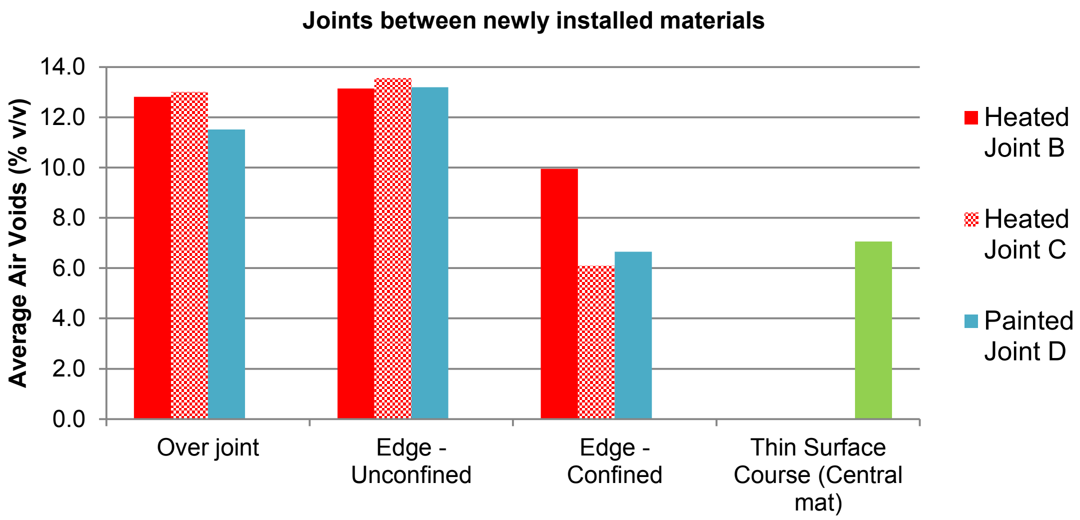


Figure 21: Average air voids for newly installed materials

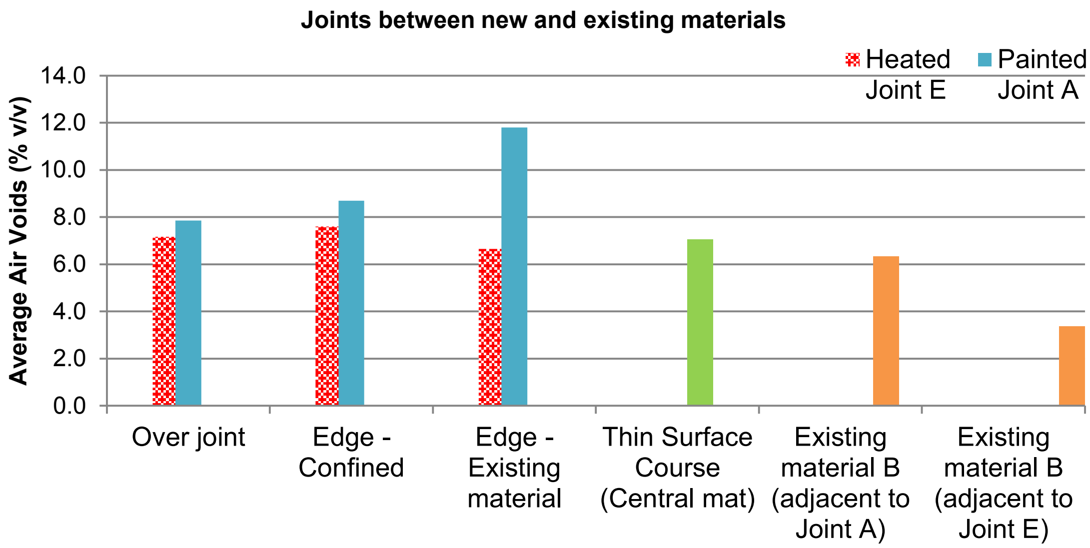
Thin surfacing at the unconfined edge was found to be similar for heated and painted joints.

The average air voids for thin surface course taken in the central mat was 7.1% (range 6.3 - 8.1%). Cores taken at the confined edge of Heated joint C (average 6.1%) and Painted joint D (average 6.7%) showed lower than average air voids than the central mat.

The confined edge of Heated Joint B was found to have 10% air voids (based on two cores at 9.9% and 10.0%) which was higher than Joints C and D and the central mat. The time before first pass of the roller is a possible contribution to higher air voids at the edge of Joint B. The time before first pass was observed to be reduced at heated Joint C compared with heated Joint B.

The painted joint has lower average air voids than the heated joints (based on the joint cores for newly installed materials). This is most likely to be due to bituminous sealant filling some of the air voids along the joint.

One core taken from Existing material B adjacent to Joint A and one core from Existing material B adjacent to Joint E were tested for maximum density. These values were used to calculate the air voids of existing materials in the central mat and the edge cores taken in existing material. Cores taken over the joint have calculated air voids which are based on a maximum density assuming 50% existing material and 50% thin surfacing. The position of the joint and difference in thickness between new and existing materials reduce certainty of the calculated air voids for joint cores. For this reason, analysis and interpretation focusses on compaction of thin surfacing at the joint (i.e. 'edge – confined' cores).



*Air voids of cores taken over the joint are estimated using a maximum density which assumes 50% existing material and 50% thin surfacing.

Figure 22: Average air voids for joints between new and existing materials

Thin surfacing compacted against existing material at Heated Joint E has lower air voids than thin surfacing compacted against existing material at Painted Joint A. Air voids of cores taken over the joint agree with this trend.

The preheating process would explain achieving better compaction of thin surfacing at the heated joint compared with the painted joint. However, construction factors may also influence the resultant air voids as it was noted that the first pass of the roller was further behind the paving machine at Joint A compared with Joint E. Therefore, the temperature of material is likely to have been lower on compaction of the painted joint compared to the heated joint due to both the heating process and the amount of time before rolling.

Edge cores:

- The unconfined edge has higher air voids than the confined edge.
- Thin surfacing at the unconfined edge showed similar air voids for heated and painted joints.
- Thin surfacing compacted against existing material showed lower average air voids at the heated joint than at the painted joint.

Joint cores:

- Painted joint has relatively lower average air voids than the heated joints (for newly installed materials)

Vertical Permeability

A column of water with a constant height is applied to a cylindrical core specimen and is allowed to permeate through the specimen for a controlled time in a vertical direction. The resultant flow rate of the water Q_v is a calculated measure of the permeability value K_v. The test is carried out at ambient temperature.

The core sample is sealed in the apparatus by inflating a rubber cuff around the specimen to prevent water flow at the edges. The sample is then placed in a bath of water with the surface of the core level with the water surface and a constant head of water is then applied and water is allowed to flow into the specimen over 10 minutes to ensure it is fully saturated. The plastic tube above the sample is then filled to 300 mm height and then the water is allowed to flow through the specimen into a separate container whilst maintaining the head of water for 1 minute. After 1 minute a (weighed) empty container is placed under the sample and the amount of water which passes through over a given time (min 60s) is recorded.

The vertical flow (Q_v) is calculated as shown in Equation 1 and vertical permeability (K_v) is calculated as shown in Equation 2.

Equation 1

$$Q_v = \frac{(m_2 - m_1)}{t} \times 10^{-6}$$

where

Q_v is the vertical flow, through the specimen, in cubic metres per second (m^3/s);

m_1 is the mass of the empty second container, in grams ± 0,5 g (g);

m_2 is the mass of the filled second container, in grams ± 0,5 g (g);

t is the time of collecting the water, in seconds (s);

Equation 2

$$K_v = \frac{4 \times Q_v \times l}{h \times \pi D^2}$$

where

K_v is the vertical permeability, in metres per second, (m/s);

Q_v is the vertical flow through the specimen, in cubic metres per second (m^3/s);

l is the thickness of the specimen, in metres (m);

h is the actual height of water column, in metres (m);

D is the diameter of the specimen, in metres (m).

Results are summarised in Figure 23 and Figure 24.

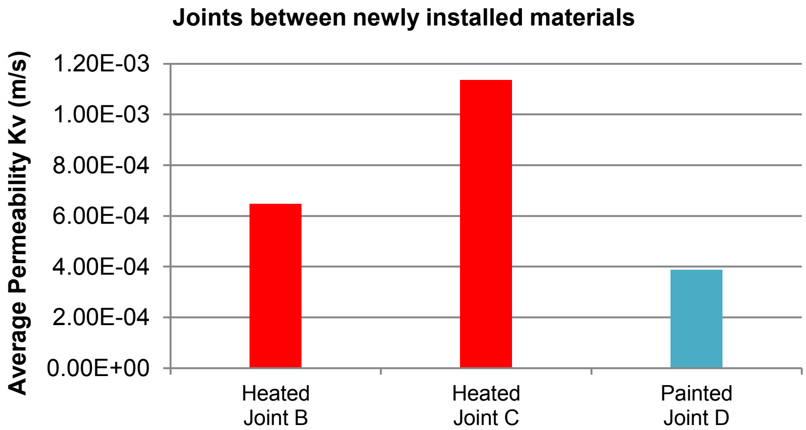


Figure 23: Average permeability of joints between newly installed materials

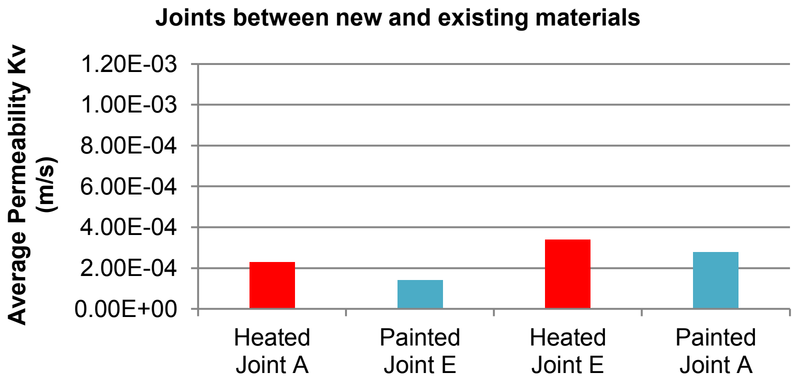


Figure 24: Average permeability of joints between new and existing materials

Results confirm that there is water flow through the test specimens which suggest the presence of interconnecting voids. With the exception of Heated joint C, there is little difference in the permeability of the samples tested. Results indicate that in general, the painted joints cores have slightly lower permeability than the heated joint cores. However, this is unlikely to be significant in the context of the accuracy of this test method.

To provide some context to the permeability results, the constant head of water was easily maintained on all test samples apart from cores from Heated Joint C which required a full fast flow of water to maintain the head height. This correlates with a slightly lower bulk density for Heated joint C cores compared with cores tested for permeability from Heated joint A.

Inspection of the core log photographs for the cores tested for permeability from Heated joint C show visually higher voids on the unconfined edge half of the core. This is generally consistent with visual assessment of other cores taken from this joint and the same is noted but to a lesser degree in cores from Heated Joint B.

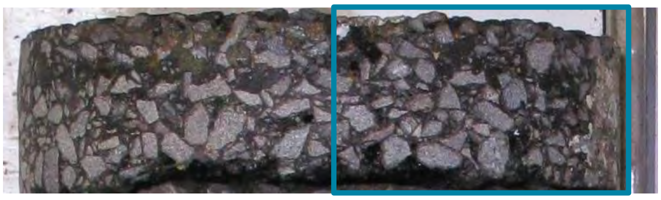


Figure 25: Heated Joint C - Core 26 (unconfined / heated edge shown in blue box)

Furthermore, it is noted that the two Heated Joint C cores tested for vertical permeability were also tested for DTT and during this test broke though material at the unconfined edge and did not split directly through the joint which suggests that the unsupported edge is having the greatest influence on the permeability results. It is expected that if Heated joint C was constructed as a painted joint, then the result may have been similar as the influence of the unconfined edge is expected to be much greater than the joint interface.

It is recognised that a large number of factors have an effect the permeability test and results. Such factors include the effectiveness of the seal around the sample and the thickness of the sample. A small leakage can have a large effect on the permeability value.

Painted joints were found to have relatively lower permeability than heated joints, however, this is unlikely to be significant in the context of the accuracy of the test method.

Indirect Tensile Strength

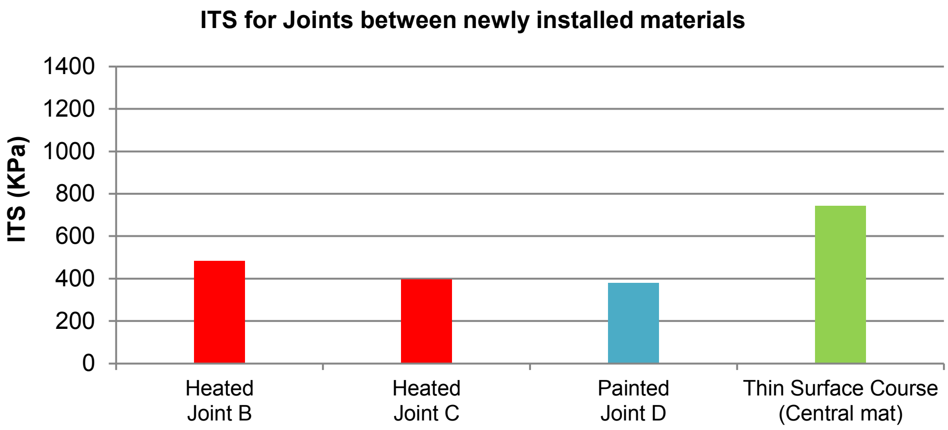
The indirect tensile strength (ITS) is the maximum tensile stress calculated from the peak load applied at break and the dimensions of the specimen. ITS testing provides a relative measure of the quality and integrity of asphalt material and the potential susceptibility for rutting or cracking. ITS also provides an indirect assessment of mixture cohesion which may also provide an indirect indication of how liable the material may be to fretting.

In order to assess the joint, samples were aligned with the joint running vertically top to bottom in the test frame. Testing a longitudinal joint in this way is a new approach and it was not known whether the test method would offer a direct measure of the joint strength. In theory the test assesses the sample as a whole and is expected to fail along a line of weakness, such as the joint.

Results are presented in Table 5:

Table 5: Summary of ITS results for joints between newly installed materials

Joint	Average ITS (min – max) kPa	Range kPa	% difference about mean	No. Samples tested
Heated Joint B	485 (463-534)	71	7%	3
Heated Joint C	396 (279-465)	186	23%	3
Painted Joint D	381 (326-414)	88	12%	3
Thin Surface Course (Central mat)	743 (658-814)	156	10%	3



Results show that cores taken in the central mat have ITS around 50% higher than cores taken over joints, with heated and painted joints showing similar average ITS values at face value.

The three Joint C samples tested showed two results with similar ITS values (443 kPa & 465 kPa) and one result at 279 KPa. If this lower result is considered to be an outlier and discounted from the mean then the resultant average for Joint C becomes 454 KPa which is very close to the average ITS measured for Heated Joint B and around 20% higher than the average ITS for the painted joint.

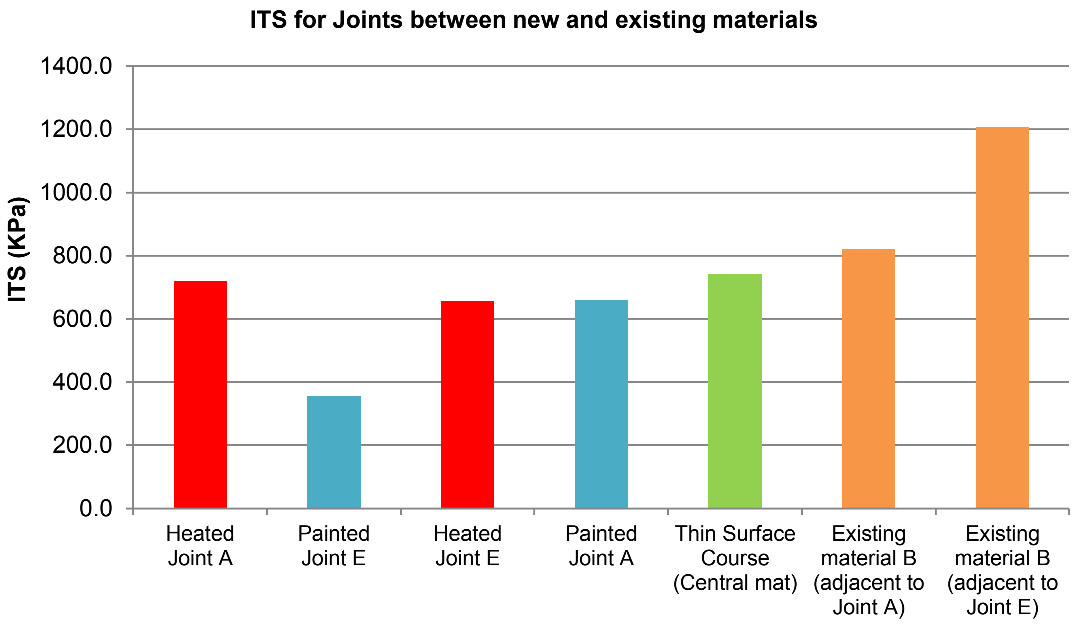
This suggests that heated joints have slightly superior performance to painted joints in terms of tensile strength.

It should be noted that the method of test is new for assessing longitudinal joints and there may be other factors which have an influence on the measured values. Such factors may include orientation of the core in the test rig and the location of the joint within the core (i.e. not all joints were positioned centrally on the core). Furthermore, some of the joints were observed to be off-centre in the core which may also have an effect on the force applied through the joint. In addition, the roughness of the joint is expected to have an influence on the test results. For example, the heated joints were observed to have greater roughness and interlock than the painted joints. However, the method of joint formation is recognised as an additional variable because the unconfined edge of Painted Joint D was cut back, while the heated joints were not treated in this way.

The test assesses the material as a whole and not solely the joint, therefore the integrity of material around the joint is also expected to have an influence on the measured ITS.

Table 6: Summary of ITS results for joints between new and existing materials)

Joint	Average ITS (min – max) kPa	Range kPa	% difference about mean	No. Samples tested
Heated Joint A	721 (641-784)	143	10%	3
Painted Joint E	355 (296-414)	118	17%	2
Heated Joint E	655 (439-889)	450	34%	3
Painted Joint A	659 (523-794)	271	21%	3
Thin Surface Course (Central mat)	743 (658-814)	156	10%	3
Existing material B (Central mat, adjacent to Painted Joint A)	821 (769-879)	110	7%	3
Existing material B (Central mat, adjacent to Heated Joint E)	1207 (1160 – 1240)	80	3%	3



ITS for non-joint cores was found to be higher than ITS measured on cores taken over the joint, which was expected and supports the theory that joints present a relative weakness in the structure. In addition, ITS of the aged 'existing materials' was higher than that for newly installed Thin Surface Course in the central mat. This is also expected since aged materials have hardened binder and higher stiffness than newly installed materials requiring greater force to failure.

In general, there was greater variation in results for the cores with joints between new and existing materials. This may be expected because both the new material and the existing material will influence the required force to failure and factors such as orientation of the joint within the test equipment and position of the joint within the core may have a greater impact than if we were measuring homogenous materials.

Changes in the existing material type should also be recognised. Existing material B appears to be SMA material based on the core logs and is incorporated in Painted Joint A and Heated Joint E. Comparing Painted Joint A and Heated Joint E shows very similar average ITS (although high variation in individual results).

Heated Joint A and Painted Joint E incorporate a different existing substrate (assumed to be asphalt concrete surfacing) which was not cored for further analysis. Some minor cracking was noted in the existing surfacing adjacent to Painted joint E. Although coring aimed to avoid cracked areas, damage to the existing surfacing could result in lower ITS. Construction factors could also have had an effect, for example, the cores tested were taken at chainage 6m and 7m in a location where the paving machine was finishing the Rip installation and stepping out onto the existing material so whilst it is expected that the material was machine laid in this location, there could have been some hand lay. Core 53 (Painted joint E) split during core logging which suggests a weak bond and may support the low measured ITS values.

All samples tested (excluding core 47) failed along the joint. Core 47 exhibited a puncture type failure and was discounted from the results.

Heated joint (new-new) Painted joint (new-new) Heated joint (new-old) Painted joint (new-old)

Figure 26: Example photographs of ITST samples after test

ITS results suggest:

- Joints have lower tensile strength than the central mat
- Heated joints have slightly higher tensile strength than painted joints
- Interlock and roughness of the heated joint are expected to be contributing factors to these findings.

Direct Tension Test

Shear tests and direct tension (pull) tests were considered as options for assessing the longitudinal joint. There are standard test methods available for both options when assessing bond between asphalt layers in a horizontal plane. However, the longitudinal joint is a vertical joint through a relatively thin layer in the case of thin surfacing and as such no ‘off the shelf’ assessment methods are available. For this reason, AECOM designed, developed and fabricated bespoke pull testing equipment for assessment of the longitudinal joint and partnered with NTEC to carry out the testing using a test rig which was able to apply the required loading rate. UniFabs Ltd (based in Nuneaton) supported with the design drawings and manufactured the test equipment.

Concept

The Direct tension Test (DTT) is designed to assess the force required to pull the core sample apart. Figure 27 presents the design concept and equipment set up for the test.

The core sample is positioned in the test rig with the longitudinal joint positioned centrally. The bottom half of the sample clamped into the test rig by hex screws and shim plates to the base plate which was designed to attach securely to the base of the test rig. Plates are adhered to the top half of the sample using Araldite 2011 adhesive and a cross bar and screws provide confinement. The pull bar is designed to fit to the load cell which measures the force applied.

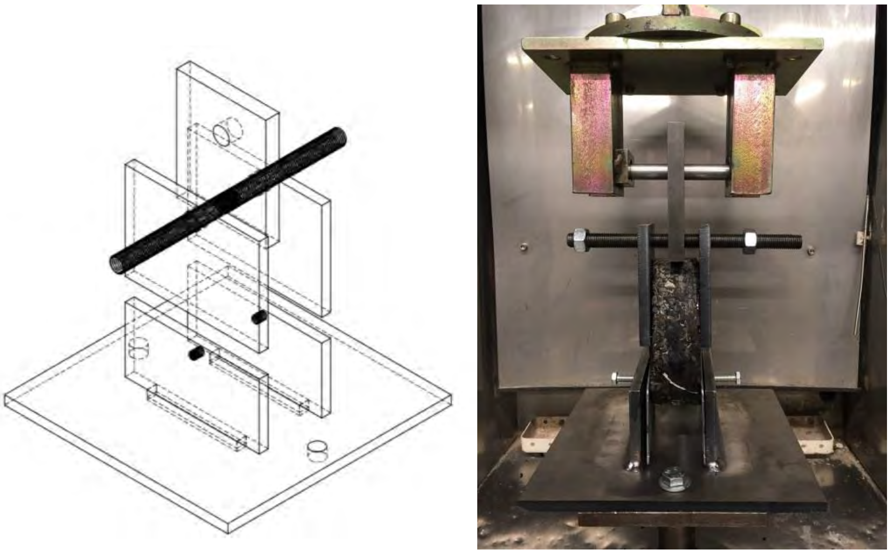


Figure 27: DTT design concept and equipment set up

Test method

The samples are conditioned to 20°C (+/- 2°C) and positioned in the test frame with the longitudinal joint running as centrally as possible [20°C was selected as the test temperature as it is considered to be within the expected range of ambient conditions in service. Furthermore, a lower test temperature was expected to yield lower peak force at failure and will be less sensitive to differences in performance].

Load rate of 1mm per minute is applied and the peak force (kN) at failure is recorded. The sample is assessed for failure type and to see if the sample fails along the joint. The surface area of the failure plane is measured (length x width) to account for samples where the joint is positioned off centre and the peak stress is reported as N/mm^2.

Figure 28: Photograph of test i) early test, started splitting, ii) testing just before failure iii) post test

DTT results

Test results are presented in Table 7.

Table 7: Summary of pull test results

Joint reference	Core number	Test temperature (°C)	Peak force (kN)	Mean Peak force (kN)	Peak stress (N/mm^2)	Mean Peak stress (N/mm^2)	Observations of failure interface
Heated Joint B	14	20.1	0.72	0.77	0.148	0.146	Ductile failure along the joint
	18	20.2	0.81		0.143		Ductile failure along the joint
Heated Joint C	26	20.1	0.53	0.53	0.109	0.097	Results not valid (did not fail through the joint. Failed through material around the clamp)
	29	20.0	0.52		0.085		
Painted Joint D	35	20.5	0.95	0.80	0.148	0.133	Ductile failure along the joint
	39	20.4	0.64		0.118		Ductile failure along the joint
Heated Joint A	43	20.4	0.87	0.87	0.122	0.122	Ductile failure along the joint
	44	20.4	0.30		-		Result not valid (did not fail through the joint)
Painted Joint E	50	20.3	0.44	0.44	0.065	0.065	Ductile failure along the joint
Painted Joint A	7	20.0	0.80	0.79	0.136	0.132	Ductile failure along the joint
	8	20.1	0.78		0.128		Ductile failure along the joint
Heated Joint E	54	20.2	1.40	1.27	0.200	0.197	Ductile failure along the joint
	58	20.2	1.13		0.193		Ductile failure along the joint

Samples which did not fail through the joint have been discounted from the analysis. The average peak stress (N/mm^2) for heated and painted joints is presented graphically in Figure 29 and Figure 30.

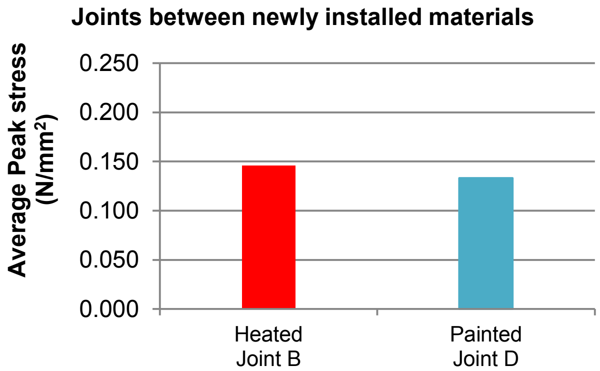


Figure 29: Average peak stress for joints between newly installed materials

For joints between newly installed thin surfacing materials, results from Joint C cores are discounted from the analysis because they did not break through the joint. Results suggest similar peak stress for heated and painted joints with the heated joint slightly higher.

Visual inspection of samples post-testing indicated a smoother surface at the failure plane for painted joints than heated joints, as may be expected due to aggregate interlock of the heated joint. Cutting back the painted joint is also expected to influence this observation.

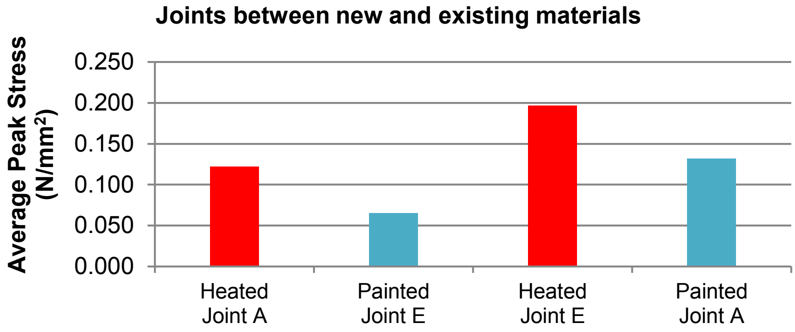


Figure 30: Average peak stress for joints between new and existing materials

Comparing Heated Joint A with Painted Joint E (both joints incorporate Existing substrate A) and Heated joint E with Painted Joint A (these joints incorporate Existing substrate B) it can be seen that heated joints have higher peak stress than painted joints. However, comparing the data set as a whole suggests that the trend is not entirely conclusive.

For joints between newly installed thin surfacing, the peak stress (N/mm^2) was similar for heated and painted joints, with heated joints slightly higher.

In general, the heated joints showed higher peak stress than the painted joints for joints between new and existing materials. However, comparing the data set as a whole suggests that the trend is not entirely conclusive.

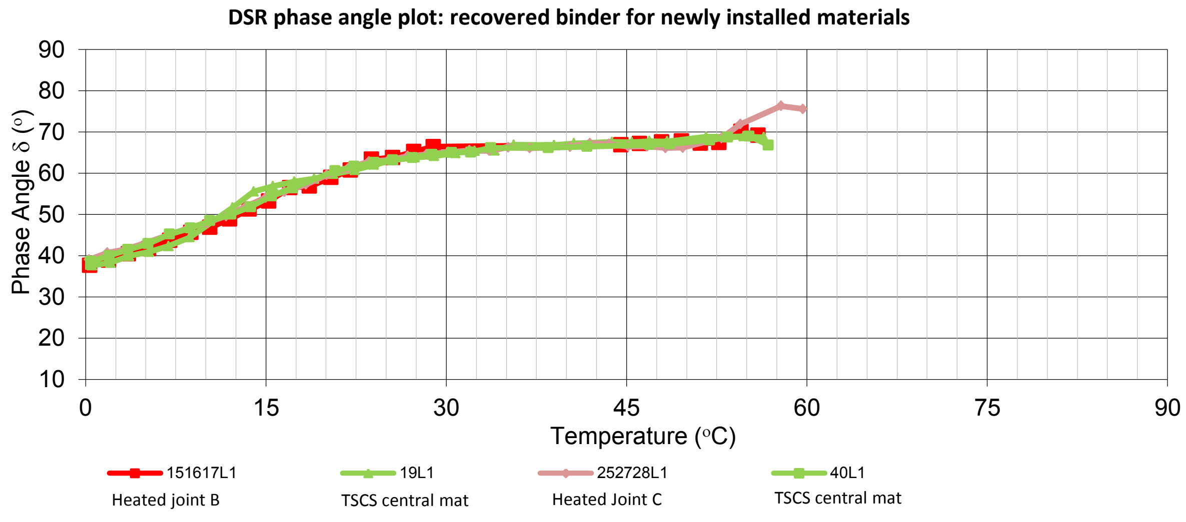
Binder properties

In order to understand the effect of the thermal heating process on the properties of the bitumen at the joint, the rheological properties of the binders were assessed before heating (based on the central mat) and after heating, based on assessment of the heated side of the joint cores after splitting by ITS testing. It is expected that the full surface of the heated side of each core tested was exposed to thermal heating by the joint heater.

Bitumen was recovered from the heated side of the ITS samples using rotary evaporator method and tested using Dynamic Shear Rheometer. The calculated penetration grade are summarised in Table 8.

Table 8: Summary of recovered binder properties

Joint	Penetration Grade (dmm)	Complex shear modulus (G*)
Heated Joint B	60	2.74 E+05
Heated Joint C	75	1.82 E+05
Painted Joint D	68	2.20 E+05
Thin Surface Course (Central mat) - RIP 1	64	2.43 E+05
Thin Surface Course (Central mat) - RIP 2	72	1.94 E+05
Heated Joint E (heated existing material)	21	1.83 E+06
Existing material B (adjacent to Joint E)	30	9.21 E+05



Results for thin surfacing exposed to the joint heating process (Joints B & C) indicate penetration grade within the expected range for a short term aged (post production and laying) PMB 75/130-75 grade which is consistent with thin surfacing tested in the central mat. Furthermore, analysis of the DSR phase angle plot shows very similar rheological properties for materials from the central mat and after heating by joint heater. These findings do not suggest evidence of binder hardening beyond what is expected during standard installation.

Analysis of recovered binder properties for existing material recovered from cores at Joint E are consistent with an age hardened binder which is expected after a long period in service. The DSR plot suggests that the existing material comprises penetration grade binder and results indicate some reduction in penetration grade. It is recognised that during the age hardening process there is likely to be variability in the penetration grade of age hardened materials. However, a change of 9 dmm penetration grade could be an indication that the joint heating process has resulted in further hardening of material at the joint. This could suggest that the age and bitumen type of material affects how prone the materials are to hardening. For example, penetration grade binders could be more prone to hardening than PMB bitumen.

Binder properties suggest:

- Penetration grade is within the expected range
- No evidence of significant binder hardening for newly installed materials
- The existing (aged) material showed some reduction in penetration grade with could suggest that materials are affected in different ways depending on age and bitumen type. For example, penetration grade binders could be more prone to hardening than PMB bitumen

5. Discussion

The trial aims to compare the performance of heated joints against painted joints for joints between newly installed thin surfacing and for joints between new and existing materials.

Key variables assessed:

1. Heated joints are constructed using a paver mounted joint heater (no joint sealant applied).
2. Painted joints are constructed using conventional paving methods (joint sealant is applied).

Other variables related to construction methods were noted during the trials, and the likely effects of each on the findings from the trials are discussed in Table 9.

The testing carried out assesses material in the proximity to the joint as well as the joint interface, therefore the material compaction in particular at the unconfined edge is highlighted as a key parameter with respect to material durability which isn't directly influenced by the heating or painting process of joint formation.

Analysis of air voids data demonstrates a significant difference in air voids between the confined edge and the unconfined edge for both joint types. In the context of material durability at and around the joint, interconnecting air voids may result in water ingress which adversely impacts durability. Permeability testing suggests that painted joints have relatively lower permeability than heated joints which may be expected due to the presence of joint sealant leading to lower air voids at the joint interface. However, this is unlikely to be significant in the context of the accuracy of the permeability test.

Air voids of the confined edge were similar to those in the central mat for one of the heated joints and the painted joint between newly installed thin surfacing materials. At the other heated joint (Heated Joint B), the confined edge air voids were found to be higher than the central mat which again is expected to be influenced by time delay in compacting the joint.

Thermocouple data suggests that material on the heated side of the joint remains above the recommended minimum initial compaction temperature for Ultipave TSCS (120^{o}C) for around 75 seconds after the heater has passed. The minimum initial compaction temperature is typically 100^{o}C to 140^{o}C depending on the material and bitumen used. Therefore, when using joint heater technology the rollers must follow the paving machine as soon as possible to realise the maximum benefit to enable compaction at both sides of the joint.

Fundamental differences at the joint interface were observed on ITS and DTT samples after testing. Considering joints between newly installed thin surfacing materials;

- the painted joint appeared relatively straight and near vertical
- the heated joints were angled and rough with aggregate interlock

It is noted that the painted joint was cut back which contributes to these findings.

ITS and DTT testing were incorporated in the evaluation to provide a relative performance measure between heated and painted joints.

Indirect tensile strength testing was carried out with the joint positioned vertically in the test frame, which is a bespoke method adopted for this research. ITS of material from the central mat was around 50% higher than ITS of the joint which supports the general view that joints are a relative point of weakness in the pavement. ITS testing provides an indirect assessment of mixture cohesion which may also provide an indirect indication of how liable the material may be to fretting.

ITS results suggest that heated joint cores have slightly higher tensile strength than painted joints. A larger degree of variation was seen for cores tested at joints comprising different material types but in general, results also suggested slightly higher tensile strength for heated joints than painted joints. It is expected that the ITS test will be more greatly affected by the roughness and angularity of the joint than DTT and the variability in each data set was observed to be quite high. Therefore, whilst the heated joints displayed slightly higher ITS than that of the painted joints, the relative significance is expected to be small.

DTT is a bespoke test designed specifically for these trials to directly assess the tensile strength of the joints and is intended to assess the joint interface. For joints between newly installed thin surfacing, the peak stress (N/mm^2) was similar for heated and painted joints, with heated joints slightly higher. In general, the heated joints showed higher peak stress than the painted joints for joints between new and existing materials however, the trend was not entirely conclusive.

DTT testing of cores from Heated Joint C did not fail through the joint and were discounted from the overall assessment. This could indicate potential issues with the material in the proximity of the joint (on the unconfined edge). The same samples were found to have air voids >13% and relatively high permeability. Again, it is likely that compaction at the unconfined edge had a greater influence than the heating process at this location.

Table 9: Summary and discussion of the effect of other variables on trial results

Variable	Affected joints	Discussion
Paving speed varied throughout the trials, but targeted the optimum speed for the joint heating process.	All	Paving speed was varied with the aim of achieving the optimum heating from the joint heater. Lower paving speed can increase material density and decrease texture at the surface. The effect of paving speed on the trial results is expected to be minimal relative to the effect of other variables.
The amount of time between paving and first compaction was observed to be variable. This factor has an influence on material temperature at initial compaction.	All	The time before first compaction of the joint was observed to be 2 to 4 minutes for all joints apart from Joint C where the roller followed approximately on minute after the paving machine.
Material surcharge varied for each joint constructed.	All	The surcharge was observed to be slightly high for Joints A, B and locally at Joint E. Joints C and D appeared to finish flush across the joints. Where surcharge is too high the roller may bridge the joint and not achieve optimum compaction. Conversely inadequate surcharge can result in low density if the thickness of material is insufficient at the joint.
Joints were not cut back, with the exception of Painted Joint D	Painted Joint D	Joints between new and existing surfaces all had planed edges which are comparable. Heated Joints between newly installed thin surfacing (Joints B and C) were not cut back and are formed at an angle. Painted Joint D was cut back to near vertical. Cutting back the joints is expected to improve density at the unconfined edge (although this didn't show in the edge cores air void results) and across the joint. In addition, the joint shape and angle is expected to have an effect on the permeability (as a consequence of air voids), ITS results (more interlock is expected to increase ITS) and the DTT (due to increased surface area of non-cut joint relative to a cut joint). The effect on ITS is expected to be greater than the effect on DTT.
The type and condition of existing surface was observed to vary through the trial area.	Joints A and E	Heated Joint A and Painted Joint E incorporate the same existing substrate type (Existing Material A). However, the condition of existing material adjacent to Joint E was observed to be cracked in some areas. The core locations were targeted away from cracks where possible but the condition of the substrate is expected to affect the results, particularly for ITS testing and potentially permeability.
Other construction factors	Joint E	The available area for coring Painted Joint E was limited and as such, there are cores taken at chainage 6 m and 7 m. In this area, the paving machine may be stepping out onto the existing material. Whilst it is expected that the material was machine laid, there may be an element of hand lay in this area which could affect density, ITS and permeability findings.

6. Conclusions

The trials demonstrate that paver mounted joint heaters can produce uniform bonded joints with good aggregate interlock. Temperature measurements taken during installation show that material is heated to an appropriate temperature above softening point and recovered binder testing suggests that this temperature increase does not adversely affecting properties of the bitumen after installation.

A comprehensive assessment and testing regime was carried out to compare the performance of heated joints and painted joints. The assessment comprised:

- Visual assessment of joints and cores
- Density and air voids at and around the joints, compared with the central mat
- Permeability of the joint and surrounding material
- Indirect tensile strength test to provide a relative index of material integrity cohesion
- Direct tension test, which is a bespoke test developed for these trials which aims to provide an indication of the force required to pull the samples apart at the joint
- Recovered binder properties to assess the effect of joint heater technology on the binder

Findings demonstrate that both heated and painted joints can achieve well compacted and well bonded joints and show that heated joints can provide good aggregate interlock across the joint.

Findings highlighted some differences in relative performance of heated and painted joints, but relative performance depends on which parameter is being considered and should be viewed in context of how the joint is formed.

Findings suggest that painted joints may achieve slightly lower permeability than heated joints (however, this is unlikely to be significant in the context of the accuracy of the permeability test). ITS and DTT testing suggests that heated joints displayed slightly higher ITS and slightly higher peak stress than that of the painted joints.

A key area which is not directly impacted by heating or painting is compaction at the unconfined edge which is expected to have a significant influence on durability of material in the proximity of the joint. In addition, construction practice is highlighted as a key factor to the success of any joint, in particular the time before rolling which should be minimised to realise the benefits from joint heater technology.

7. Recommendations

Continued annual monitoring of the trials is recommended to assess performance of the different joints over time. Caution is noted in areas which exhibited cracking and crazing in the substrate prior to inlay as the level of structural support is expected to influence the performance of materials and joints in these locations.

Air voids at the uncompacted edge of surface course joints is highlighted as an area which could potentially benefit from further research with the aim of reducing air voids, closer to that of the central mat.

It was noted that paving speed was limited due to the relatively small scale of these trials. Further consideration could be given to the effect of different paving speeds on heat penetration and the resultant joint.

Coring of echelon paved joints would be interesting to provide comparative air voids and permeability assessment.

These trials along with track record in other applications provide a good level of confidence in relation to joint heater technology. Further application of the technology on the Network is recommended to inform the relative performance in situ of heated vs painted joints over time and use.

These trials were limited to assessment of premium thin surface course PMB material. Different PMB's may behave in a different way under the joint heater therefore assessment of PMB with a different grade or polymer content is suggested. In addition, penetration grade materials may require further consideration to determine their resistance to heat in terms of binder hardening.

It is also recommended that an assessment of the impact of paving outputs vs benefits from joint heater technology is considered in order to determine whether Highways England's key objectives are achieved. Assessment of the whole life cost between painting and heated joints would be beneficial to inform this assessment.

8. Acknowledgements

Many thanks to all involved, including; Highways England for funding this project under 'Innovations Designated funds' in particular Martin Bolt and Robin Hudson-Griffiths for their involvement and contributions; Mike Holmes (Kier Highways) for chairing and organising the trials; Aidan Conway and colleagues from Thermal Road Repairs for providing expertise, technical support and the paver mounted heater technology; Tim Ordidge and colleagues from Tarmac for material supply and installation; Neil Leake for providing the trial and test plans and involvement on behalf of Aggregate Industries and the Pavement Efficiency Group.

Appendix A Laying records

Asphalt Production Site Sheet

AECOM

Site Name	Joint Heater Trials: Keir Highways, Stafford Park Depot, Telford,
Project Number	60485963.JHT
AECOM staff name	John Draper

Supplier/Plant	1 Baston Hill (Tarmac). Ultipave 10 surf PMB 65 PSV
Supplier/Plant	2
Supplier/Plant	3
Supplier/Plant	4
Supplier/Plant	5

Notes:-

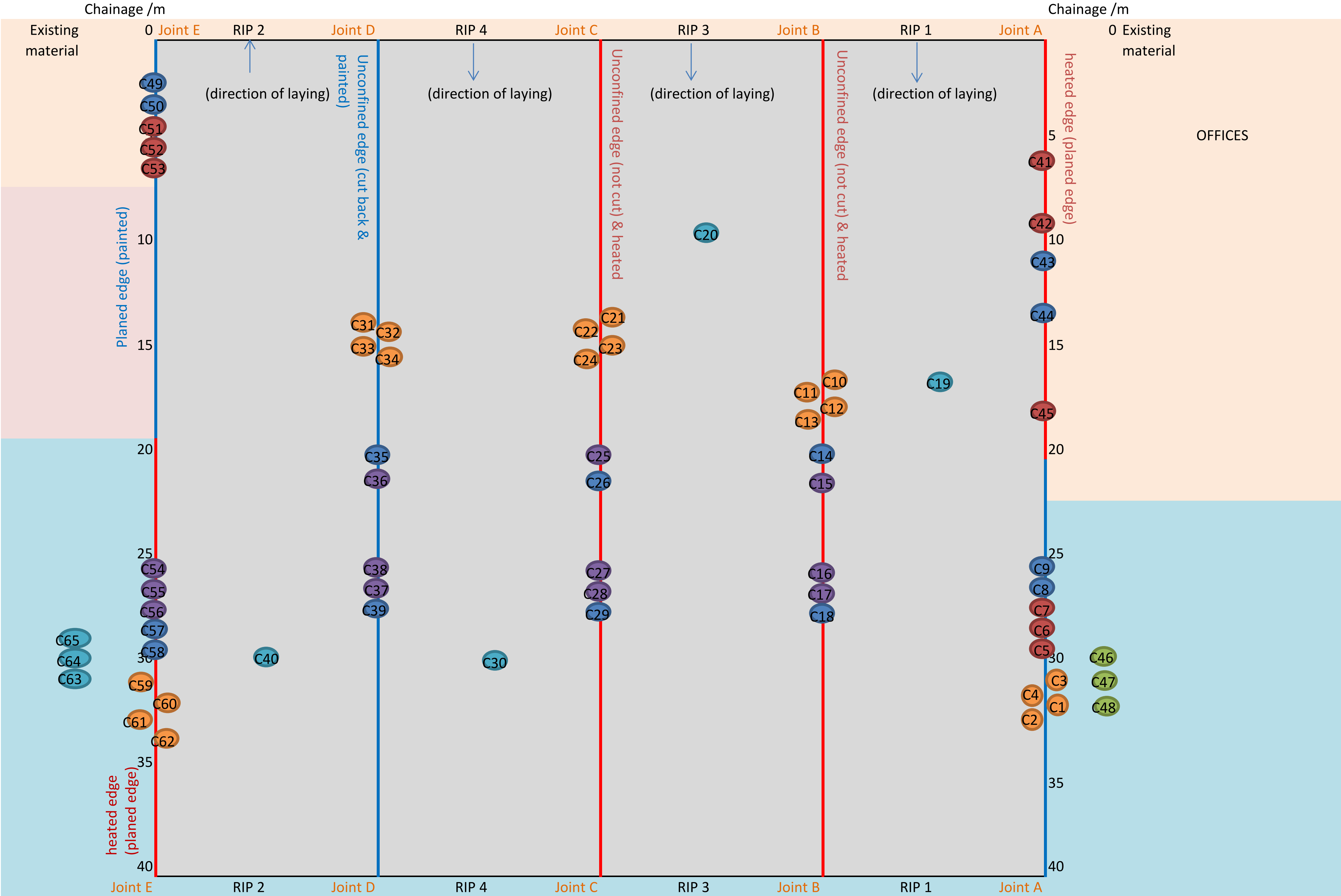
Joint Heater Trials Monday 27th November

Ambient Temperature	7oC to 9oC
Ground temperature	5.6oC
Paving machine	Volvo P687
Joint heater model	GRR126
Rollers	Bomag 135 & HAM deadweight HW90

			Time			Temp (°C)			Location				
Ticket No.	Supplier/Plant	Load (T)	Arrival	Unload	End	Initial	Paver out	Finished rolling	Start Ch. (m)	End Ch. (m)	Rip	Layer	Remarks
Q116101E	1		08:45	10:10	10:21	179.2	170	123	0	40	1	1	
Q116101E	1	20+		10:27	10:42	179.5	163		40	15	2	1	
116102E	1	20+	10:20	10:44	11:00	166.6	149.8	127.2	15	0	2	1	
116102E	1	20+	10:20	11:09	11:16	168.7	165.4	96.2	0	40	3	1	
116104E	1	147	12:50	12:58	13:10	144.1	163.2	93.7	0	40	4	1	

Appendix B Core location diagram

Appendix B: Trial layout and core locations



KEY

Heated joints

Painted joints

Newly installed Ultipave 10 pmb surf

Existing material A

Existing material C

Existing material B

Number	Coring & testing:	
14	150 mm	Permeability & bespoke shear test
20	150 mm	Bulk density
9	150 mm	Indirect tensile strength, recovered binder & DSR
12	150 mm	Indirect tensile strength
7	150 mm	Bulk density, Indirect tensile strength & DSR, plus max density on one of the 'existing' set of 3
3	150 mm	Bulk density, Indirect tensile strength, plus max density on one of the cores
Total **65**		

APPENDIX B (continued) SUMMARY OF CORE LOCATIONS

Core	Ch.	Rip
1	31m	old
2	31m	1
3	30m	old
4	30m	1
5	29m	1-old
6	28m	1-old
7	27m	1-old
8	26m	1-old
9	25m	1-old
10	18m	1
11	18m	3
12	20m	1
13	20m	3
14	21m	1-3
15	22m	1-3
16	25m	1-3
17	27m	1-3
18	27m	1-3
19	16m	1
20	11m	3
21	15m	3
22	15m	4
23	16m	3
24	16m	4
25	22m	3-4
26	22m	3-4
27	25m	3-4
28	26m	3-4
29	26m	3-4
30	28m	4
31	15m	2
32	15m	4
33	16m	2
34	16m	4

Core	Ch.	Rip
35	22m	2-4
36	22m	2-4
37	26m	2-4
38	26m	2-4
39	27m	2-4
40	30m	2
41	8m	1-old
42	9m	1-old
43	10m	1-old
44	13m	1-old
45	15m	1-old
46	31m	old
47	31m	old
48	48m	old
49	5m*	2-old
50	6m*	2-old
51	6m*	2-old
52	7m*	2-old
53	7m*	2-old
54	28m*	2-old
55	28m*	2-old
56	28m*	2-old
57	29m*	2-old
58	29m*	2-old
59	29m*	old
60	29m*	2
61	30m*	old
62	30m*	2
63	30m*	old
64	30m*	old
65	31m*	old

Key: * denotes approximate chain

Appendix C Core logs

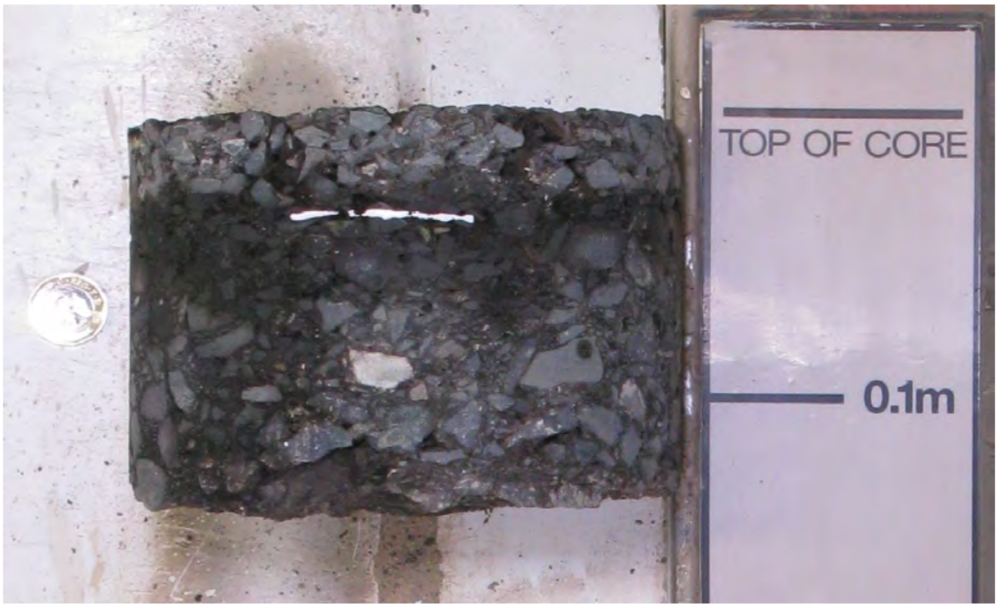
CORE LOGGING OF PAVEMENT MATERIAL

In Accordance with AECOM in House Procedures

Job Number :	**60485963**	Scheme :	**Stafford Depot : Telford**
Sample Number :	**T0824**	Notes:	**1. Edge core**
Core Number :	**01**		**2. Coin is placed on the edge closest to the joint**
Cored / Logged By :	**RF / BM**		**3. Existing material**
Date Cored / Logged :	**07-12-17 / 20-12-17**		
Nominal Diameter :	**150mm**		

Layer	Depth (mm)		Thickness (mm)	Material Description [1]	Suitable for NAT/CS Testing (Yes/No)	PAK-Marker [2]	Binder [3]	Aggregate	
	From	To						Size [4]	Type
1	0	30	30	Asphalt Surfacing (voided)(left of rip)	Yes	-ve	Bitumen	10	Crushed Rock
2	30	110	80	Asphalt Concrete (voided)	Yes	-ve	Bitumen	20	Crushed Rock

Notes : The scale is for guidance only. It does not necessarily reflect the actual thicknesses of individual layer(s).



Core Surface

Material Description [1]

The material description given (such as hot rolled asphalt or asphalt concrete) is generic only and is based upon a visual assessment of the material. Similarly, use of additional descriptive (such as voided) is based on visual assessment only and the relationship between air voids visually to the naked eye and degree of compaction is complex and materials specific.

PAK-Marker (PAH Spray) [2]

The Tar Spray Test is a rapid, qualitative indicator of the presence of polyaromatic compounds (PACs) typically found in tar. PACs also exist in other road construction materials (e.g. bitumen and cutbacks like kerosene), but at low concentrations. The probability of obtaining a false positive result in the tar spray test with such materials is low, and a positive result in the tar spray test is a strong (but not definitive) indicator of the presence of tar. For quantitative results, this test should be considered in conjunction with the results from other tests (i.e. Total Polynuclear Aromatic Hydrocarbons (PAH) by Gas Chromatography - Flame Ionisation Detection (GC-FID)).

Binder [3]

The binder type is assessed based on visual and aromatic inspection. The PAK-Marker result is also considered.

Aggregate Size [4]

The sizes indicated are given as the best estimate of the nominal size of the material.

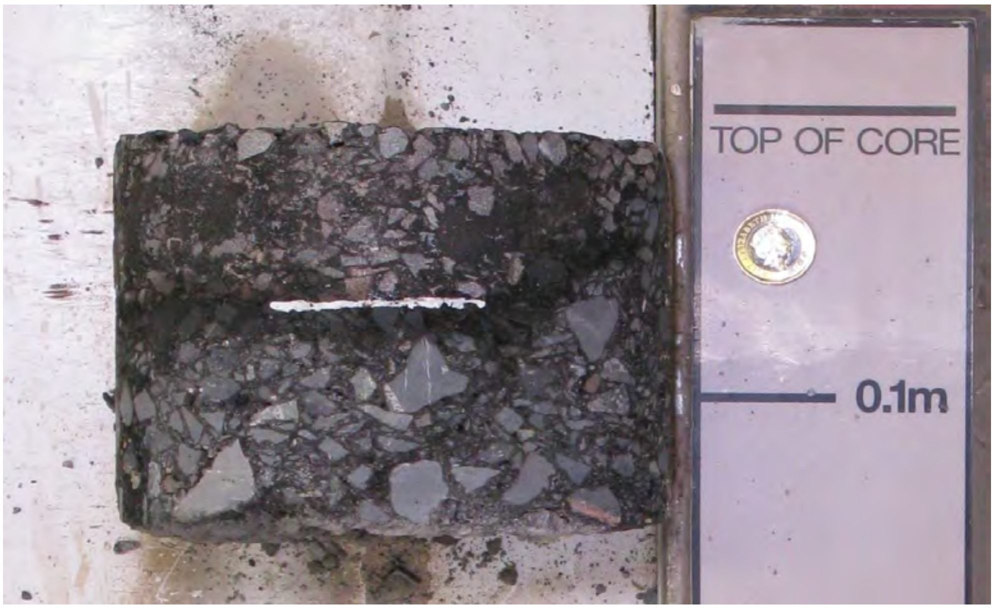
CORE LOGGING OF PAVEMENT MATERIAL

In Accordance with AECOM in House Procedures

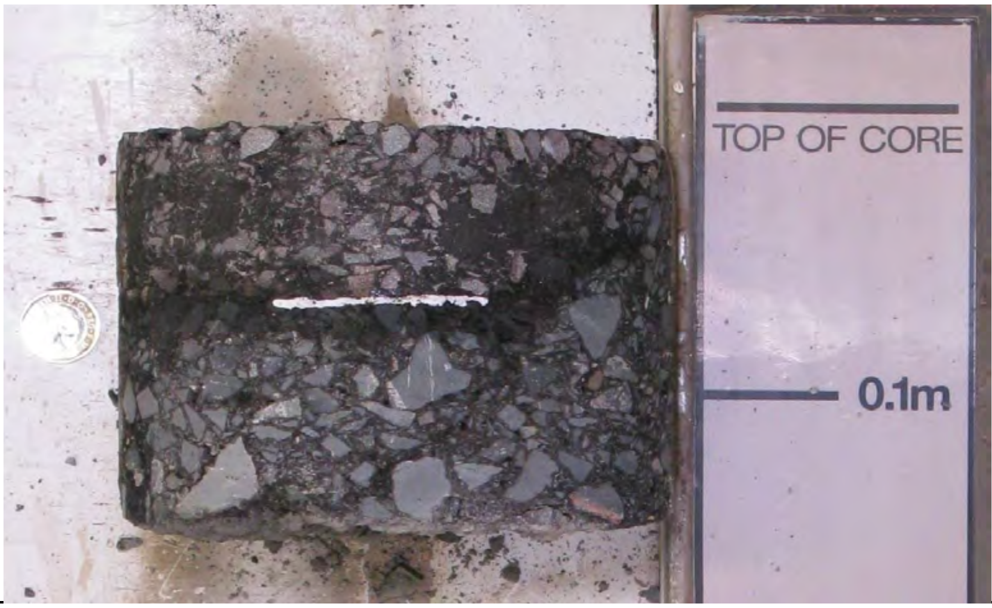
Job Number :	**60485963**	Scheme :	**Stafford Depot : Telford**
Sample Number :	**T0824**	Notes:	**1. Edge core**
Core Number :	**02**		**2. Coin is placed on the edge closest to the joint**
Cored / Logged By :	**RF / BM**		
Date Cored / Logged :	**07-12-17 / 20-12-17**		
Nominal Diameter :	**150mm**		

Layer	Depth (mm)		Thickness (mm)	Material Description [1]	Suitable for NAT/CS Testing (Yes/No)	PAK-Marker [2]	Binder [3]	Aggregate	
	From	To						Size [4]	Type
1	0	50	50	Asphalt Surfacing (Right of rip)	Yes	-ve	Bitumen	10	Crushed Rock
2	50	118	68	Asphalt Concrete (voided)	Yes	-ve	Bitumen	20	Crushed Rock

Notes : The scale is for guidance only. It does not necessarily reflect the actual thicknesses of individual layer(s).



Core Surface



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Binder [3]

The binder type is assessed based on visual and aromatic inspection. The PAK-Marker result is also considered.

Aggregate Size [4]

The sizes indicated are given as the best estimate of the nominal size of the material.

AECOM

CORE LOGGING OF PAVEMENT MATERIAL

In Accordance with AECOM in House Procedures

Job Number :	**60485963**	Scheme :	**Stafford Depot : Telford**
Sample Number :	**T0824**	Notes:	**1. Edge core**
Core Number :	**03**		**2. Coin is placed on the edge closest to the joint**
Cored / Logged By :	**RF / BM**		**3. Existing material**
Date Cored / Logged :	**07-12-17 / 20-12-17**		
Nominal Diameter :	**150mm**		

Layer	Depth (mm)		Thickness (mm)	Material Description [1]	Suitable for NAT/CS Testing (Yes/No)	PAK-Marker [2]	Binder [3]	Aggregate	
	From	To						Size [4]	Type
1	0	28	28	Asphalt Surfacing (voided)(Left of rip)	No	-ve	Bitumen	10	Crushed Rock
2	28	100	72	Asphalt Concrete (voided)	Yes	-ve	Bitumen	20	Crushed Rock

Notes : The scale is for guidance only. It does not necessarily reflect the actual thicknesses of individual layer(s).

Core Surface

Material Description [1]

The material description given (such as hot rolled asphalt or asphalt concrete) is generic only and is based upon a visual assessment of the material. Similarly, use of additional descriptive (such as voided) is based on visual assessment only and the relationship between air voids visually to the naked eye and degree of compaction is complex and materials specific.

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Binder [3]

The binder type is assessed based on visual and aromatic inspection. The PAK-Marker result is also considered.

Aggregate Size [4]

The sizes indicated are given as the best estimate of the nominal size of the material.

AECOM

CORE LOGGING OF PAVEMENT MATERIAL

In Accordance with AECOM in House Procedures

UKAS TESTING 4410

Job Number :	**60485963**	Scheme :	**Stafford Depot : Telford**
Sample Number :	**T0824**	Notes:	**1. Edge core**
Core Number :	**04**		**2. Coin is placed on the edge closest to the joint**
Cored / Logged By :	**RF / BM**		
Date Cored / Logged :	**07-12-17 / 20-12-17**		
Nominal Diameter :	**150mm**		

Layer	Depth (mm)		Thickness (mm)	Material Description [1]	Suitable for NAT/CS Testing (Yes/No)	PAK-Marker [2]	Binder [3]	Aggregate	
	From	To						Size [4]	Type
1	0	40	40	Asphalt Surfacing (Right of rip)	Yes	-ve	Bitumen	10	Crushed Rock
2	40	114	74	Asphalt Concrete	Yes	-ve	Bitumen	20	Crushed Rock

Notes : The scale is for guidance only. It does not necessarily reflect the actual thicknesses of individual layer(s).

Core Surface

Material Description [1]

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Binder [3]

The binder type is assessed based on visual and aromatic inspection. The PAK-Marker result is also considered.

Aggregate Size [4]

The sizes indicated are given as the best estimate of the nominal size of the material.

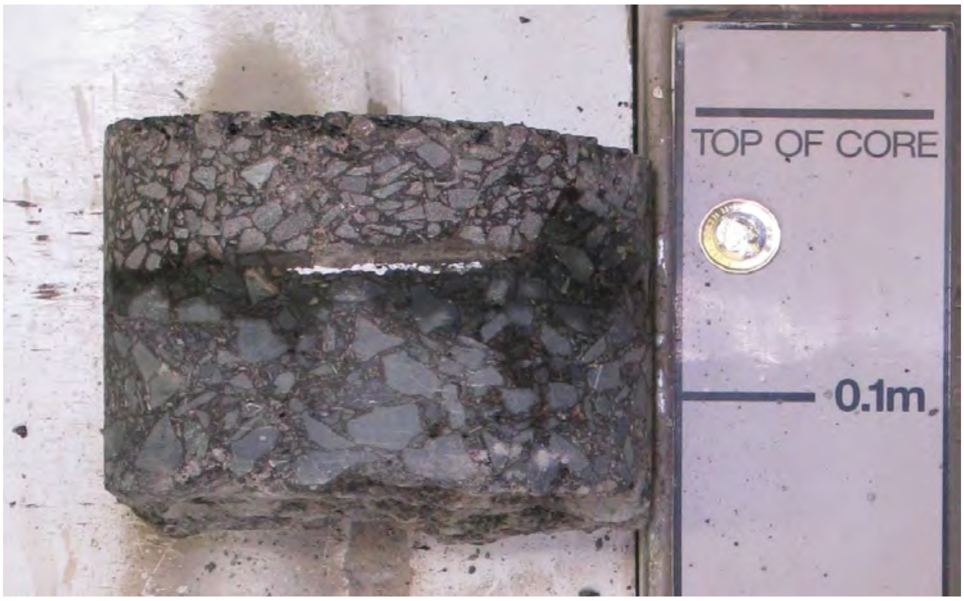
CORE LOGGING OF PAVEMENT MATERIAL

In Accordance with AECOM in House Procedures

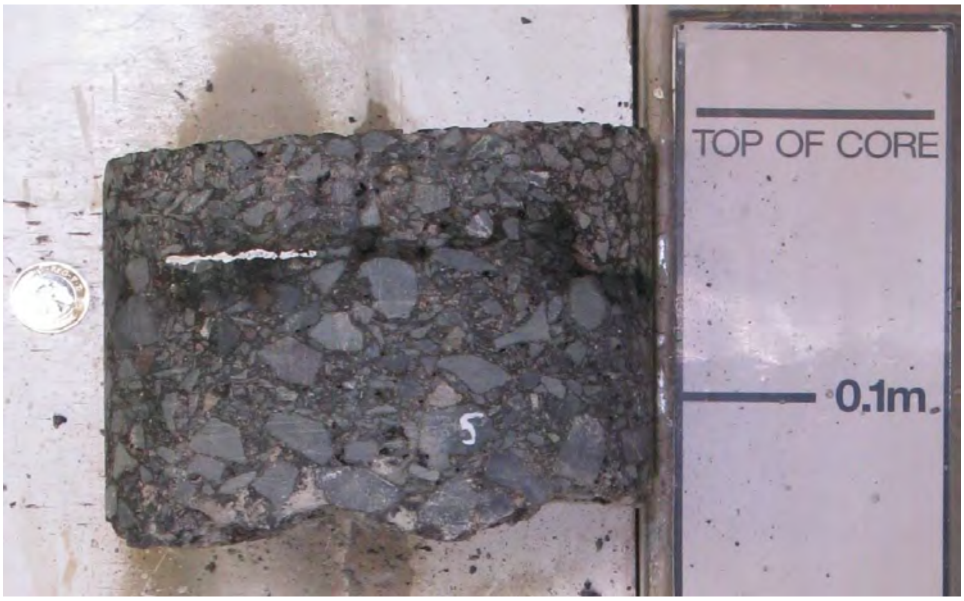
Job Number :	60485963	Scheme :	Stafford Depot : Telford
Sample Number :	T0824	Notes:	1. Core taken over joint
Core Number :	05		2. Painted joint
Cored / Logged By :	RF / BM		
Date Cored / Logged :	07-12-17 / 20-12-17		
Nominal Diameter :	150mm		

Layer	Depth (mm)		Thickness (mm)	Material Description [1]	Suitable for NAT/CS Testing (Yes/No)	PAK-Marker [2]	Binder [3]	Aggregate	
	From	To						Size [4]	Type
1	0	45	45	Asphalt Surfacing (voided)	Yes	-ve	Bitumen	10	Crushed Rock
2	45	120	75	Asphalt Concrete (voided)	Yes	-ve	Bitumen	20	Crushed Rock

Notes : The scale is for guidance only. It does not necessarily reflect the actual thicknesses of individual layer(s).



Core Surface



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Binder [3]

The binder type is assessed based on visual and aromatic inspection. The PAK-Marker result is also considered.

Aggregate Size [4]

The sizes indicated are given as the best estimate of the nominal size of the material.

CORE LOGGING OF PAVEMENT MATERIAL

In Accordance with AECOM in House Procedures

Job Number :	**60485963**	Scheme :	**Stafford Depot : Telford**
Sample Number :	**T0824**	Notes:	**1. Core taken over joint**
Core Number :	**06**		**2. Painted joint**
Cored / Logged By :	**RF / BM**		
Date Cored / Logged :	**07-12-17 / 20-12-17**		
Nominal Diameter :	**150mm**		

Layer	Depth (mm)		Thickness (mm)	Material Description [1]	Suitable for NAT/CS Testing (Yes/No)	PAK-Marker [2]	Binder [3]	Aggregate	
	From	To						Size [4]	Type
1	0	45	45	Asphalt Surfacing (voided)(offset)	Yes	-ve	Bitumen	10	Crushed Rock
2	45	115	70	Asphalt Concrete (voided)	Yes	-ve	Bitumen	20	Crushed Rock

Notes : The scale is for guidance only. It does not necessarily reflect the actual thicknesses of individual layer(s).

Core Surface

Material Description [1]

The material description given (such as hot rolled asphalt or asphalt concrete) is generic only and is based upon a visual assessment of the material. Similarly, use of additional descriptive (such as voided) is based on visual assessment only and the relationship between air voids visually to the naked eye and degree of compaction is complex and materials specific.

PAK-Marker (PAH Spray) [2]

The Tar Spray Test is a rapid, qualitative indicator of the presence of polyaromatic compounds (PACs) typically found in tar. PACs also exist in other road construction materials (e.g. bitumen and cutbacks like kerosene), but at low concentrations. The probability of obtaining a false positive result in the tar spray test with such materials is low, and a positive result in the tar spray test is a strong (but not definitive) indicator of the presence of tar. For quantitative results, this test should be considered in conjunction with the results from other tests (i.e. Total Polynuclear Aromatic Hydrocarbons (PAH) by Gas Chromatography - Flame Ionisation Detection (GC-FID)).

Binder [3]

The binder type is assessed based on visual and aromatic inspection. The PAK-Marker result is also considered.

Aggregate Size [4]

The sizes indicated are given as the best estimate of the nominal size of the material.

CORE LOGGING OF PAVEMENT MATERIAL

In Accordance with AECOM in House Procedures

Job Number :	**60485963**	Scheme :	**Stafford Depot : Telford**
Sample Number :	**T0824**	Notes:	**1. Core taken over joint**
Core Number :	**07**		**2. Painted joint**
Cored / Logged By :	**RF / BM**		
Date Cored / Logged :	**07-12-17 / 20-12-17**		
Nominal Diameter :	**150mm**		

Layer	Depth (mm)		Thickness (mm)	Material Description [1]	Suitable for NAT/CS Testing (Yes/No)	PAK-Marker [2]	Binder [3]	Aggregate	
	From	To						Size [4]	Type
1	0	50	50	Asphalt Surfacing	Yes	-ve	Bitumen	10	Crushed Rock
2	50	135	85	Asphalt Concrete	Yes	-ve	Bitumen	20	Crushed Rock

Notes : The scale is for guidance only. It does not necessarily reflect the actual thicknesses of individual layer(s).

Core Surface

Material Description [1]

The material description given (such as hot rolled asphalt or asphalt concrete) is generic only and is based upon a visual assessment of the material. Similarly, use of additional descriptive (such as voided) is based on visual assessment only and the relationship between air voids visually to the naked eye and degree of compaction is complex and materials specific.

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Binder [3]

The binder type is assessed based on visual and aromatic inspection. The PAK-Marker result is also considered.

Aggregate Size [4]

The sizes indicated are given as the best estimate of the nominal size of the material.

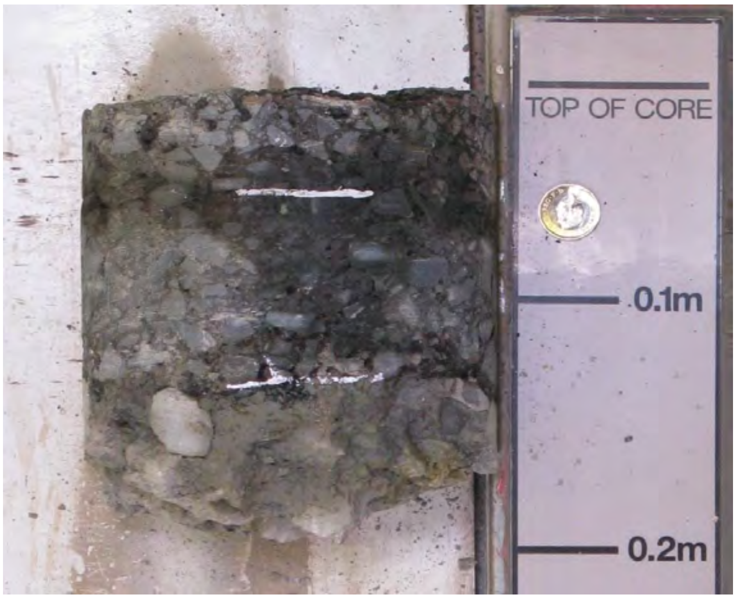
CORE LOGGING OF PAVEMENT MATERIAL

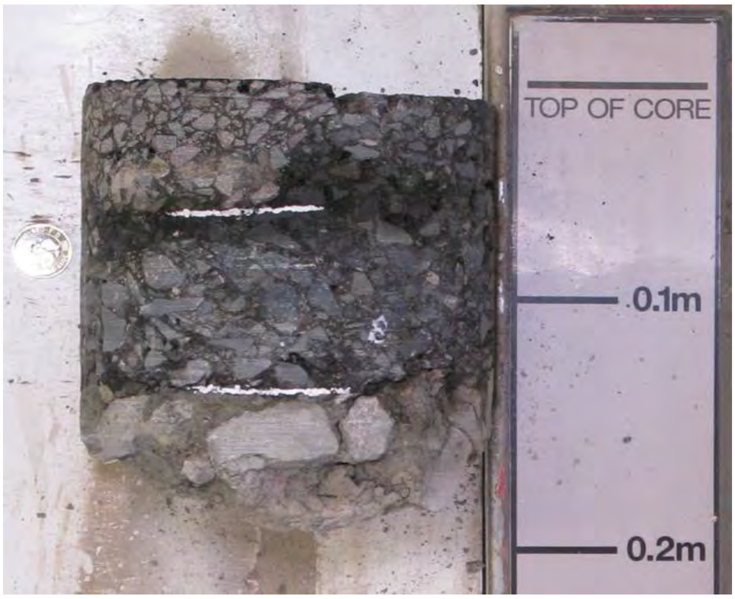
In Accordance with AECOM in House Procedures

Job Number :	60485963	Scheme :	Stafford Depot : Telford
Sample Number :	T0824	Notes:	1. Core taken over joint
Core Number :	08		2. Painted joint
Cored / Logged By :	RF / BM		
Date Cored / Logged :	07-12-17 / 20-12-17		
Nominal Diameter :	150mm		

Layer	Depth (mm)		Thickness (mm)	Material Description [1]	Suitable for NAT/CS Testing (Yes/No)	PAK-Marker [2]	Binder [3]	Aggregate	
	From	To						Size [4]	Type
1	0	40	40	Asphalt Surfacing (voided)	Yes	-ve	Bitumen	10	Crushed Rock
2	40	120	80	Asphalt Concrete (voided)	Yes	-ve	Bitumen	20	Crushed Rock
3	120	175	55	Weakly bound granular material					

Notes : The scale is for guidance only. It does not necessarily reflect the actual thicknesses of individual layer(s).





Core Surface

Material Description [1]

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Binder [3]

The binder type is assessed based on visual and aromatic inspection. The PAK-Marker result is also considered.

Aggregate Size [4]

The sizes indicated are given as the best estimate of the nominal size of the material.

CORE LOGGING OF PAVEMENT MATERIAL

In Accordance with AECOM in House Procedures

Job Number :	**60485963**	Scheme :	**Stafford Depot : Telford**
Sample Number :	**T0824**	Notes:	**1. Core taken over joint**
Core Number :	**09**		**2. Painted joint**
Cored / Logged By :	**RF / BM**		
Date Cored / Logged :	**07-12-17 / 20-12-17**		
Nominal Diameter :	**150mm**		

Layer	Depth (mm)		Thickness (mm)	Material Description [1]	Suitable for NAT/CS Testing (Yes/No)	PAK-Marker [2]	Binder [3]	Aggregate	
	From	To						Size [4]	Type
1	0	40	40	Asphalt Surfacing (voided)	Yes	-ve	Bitumen	10	Crushed Rock
2	40	110	70	Asphalt Concrete (voided)	Yes	-ve	Bitumen	20	Crushed Rock

Notes : The scale is for guidance only. It does not necessarily reflect the actual thicknesses of individual layer(s).

Core Surface

Material Description [1]

The material description given (such as hot rolled asphalt or asphalt concrete) is generic only and is based upon a visual assessment of the material. Similarly, use of additional descriptive (such as voided) is based on visual assessment only and the relationship between air voids visually to the naked eye and degree of compaction is complex and materials specific.

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Binder [3]

The binder type is assessed based on visual and aromatic inspection. The PAK-Marker result is also considered.

Aggregate Size [4]

The sizes indicated are given as the best estimate of the nominal size of the material.

CORE LOGGING OF PAVEMENT MATERIAL

In Accordance with AECOM in House Procedures

Job Number :	**60485963**	Scheme :	**Stafford Depot : Telford**
Sample Number :	**T0824**	Notes:	**1. Edge core**
Core Number :	**10**		**2. Coin is placed on the edge closest to the joint**
Cored / Logged By :	**RF / BM**		
Date Cored / Logged :	**07-12-17 / 20-12-17**		
Nominal Diameter :	**150mm**		

Layer	Depth (mm)		Thickness (mm)	Material Description [1]	Suitable for NAT/CS Testing (Yes/No)	PAK-Marker [2]	Binder [3]	Aggregate	
	From	To						Size [4]	Type
1	0	50	50	Asphalt Surfacing	Yes	-ve	Bitumen	10	Crushed Rock
				Layers 1 & 2 Debonded After Extraction					
2	50	100	50	Asphalt Concrete	Yes	-ve	Bitumen	20	Crushed Rock

Notes : The scale is for guidance only. It does not necessarily reflect the actual thicknesses of individual layer(s).

Core Surface

Material Description [1]

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Binder [3]

The binder type is assessed based on visual and aromatic inspection. The PAK-Marker result is also considered.

Aggregate Size [4]

The sizes indicated are given as the best estimate of the nominal size of the material.

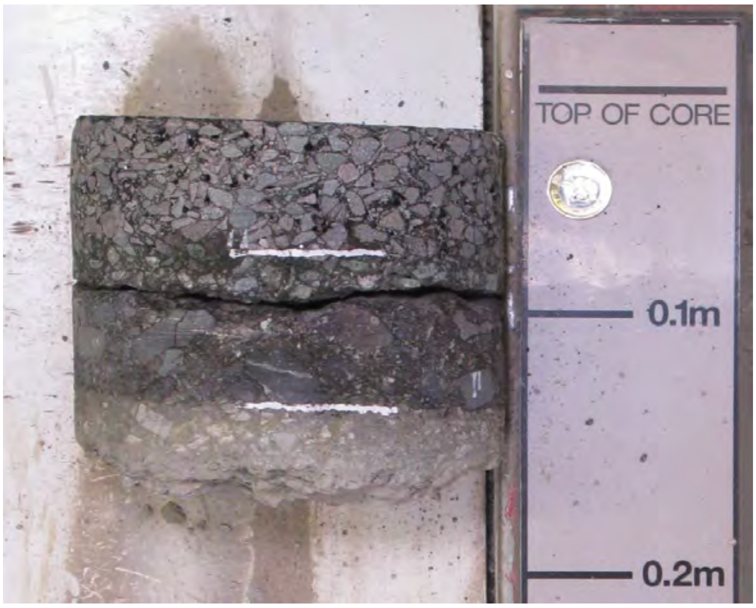
CORE LOGGING OF PAVEMENT MATERIAL

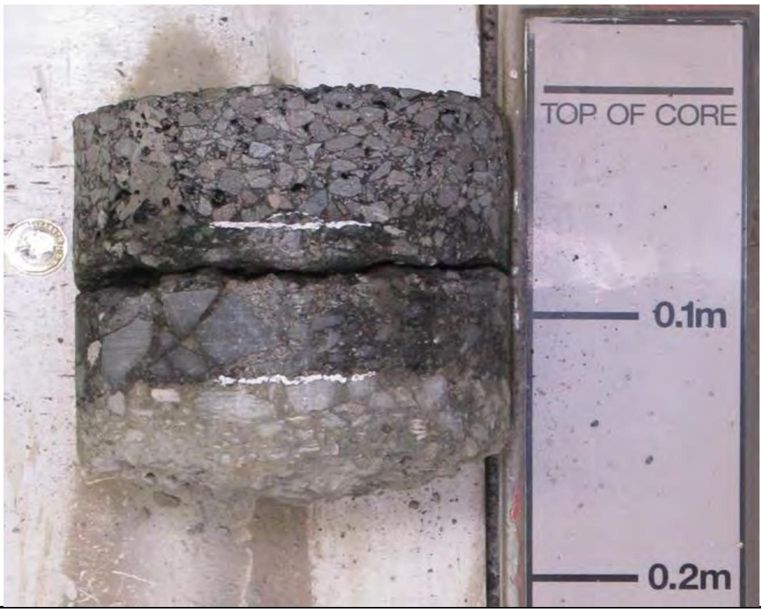
In Accordance with AECOM in House Procedures

Job Number :	**60485963**	Scheme :	**Stafford Depot : Telford**
Sample Number :	**T0824**	Notes:	**1. Edge core**
Core Number :	**11**		**2. Coin is placed on the edge closest to the joint**
Cored / Logged By :	**RF / BM**		
Date Cored / Logged :	**07-12-17 / 20-12-17**		
Nominal Diameter :	**150mm**		

Layer	Depth (mm)		Thickness (mm)	Material Description [1]	Suitable for NAT/CS Testing (Yes/No)	PAK-Marker [2]	Binder [3]	Aggregate	
	From	To						Size [4]	Type
1	0	50	50	Asphalt Surfacing (voided)	Yes	-ve	Bitumen	10	Crushed Rock
2	50	65	15	Asphalt Surfacing (voided)	No	-ve	Bitumen	10	Crushed Rock
				Layers 2 & 3 Debonded After Extraction					
3	65	117	52	Asphalt Concrete	Yes	-ve	Bitumen	20	Crushed Rock
4	117	150	33	Weakly bound granular material					

Notes : The scale is for guidance only. It does not necessarily reflect the actual thicknesses of individual layer(s).





Core Surface

Material Description [1]

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Binder [3]

The binder type is assessed based on visual and aromatic inspection. The PAK-Marker result is also considered.

Aggregate Size [4]

The sizes indicated are given as the best estimate of the nominal size of the material.

CORE LOGGING OF PAVEMENT MATERIAL

In Accordance with AECOM in House Procedures

Job Number :	**60485963**	Scheme :	**Stafford Depot : Telford**
Sample Number :	**T0824**	Notes:	**1. Edge core**
Core Number :	**12**		**2. Coin is placed on the edge closest to the joint**
Cored / Logged By :	**RF / BM**		
Date Cored / Logged :	**07-12-17 / 20-12-17**		
Nominal Diameter :	**150mm**		

Layer	Depth (mm)		Thickness (mm)	Material Description [1]	Suitable for NAT/CS Testing (Yes/No)	PAK-Marker [2]	Binder [3]	Aggregate	
	From	To						Size [4]	Type
1	0	40	40	Asphalt Surfacing	Yes	-ve	Bitumen	10	Crushed Rock
2	40	70	30	Asphalt Surfacing	Yes	-ve	Bitumen	14	Crushed Rock
3	70	100	30	Asphalt Concrete	Yes	-ve	Bitumen	20	Crushed Rock

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Core Surface

Material Description [1]

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Binder [3]

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Aggregate Size [4]

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CORE LOGGING OF PAVEMENT MATERIAL

In Accordance with AECOM in House Procedures

Job Number :	**60485963**	Scheme :	**Stafford Depot : Telford**
Sample Number :	**T0824**	Notes:	**1. Edge core**
Core Number :	**13**		**2. Coin is placed on the edge closest to the joint**
Cored / Logged By :	**RF / BM**		
Date Cored / Logged :	**07-12-17 / 20-12-17**		
Nominal Diameter :	**150mm**		

Layer	Depth (mm)		Thickness (mm)	Material Description [1]	Suitable for NAT/CS Testing (Yes/No)	PAK-Marker [2]	Binder [3]	Aggregate	
	From	To						Size [4]	Type
1	0	50	50	Asphalt Surfacing	Yes	-ve	Bitumen	10	Crushed Rock
2	50	65	15	Asphalt Surfacing	No	-ve	Bitumen	14	Crushed Rock
3	65	80	15	Asphalt Concrete	No	-ve	Bitumen	20	Crushed Rock

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Core Surface

Material Description [1]

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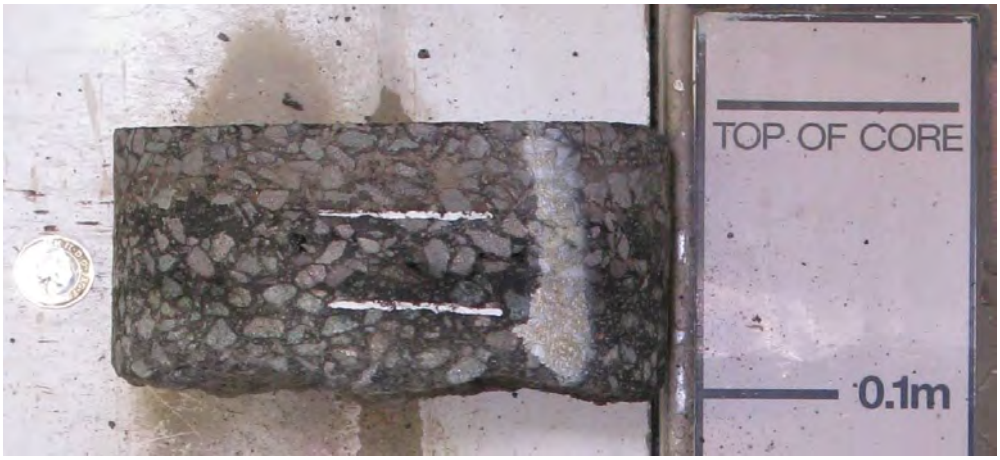
CORE LOGGING OF PAVEMENT MATERIAL

In Accordance with AECOM in House Procedures

Job Number :	**60485963**	Scheme :	**Stafford Depot : Telford**
Sample Number :	**T0824**	Notes:	**1. Core taken over joint**
Core Number :	**14**		**2. Coin placed on the heated side of the joint**
Cored / Logged By :	**RF / BM**		
Date Cored / Logged :	**07-12-17 / 20-12-17**		
Nominal Diameter :	**150mm**		

Layer	Depth (mm)		Thickness (mm)	Material Description [1]	Suitable for NAT/CS Testing (Yes/No)	PAK-Marker [2]	Binder [3]	Aggregate	
	From	To						Size [4]	Type
1	0	30	30	Asphalt Surfacing	Yes	-ve	Bitumen	10	Crushed Rock
2	30	55	25	Asphalt Surfacing	No	-ve	Bitumen	14	Crushed Rock
3	55	80	25	Asphalt Concrete	No	-ve	Bitumen	20	Crushed Rock

Notes : The scale is for guidance only. It does not necessarily reflect the actual thicknesses of individual layer(s).



Core Surface

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Binder [3]

The binder type is assessed based on visual and aromatic inspection. The PAK-Marker result is also considered.

Aggregate Size [4]

The sizes indicated are given as the best estimate of the nominal size of the material.

CORE LOGGING OF PAVEMENT MATERIAL

In Accordance with AECOM in House Procedures

Job Number :	**60485963**	Scheme :	**Stafford Depot : Telford**
Sample Number :	**T0824**	Notes:	**1. Core taken over joint**
Core Number :	**15**		**2. Coin placed on the heated side of the joint**
Cored / Logged By :	**RF / BM**		
Date Cored / Logged :	**07-12-17 / 20-12-17**		
Nominal Diameter :	**150mm**		

Layer	Depth (mm)		Thickness (mm)	Material Description [1]	Suitable for NAT/CS Testing (Yes/No)	PAK-Marker [2]	Binder [3]	Aggregate	
	From	To						Size [4]	Type
1	0	45	45	Asphalt Surfacing	Yes	-ve	Bitumen	10	Crushed Rock
2	45	135	90	Asphalt Concrete	Yes	-ve	Bitumen	20	Crushed Rock

Notes : The scale is for guidance only. It does not necessarily reflect the actual thicknesses of individual layer(s).

Core Surface

Material Description [1]
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The sizes indicated are given as the best estimate of the nominal size of the material.

CORE LOGGING OF PAVEMENT MATERIAL

In Accordance with AECOM in House Procedures

Job Number :	**60485963**	Scheme :	**Stafford Depot : Telford**
Sample Number :	**T0824**	Notes:	**1. Core taken over joint**
Core Number :	**16**		**2. Coin placed on the heated side of the joint**
Cored / Logged By :	**RF / BM**		
Date Cored / Logged :	**07-12-17 / 20-12-17**		
Nominal Diameter :	**150mm**		

Layer	Depth (mm)		Thickness (mm)	Material Description [1]	Suitable for NAT/CS Testing (Yes/No)	PAK-Marker [2]	Binder [3]	Aggregate	
	From	To						Size [4]	Type
1	0	35	35	Asphalt Surfacing (Joint unclear)	Yes	-ve	Bitumen	10	Crushed Rock
2	35	100	65	Asphalt Concrete	Yes	-ve	Bitumen	20	Crushed Rock

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Core Surface

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Aggregate Size [4]

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CORE LOGGING OF PAVEMENT MATERIAL

In Accordance with AECOM in House Procedures

Job Number :	**60485963**	Scheme :	**Stafford Depot : Telford**
Sample Number :	**T0824**	Notes:	**1. Core taken over joint**
Core Number :	**17**		**2. Coin placed on the heated side of the joint**
Cored / Logged By :	**RF / BM**		
Date Cored / Logged :	**07-12-17 / 20-12-17**		
Nominal Diameter :	**150mm**		

Layer	Depth (mm)		Thickness (mm)	Material Description [1]	Suitable for NAT/CS Testing (Yes/No)	PAK-Marker [2]	Binder [3]	Aggregate	
	From	To						Size [4]	Type
1	0	45	45	Asphalt Surfacing (Joint unclear)	Yes	-ve	Bitumen	10	Crushed Rock
				Layers 1 & 2 Debonded After Extraction					
2	45	90	45	Asphalt Concrete (voided)	Yes	-ve	Bitumen	20	Crushed Rock

Notes : The scale is for guidance only. It does not necessarily reflect the actual thicknesses of individual layer(s).

Core Surface

Material Description [1]

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Binder [3]

The binder type is assessed based on visual and aromatic inspection. The PAK-Marker result is also considered.

Aggregate Size [4]

The sizes indicated are given as the best estimate of the nominal size of the material.

CORE LOGGING OF PAVEMENT MATERIAL

In Accordance with AECOM in House Procedures

Job Number :	60485963	Scheme :	Stafford Depot : Telford
Sample Number :	T0824	Notes:	1. Core taken over joint
Core Number :	18		2. Coin placed on the heated side of the joint
Cored / Logged By :	RF / BM		
Date Cored / Logged :	07-12-17 / 20-12-17		
Nominal Diameter :	150mm		

Layer	Depth (mm)		Thickness (mm)	Material Description [1]	Suitable for NAT/CS Testing (Yes/No)	PAK-Marker [2]	Binder [3]	Aggregate	
	From	To						Size [4]	Type
1	0	40	40	Asphalt Surfacing	Yes	-ve	Bitumen	10	Crushed Rock
2	40	55	15	Asphalt Concrete	No	-ve	Bitumen	14	Crushed Rock
3	55	95	40	Asphalt Concrete (voided)	Yes	-ve	Bitumen	20	Crushed Rock

Notes : The scale is for guidance only. It does not necessarily reflect the actual thicknesses of individual layer(s).

Core Surface

Material Description [1]

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PAK-Marker (PAH Spray) [2]

The Tar Spray Test is a rapid, qualitative indicator of the presence of polyaromatic compounds (PACs) typically found in tar. PACs also exist in other road construction materials (e.g. bitumen and cutbacks like kerosene), but at low concentrations. The probability of obtaining a false positive result in the tar spray test with such materials is low, and a positive result in the tar spray test is a strong (but not definitive) indicator of the presence of tar. For quantitative results, this test should be considered in conjunction with the results from other tests (i.e. Total Polynuclear Aromatic Hydrocarbons (PAH) by Gas Chromatography - Flame Ionisation Detection (GC-FID)).

Binder [3]

The binder type is assessed based on visual and aromatic inspection. The PAK-Marker result is also considered.

Aggregate Size [4]

The sizes indicated are given as the best estimate of the nominal size of the material.

CORE LOGGING OF PAVEMENT MATERIAL

In Accordance with AECOM in House Procedures

Job Number :	**60485963**	Scheme :	**Stafford Depot : Telford**
Sample Number :	**T0824**	Notes:	**1. Core taken in central mat**
Core Number :	**19**		
Cored / Logged By :	**RF / BM**		
Date Cored / Logged :	**07-12-17 / 20-12-17**		
Nominal Diameter :	**150mm**		

Layer	Depth (mm)		Thickness (mm)	Material Description [1]	Suitable for NAT/CS Testing (Yes/No)	PAK-Marker [2]	Binder [3]	Aggregate	
	From	To						Size [4]	Type
1	0	45	45	Asphalt Surfacing	Yes	-ve	Bitumen	10	Crushed Rock
2	45	70	25	Asphalt Concrete	No	-ve	Bitumen	20	Crushed Rock

Notes : The scale is for guidance only. It does not necessarily reflect the actual thicknesses of individual layer(s).

Core Surface

Material Description [1]

The material description given (such as hot rolled asphalt or asphalt concrete) is generic only and is based upon a visual assessment of the material. Similarly, use of additional descriptive (such as voided) is based on visual assessment only and the relationship between air voids visually to the naked eye and degree of compaction is complex and materials specific.

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Binder [3]

The binder type is assessed based on visual and aromatic inspection. The PAK-Marker result is also considered.

Aggregate Size [4]

The sizes indicated are given as the best estimate of the nominal size of the material.

CORE LOGGING OF PAVEMENT MATERIAL

In Accordance with AECOM in House Procedures

Job Number :	**60485963**	Scheme :	**Stafford Depot : Telford**
Sample Number :	**T0824**	Notes:	**1. Core taken in central mat**
Core Number :	**20**		
Cored / Logged By :	**RF / BM**		
Date Cored / Logged :	**07-12-17 / 20-12-17**		
Nominal Diameter :	**150mm**		

Layer	Depth (mm)		Thickness (mm)	Material Description [1]	Suitable for NAT/CS Testing (Yes/No)	PAK-Marker [2]	Binder [3]	Aggregate	
	From	To						Size [4]	Type
1	0	55	55	Asphalt Surfacing (voided)	Yes	-ve	Bitumen	10	Crushed Rock
2	55	110	55	Asphalt Concrete	Yes	-ve	Bitumen	20	Crushed Rock

Notes : The scale is for guidance only. It does not necessarily reflect the actual thicknesses of individual layer(s).

Core Surface

Material Description [1]

The material description given (such as hot rolled asphalt or asphalt concrete) is generic only and is based upon a visual assessment of the material. Similarly, use of additional descriptive (such as voided) is based on visual assessment only and the relationship between air voids visually to the naked eye and degree of compaction is complex and materials specific.

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Binder [3]

The binder type is assessed based on visual and aromatic inspection. The PAK-Marker result is also considered.

Aggregate Size [4]

The sizes indicated are given as the best estimate of the nominal size of the material.

CORE LOGGING OF PAVEMENT MATERIAL

In Accordance with AECOM in House Procedures

Job Number :	**60485963**	Scheme :	**Stafford Depot : Telford**
Sample Number :	**T0824**	Notes:	**1. Edge core**
Core Number :	**21**		**2. Coin is placed on the edge closest to the joint**
Cored / Logged By :	**RF / BM**		
Date Cored / Logged :	**07-12-17 / 20-12-17**		
Nominal Diameter :	**150mm**		**Notes: N/A**

Layer	Depth (mm)		Thickness (mm)	Material Description [1]	Suitable for NAT/CS Testing (Yes/No)	PAK-Marker [2]	Binder [3]	Aggregate	
	From	To						Size [4]	Type
1	0	45	45	Asphalt Surfacing (voided)(Left of rip)	Yes	-ve	Bitumen	10	Crushed Rock
2	45	100	55	Asphalt Concrete	Yes	-ve	Bitumen	20	Crushed Rock

Notes : The scale is for guidance only. It does not necessarily reflect the actual thicknesses of individual layer(s).

Core Surface

Material Description [1]

The material description given (such as hot rolled asphalt or asphalt concrete) is generic only and is based upon a visual assessment of the material. Similarly, use of additional descriptive (such as voided) is based on visual assessment only and the relationship between air voids visually to the naked eye and degree of compaction is complex and materials specific.

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Binder [3]

The binder type is assessed based on visual and aromatic inspection. The PAK-Marker result is also considered.

Aggregate Size [4]

The sizes indicated are given as the best estimate of the nominal size of the material.

CORE LOGGING OF PAVEMENT MATERIAL

AECOM

In Accordance with AECOM in House Procedures

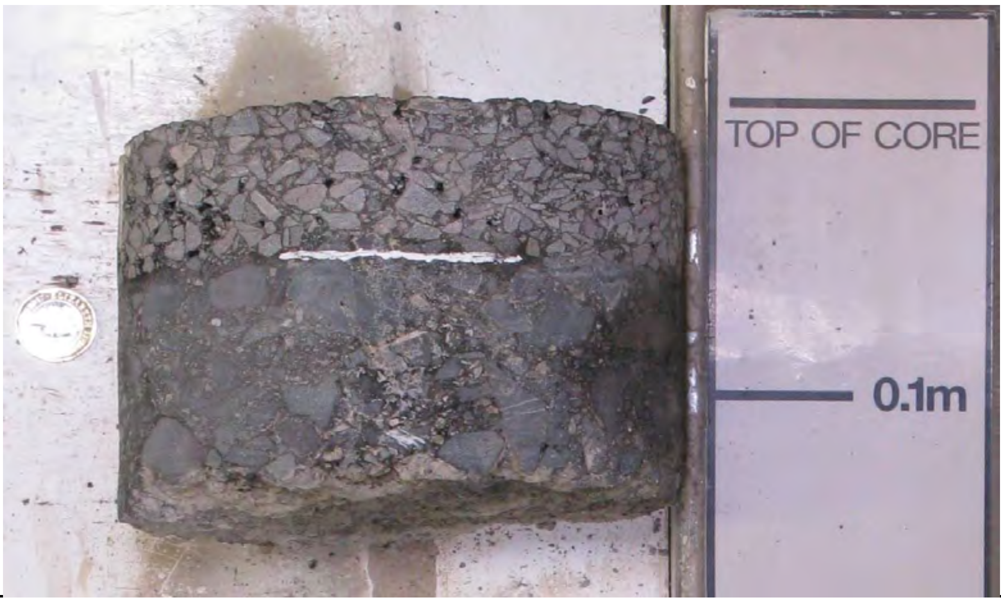
UKAS TESTING 4410

Job Number :	60485963	Scheme :	Stafford Depot : Telford
Sample Number :	T0824	Notes:	1. Edge core
Core Number :	22		2. Coin is placed on the edge closest to the joint
Cored / Logged By :	RF / BM		
Date Cored / Logged :	07-12-17 / 20-12-17		
Nominal Diameter :	150mm		Notes: N/A

Layer	Depth (mm)		Thickness (mm)	Material Description [1]	Suitable for NAT/CS Testing (Yes/No)	PAK-Marker [2]	Binder [3]	Aggregate	
	From	To						Size [4]	Type
1	0	45	45	Asphalt Surfacing (voided)(Right of rip)	Yes	-ve	Bitumen	10	Crushed Rock
2	45	110	65	Asphalt Concrete	Yes	-ve	Bitumen	20	Crushed Rock

Notes : The scale is for guidance only. It does not necessarily reflect the actual thicknesses of individual layer(s).

Core Surface



Material Description [1]

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Binder [3]

The binder type is assessed based on visual and aromatic inspection. The PAK-Marker result is also considered.

Aggregate Size [4]

The sizes indicated are given as the best estimate of the nominal size of the material.

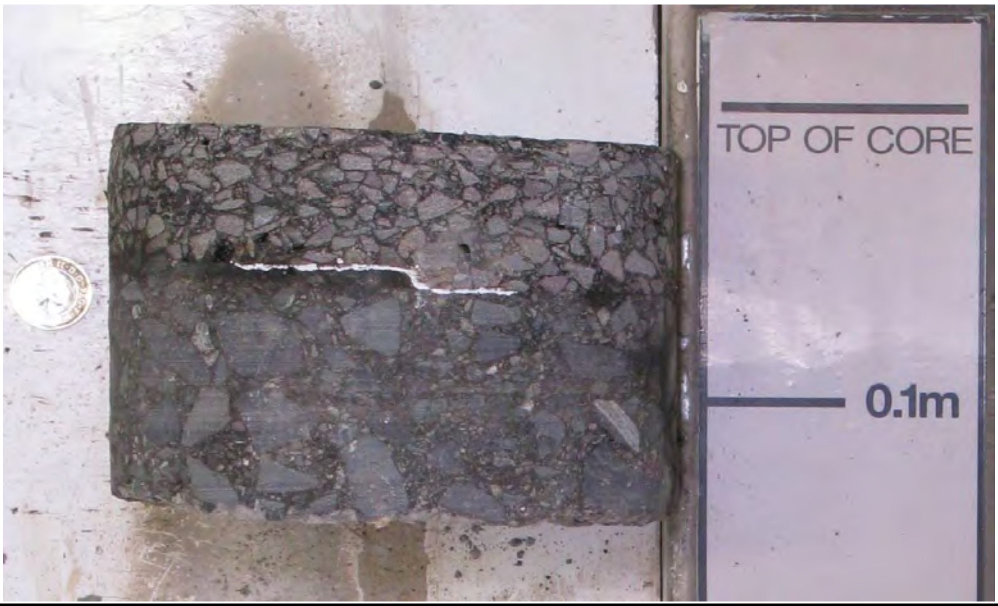
CORE LOGGING OF PAVEMENT MATERIAL

In Accordance with AECOM in House Procedures

Job Number :	**60485963**	Scheme :	**Stafford Depot : Telford**
Sample Number :	**T0824**	Notes:	**1. Edge core**
Core Number :	**23**		**2. Coin is placed on the edge closest to the joint**
Cored / Logged By :	**RF / BM**		
Date Cored / Logged :	**07-12-17 / 20-12-17**		
Nominal Diameter :	**150mm**		**Notes: N/A**

Layer	Depth (mm)		Thickness (mm)	Material Description [1]	Suitable for NAT/CS Testing (Yes/No)	PAK-Marker [2]	Binder [3]	Aggregate	
	From	To						Size [4]	Type
1	0	45	45	Asphalt Surfacing (Left of rip)	Yes	-ve	Bitumen	10	Crushed Rock
2	45	110	65	Asphalt Concrete	Yes	-ve	Bitumen	20	Crushed Rock

Notes : The scale is for guidance only. It does not necessarily reflect the actual thicknesses of individual layer(s).



Core Surface

Material Description [1]

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PAK-Marker (PAH Spray) [2]

The Tar Spray Test is a rapid, qualitative indicator of the presence of polyaromatic compounds (PACs) typically found in tar. PACs also exist in other road construction materials (e.g. bitumen and cutbacks like kerosene), but at low concentrations. The probability of obtaining a false positive result in the tar spray test with such materials is low, and a positive result in the tar spray test is a strong (but not definitive) indicator of the presence of tar. For quantitative results, this test should be considered in conjunction with the results from other tests (i.e. Total Polynuclear Aromatic Hydrocarbons (PAH) by Gas Chromatography - Flame Ionisation Detection (GC-FID)).

Binder [3]

The binder type is assessed based on visual and aromatic inspection. The PAK-Marker result is also considered.

Aggregate Size [4]

The sizes indicated are given as the best estimate of the nominal size of the material.

CORE LOGGING OF PAVEMENT MATERIAL

In Accordance with AECOM in House Procedures

Job Number :	**60485963**	Scheme :	**Stafford Depot : Telford**
Sample Number :	**T0824**	Notes:	**1. Edge core**
Core Number :	**24**		**2. Coin is placed on the edge closest to the joint**
Cored / Logged By :	**RF / BM**		
Date Cored / Logged :	**07-12-17 / 20-12-17**		
Nominal Diameter :	**150mm**		**Notes: N/A**

Layer	Depth (mm)		Thickness (mm)	Material Description [1]	Suitable for NAT/CS Testing (Yes/No)	PAK-Marker [2]	Binder [3]	Aggregate	
	From	To						Size [4]	Type
1	0	45	45	Asphalt Surfacing (Right of rip)	Yes	-ve	Bitumen	10	Crushed Rock
2	45	115	70	Asphalt Concrete	Yes	-ve	Bitumen	20	Crushed Rock

Notes : The scale is for guidance only. It does not necessarily reflect the actual thicknesses of individual layer(s).

Core Surface

Material Description [1]

The material description given (such as hot rolled asphalt or asphalt concrete) is generic only and is based upon a visual assessment of the material. Similarly, use of additional descriptive (such as voided) is based on visual assessment only and the relationship between air voids visually to the naked eye and degree of compaction is complex and materials specific.

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Binder [3]

The binder type is assessed based on visual and aromatic inspection. The PAK-Marker result is also considered.

Aggregate Size [4]

The sizes indicated are given as the best estimate of the nominal size of the material.

CORE LOGGING OF PAVEMENT MATERIAL

In Accordance with AECOM in House Procedures

Job Number :	**60485963**	Scheme :	**Stafford Depot : Telford**
Sample Number :	**T0824**	Notes:	**1. Core taken over joint**
Core Number :	**25**		**2. Coin placed on the heated side of the joint**
Cored / Logged By :	**RF / BM**		
Date Cored / Logged :	**07-12-17 / 20-12-17**		
Nominal Diameter :	**150mm**		

Layer	Depth (mm)		Thickness (mm)	Material Description [1]	Suitable for NAT/CS Testing (Yes/No)	PAK-Marker [2]	Binder [3]	Aggregate	
	From	To						Size [4]	Type
1	0	50	50	Asphalt Surfacing (voided)	Yes	-ve	Bitumen	10	Crushed Rock
				Layers 1 & 2 Debonded After Extraction					
2	50	110	60	Asphalt Concrete (full depth crack)	No	-ve	Bitumen	20	Crushed Rock

Notes : The scale is for guidance only. It does not necessarily reflect the actual thicknesses of individual layer(s).

Core Surface

Material Description [1]

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Binder [3]

The binder type is assessed based on visual and aromatic inspection. The PAK-Marker result is also considered.

Aggregate Size [4]

The sizes indicated are given as the best estimate of the nominal size of the material.

CORE LOGGING OF PAVEMENT MATERIAL

In Accordance with AECOM in House Procedures

Job Number :	60485963	Scheme :	Stafford Depot : Telford
Sample Number :	T0824	Notes:	1. Core taken over joint
Core Number :	26		2. Coin placed on the heated side of the joint
Cored / Logged By :	RF / BM		
Date Cored / Logged :	07-12-17 / 20-12-17		
Nominal Diameter :	150mm		

Layer	Depth (mm)		Thickness (mm)	Material Description [1]	Suitable for NAT/CS Testing (Yes/No)	PAK-Marker [2]	Binder [3]	Aggregate	
	From	To						Size [4]	Type
1	0	40	40	Asphalt Surfacing (voided)	Yes	-ve	Bitumen	10	Crushed Rock
2	40	125	85	Asphalt Concrete	Yes	-ve	Bitumen	20	Crushed Rock

Notes : The scale is for guidance only. It does not necessarily reflect the actual thicknesses of individual layer(s).

Core Surface

Material Description [1]

The material description given (such as hot rolled asphalt or asphalt concrete) is generic only and is based upon a visual assessment of the material. Similarly, use of additional descriptive (such as voided) is based on visual assessment only and the relationship between air voids visually to the naked eye and degree of compaction is complex and materials specific.

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Binder [3]

The binder type is assessed based on visual and aromatic inspection. The PAK-Marker result is also considered.

Aggregate Size [4]

The sizes indicated are given as the best estimate of the nominal size of the material.

CORE LOGGING OF PAVEMENT MATERIAL

AECOM

UKAS TESTING 4410

In Accordance with AECOM in House Procedures

Job Number :	**60485963**	Scheme :	**Stafford Depot : Telford**
Sample Number :	**T0824**	Notes:	**1. Core taken over joint**
Core Number :	**27**		**2. Coin placed on the heated side of the joint**
Cored / Logged By :	**RF / BM**		
Date Cored / Logged :	**07-12-17 / 20-12-17**		
Nominal Diameter :	**150mm**		

Layer	Depth (mm)		Thickness (mm)	Material Description [1]	Suitable for NAT/CS Testing (Yes/No)	PAK-Marker [2]	Binder [3]	Aggregate	
	From	To						Size [4]	Type
1	0	45	45	Asphalt Surfacing (voided)	Yes	-ve	Bitumen	10	Crushed Rock
2	45	115	70	Asphalt Concrete	Yes	-ve	Bitumen	20	Crushed Rock

Notes : The scale is for guidance only. It does not necessarily reflect the actual thicknesses of individual layer(s).

Core Surface

Material Description [1]

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Binder [3]

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Aggregate Size [4]

The sizes indicated are given as the best estimate of the nominal size of the material.

CORE LOGGING OF PAVEMENT MATERIAL

In Accordance with AECOM in House Procedures

Job Number :	**60485963**	Scheme :	**Stafford Depot : Telford**
Sample Number :	**T0824**	Notes:	**1. Core taken over joint**
Core Number :	**28**		**2. Coin placed on the heated side of the joint**
Cored / Logged By :	**RF / BM**		
Date Cored / Logged :	**07-12-17 / 20-12-17**		
Nominal Diameter :	**150mm**		

Layer	Depth (mm)		Thickness (mm)	Material Description [1]	Suitable for NAT/CS Testing (Yes/No)	PAK-Marker [2]	Binder [3]	Aggregate	
	From	To						Size [4]	Type
1	0	50	50	Asphalt Surfacing (Joint Unclear + Offset)	Yes	-ve	Bitumen	10	Crushed Rock
2	50	115	65	Asphalt Concrete (in half)	No	-ve	Bitumen	20	Crushed Rock

Notes : The scale is for guidance only. It does not necessarily reflect the actual thicknesses of individual layer(s).

Core Surface

Material Description [1]

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Binder [3]

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Aggregate Size [4]

The sizes indicated are given as the best estimate of the nominal size of the material.

CORE LOGGING OF PAVEMENT MATERIAL

In Accordance with AECOM in House Procedures

Job Number :	60485963	Scheme :	Stafford Depot : Telford
Sample Number :	T0824	Notes:	1. Core taken over joint
Core Number :	29		2. Coin placed on the heated side of the joint
Cored / Logged By :	RF / BM		
Date Cored / Logged :	07-12-17 / 20-12-17		
Nominal Diameter :	150mm		

Layer	Depth (mm)		Thickness (mm)	Material Description [1]	Suitable for NAT/CS Testing (Yes/No)	PAK-Marker [2]	Binder [3]	Aggregate	
	From	To						Size [4]	Type
1	0	45	45	Asphalt Surfacing (Joint Unclear + Offset)	Yes	-ve	Bitumen	10	Crushed Rock

Notes : The scale is for guidance only. It does not necessarily reflect the actual thicknesses of individual layer(s).

Core Surface

Material Description [1]

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Binder [3]

The binder type is assessed based on visual and aromatic inspection. The PAK-Marker result is also considered.

Aggregate Size [4]

The sizes indicated are given as the best estimate of the nominal size of the material.

CORE LOGGING OF PAVEMENT MATERIAL

In Accordance with AECOM in House Procedures

Job Number :	**60485963**	Scheme :	**Stafford Depot : Telford**
Sample Number :	**T0824**	Notes:	**1. Core taken in central mat**
Core Number :	**30**		
Cored / Logged By :	**RF / BM**		
Date Cored / Logged :	**07-12-17 / 20-12-17**		
Nominal Diameter :	**150mm**		

Layer	Depth (mm)		Thickness (mm)	Material Description [1]	Suitable for NAT/CS Testing (Yes/No)	PAK-Marker [2]	Binder [3]	Aggregate	
	From	To						Size [4]	Type
1	0	50	50	Asphalt Surfacing (voided)	Yes	-ve	Bitumen	10	Crushed Rock
2	50	115	65	Asphalt Concrete (voided)	Yes	-ve	Bitumen	20	Crushed Rock

Notes : The scale is for guidance only. It does not necessarily reflect the actual thicknesses of individual layer(s).

Core Surface

Material Description [1]

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Binder [3]

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Aggregate Size [4]

The sizes indicated are given as the best estimate of the nominal size of the material.

CORE LOGGING OF PAVEMENT MATERIAL

In Accordance with AECOM in House Procedures

Job Number :	**60485963**	Scheme :	**Stafford Depot : Telford**
Sample Number :	**T0824**	Notes:	**1. Edge core**
Core Number :	**31**		**2. Coin is placed on the edge closest to the joint**
Cored / Logged By :	**RF / BM**		
Date Cored / Logged :	**07-12-17 / 20-12-17**		
Nominal Diameter :	**150mm**		**Notes: N/A**

Layer	Depth (mm)		Thickness (mm)	Material Description [1]	Suitable for NAT/CS Testing (Yes/No)	PAK-Marker [2]	Binder [3]	Aggregate	
	From	To						Size [4]	Type
1	0	40	40	Asphalt Surfacing (voided)(Right of rip)	Yes	-ve	Bitumen	10	Crushed Rock
2	40	115	75	Asphalt Concrete (voided)	Yes	-ve	Bitumen	20	Crushed Rock

Notes : The scale is for guidance only. It does not necessarily reflect the actual thicknesses of individual layer(s).

Core Surface

Material Description [1]

The material description given (such as hot rolled asphalt or asphalt concrete) is generic only and is based upon a visual assessment of the material. Similarly, use of additional descriptive (such as voided) is based on visual assessment only and the relationship between air voids visually to the naked eye and degree of compaction is complex and materials specific.

PAK-Marker (PAH Spray) [2]

The Tar Spray Test is a rapid, qualitative indicator of the presence of polyaromatic compounds (PACs) typically found in tar. PACs also exist in other road construction materials (e.g. bitumen and cutbacks like kerosene), but at low concentrations. The probability of obtaining a false positive result in the tar spray test with such materials is low, and a positive result in the tar spray test is a strong (but not definitive) indicator of the presence of tar. For quantitative results, this test should be considered in conjunction with the results from other tests (i.e. Total Polynuclear Aromatic Hydrocarbons (PAH) by Gas Chromatography - Flame Ionisation Detection (GC-FID)).

Binder [3]

The binder type is assessed based on visual and aromatic inspection. The PAK-Marker result is also considered.

Aggregate Size [4]

The sizes indicated are given as the best estimate of the nominal size of the material.

AECOM

CORE LOGGING OF PAVEMENT MATERIAL

In Accordance with AECOM in House Procedures

UKAS TESTING 4410

Job Number :	**60485963**	Scheme :	**Stafford Depot : Telford**
Sample Number :	**T0824**	Notes:	**1. Edge core**
Core Number :	**32**		**2. Coin is placed on the edge closest to the joint**
Cored / Logged By :	**RF / BM**		
Date Cored / Logged :	**07-12-17 / 20-12-17**		
Nominal Diameter :	**150mm**		**Notes: N/A**

Layer	Depth (mm)		Thickness (mm)	Material Description [1]	Suitable for NAT/CS Testing (Yes/No)	PAK-Marker [2]	Binder [3]	Aggregate	
	From	To						Size [4]	Type
1	0	40	40	Asphalt Surfacing (voided)	Yes	-ve	Bitumen	10	Crushed Rock
2	40	135	95	Asphalt Concrete (voided)	Yes	-ve	Bitumen	20	Crushed Rock

Notes : The scale is for guidance only. It does not necessarily reflect the actual thicknesses of individual layer(s).

Core Surface

Material Description [1]

The material description given (such as hot rolled asphalt or asphalt concrete) is generic only and is based upon a visual assessment of the material. Similarly, use of additional descriptive (such as voided) is based on visual assessment only and the relationship between air voids visually to the naked eye and degree of compaction is complex and materials specific.

PAK-Marker (PAH Spray) [2]

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Binder [3]

The binder type is assessed based on visual and aromatic inspection. The PAK-Marker result is also considered.

Aggregate Size [4]

The sizes indicated are given as the best estimate of the nominal size of the material.

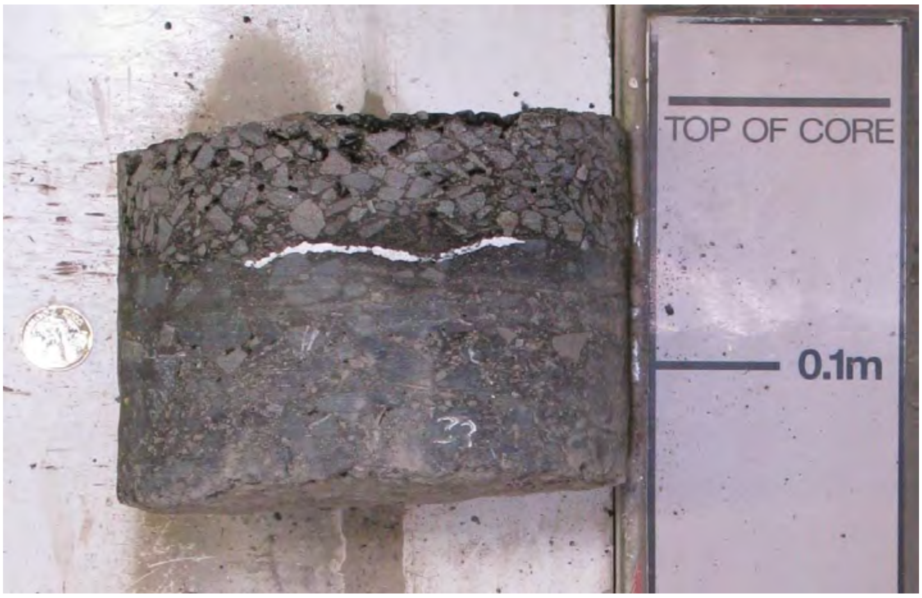
CORE LOGGING OF PAVEMENT MATERIAL

In Accordance with AECOM in House Procedures

Job Number :	**60485963**	Scheme :	**Stafford Depot : Telford**
Sample Number :	**T0824**	Notes:	**1. Edge core**
Core Number :	**33**		**2. Coin is placed on the edge closest to the joint**
Cored / Logged By :	**RF / BM**		
Date Cored / Logged :	**07-12-17 / 20-12-17**		
Nominal Diameter :	**150mm**		**Notes: N/A**

Layer	Depth (mm)		Thickness (mm)	Material Description [1]	Suitable for NAT/CS Testing (Yes/No)	PAK-Marker [2]	Binder [3]	Aggregate	
	From	To						Size [4]	Type
1	0	40	40	Asphalt Surfacing (voided)	Yes	-ve	Bitumen	10	Crushed Rock
2	40	110	70	Asphalt Concrete	Yes	-ve	Bitumen	20	Crushed Rock

Notes : The scale is for guidance only. It does not necessarily reflect the actual thicknesses of individual layer(s).



Core Surface

Material Description [1]

The material description given (such as hot rolled asphalt or asphalt concrete) is generic only and is based upon a visual assessment of the material. Similarly, use of additional descriptive (such as voided) is based on visual assessment only and the relationship between air voids visually to the naked eye and degree of compaction is complex and materials specific.

PAK-Marker (PAH Spray) [2]

The Tar Spray Test is a rapid, qualitative indicator of the presence of polyaromatic compounds (PACs) typically found in tar. PACs also exist in other road construction materials (e.g. bitumen and cutbacks like kerosene), but at low concentrations. The probability of obtaining a false positive result in the tar spray test with such materials is low, and a positive result in the tar spray test is a strong (but not definitive) indicator of the presence of tar. For quantitative results, this test should be considered in conjunction with the results from other tests (i.e. Total Polynuclear Aromatic Hydrocarbons (PAH) by Gas Chromatography - Flame Ionisation Detection (GC-FID)).

Binder [3]

The binder type is assessed based on visual and aromatic inspection. The PAK-Marker result is also considered.

Aggregate Size [4]

The sizes indicated are given as the best estimate of the nominal size of the material.

CORE LOGGING OF PAVEMENT MATERIAL

In Accordance with AECOM in House Procedures

Job Number :	**60485963**	Scheme :	**Stafford Depot : Telford**
Sample Number :	**T0824**	Notes:	**1. Edge core**
Core Number :	**34**		**2. Coin is placed on the edge closest to the joint**
Cored / Logged By :	**RF / BM**		
Date Cored / Logged :	**07-12-17 / 20-12-17**		
Nominal Diameter :	**150mm**		**Notes: N/A**

Layer	Depth (mm)		Thickness (mm)	Material Description [1]	Suitable for NAT/CS Testing (Yes/No)	PAK-Marker [2]	Binder [3]	Aggregate	
	From	To						Size [4]	Type
1	0	40	40	Asphalt Surfacing	Yes	-ve	Bitumen	10	Crushed Rock
2	40	115	75	Asphalt Concrete	Yes	-ve	Bitumen	20	Crushed Rock

Notes : The scale is for guidance only. It does not necessarily reflect the actual thicknesses of individual layer(s).

Core Surface

Material Description [1]

The material description given (such as hot rolled asphalt or asphalt concrete) is generic only and is based upon a visual assessment of the material. Similarly, use of additional descriptive (such as voided) is based on visual assessment only and the relationship between air voids visually to the naked eye and degree of compaction is complex and materials specific.

PAK-Marker (PAH Spray) [2]

The Tar Spray Test is a rapid, qualitative indicator of the presence of polyaromatic compounds (PACs) typically found in tar. PACs also exist in other road construction materials (e.g. bitumen and cutbacks like kerosene), but at low concentrations. The probability of obtaining a false positive result in the tar spray test with such materials is low, and a positive result in the tar spray test is a strong (but not definitive) indicator of the presence of tar. For quantitative results, this test should be considered in conjunction with the results from other tests (i.e. Total Polynuclear Aromatic Hydrocarbons (PAH) by Gas Chromatography - Flame Ionisation Detection (GC-FID)).

Binder [3]

The binder type is assessed based on visual and aromatic inspection. The PAK-Marker result is also considered.

Aggregate Size [4]

The sizes indicated are given as the best estimate of the nominal size of the material.

CORE LOGGING OF PAVEMENT MATERIAL

In Accordance with AECOM in House Procedures

Job Number :	**60485963**	Scheme :	**Stafford Depot : Telford**
Sample Number :	**T0824**	Notes:	**1. Core taken over the joint**
Core Number :	**35**		**2. Painted joint**
Cored / Logged By :	**RF / BM**		**3. Coin is placed on the unsupported edge side of the joint**
Date Cored / Logged :	**07-12-17 / 20-12-17**		
Nominal Diameter :	**150mm**		

Layer	Depth (mm)		Thickness (mm)	Material Description [1]	Suitable for NAT/CS Testing (Yes/No)	PAK-Marker [2]	Binder [3]	Aggregate	
	From	To						Size [4]	Type
1	0	45	45	Asphalt Surfacing (voided)(Joint Unclear)	Yes	-ve	Bitumen	10	Crushed Rock
2	45	115	70	Asphalt Concrete	Yes	-ve	Bitumen	20	Crushed Rock

Notes : The scale is for guidance only. It does not necessarily reflect the actual thicknesses of individual layer(s).

Core Surface

Material Description [1]
The material description given (such as hot rolled asphalt or asphalt concrete) is generic only and is based upon a visual assessment of the material. Similarly, use of additional descriptive (such as voided) is based on visual assessment only and the relationship between air voids visually to the naked eye and degree of compaction is complex and materials specific.

PAK-Marker (PAH Spray) [2]
The Tar Spray Test is a rapid, qualitative indicator of the presence of polyaromatic compounds (PACs) typically found in tar. PACs also exist in other road construction materials (e.g. bitumen and cutbacks like kerosene), but at low concentrations. The probability of obtaining a false positive result in the tar spray test with such materials is low, and a positive result in the tar spray test is a strong (but not definitive) indicator of the presence of tar. For quantitative results, this test should be considered in conjunction with the results from other tests (i.e. Total Polynuclear Aromatic Hydrocarbons (PAH) by Gas Chromatography - Flame Ionisation Detection (GC-FID)).

Binder [3]
The binder type is assessed based on visual and aromatic inspection. The PAK-Marker result is also considered.

Aggregate Size [4]
The sizes indicated are given as the best estimate of the nominal size of the material.

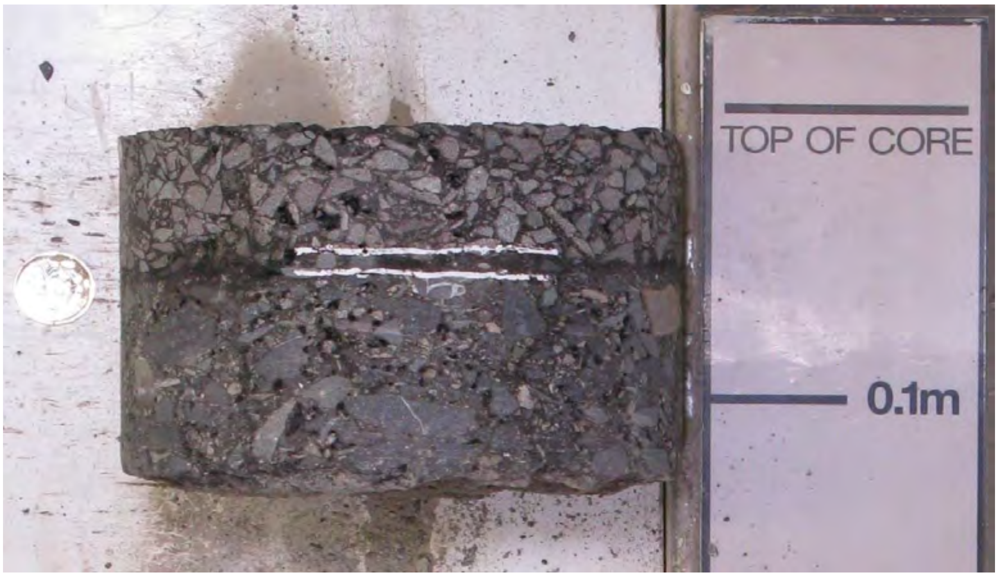
CORE LOGGING OF PAVEMENT MATERIAL

In Accordance with AECOM in House Procedures

Job Number :	**60485963**	Scheme :	**Stafford Depot : Telford**
Sample Number :	**T0824**	Notes:	**1. Core taken over the joint**
Core Number :	**36**		**2. Painted joint**
Cored / Logged By :	**RF / BM**		**3. Coin is placed on the unsupported edge side of the joint**
Date Cored / Logged :	**07-12-17 / 20-12-17**		
Nominal Diameter :	**150mm**		**Notes: N/A**

Layer	Depth (mm)		Thickness (mm)	Material Description [1]	Suitable for NAT/CS Testing (Yes/No)	PAK-Marker [2]	Binder [3]	Aggregate	
	From	To						Size [4]	Type
1	0	35	35	Asphalt Surfacing (voided)	Yes	-ve	Bitumen	10	Crushed Rock
2	35	45	10	Hot Rolled Asphalt	No	-ve	Bitumen	10	Gravel
3	45	110	65	Asphalt Concrete (voided)	Yes	-ve	Bitumen	20	Crushed Rock

Notes : The scale is for guidance only. It does not necessarily reflect the actual thicknesses of individual layer(s).



Core Surface

Material Description [1]

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Binder [3]

The binder type is assessed based on visual and aromatic inspection. The PAK-Marker result is also considered.

Aggregate Size [4]

The sizes indicated are given as the best estimate of the nominal size of the material.

CORE LOGGING OF PAVEMENT MATERIAL

In Accordance with AECOM in House Procedures

Job Number :	**60485963**	Scheme :	**Stafford Depot : Telford**
Sample Number :	**T0824**	Notes:	**1. Core taken over the joint**
Core Number :	**37**		**2. Painted joint**
Cored / Logged By :	**RF / BM**		**3. Coin is placed on the unsupported edge side of the joint**
Date Cored / Logged :	**07-12-17 / 20-12-17**		
Nominal Diameter :	**150mm**		

Layer	Depth (mm)		Thickness (mm)	Material Description [1]	Suitable for NAT/CS Testing (Yes/No)	PAK-Marker [2]	Binder [3]	Aggregate	
	From	To						Size [4]	Type
1	0	35	35	Asphalt Surfacing (voided)(Joint Offset)	Yes	-ve	Bitumen	10	Crushed Rock
2	35	90	55	Asphalt Concrete (voided)	Yes	-ve	Bitumen	20	Crushed Rock
3	90	110	20	Asphalt Concrete	No	-ve	Bitumen	14	Crushed Rock
				Weakly Bound Material					

Notes : The scale is for guidance only. It does not necessarily reflect the actual thicknesses of individual layer(s).

Core Surface

Material Description [1]

The material description given (such as hot rolled asphalt or asphalt concrete) is generic only and is based upon a visual assessment of the material. Similarly, use of additional descriptive (such as voided) is based on visual assessment only and the relationship between air voids visually to the naked eye and degree of compaction is complex and materials specific.

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Binder [3]

The binder type is assessed based on visual and aromatic inspection. The PAK-Marker result is also considered.

Aggregate Size [4]

The sizes indicated are given as the best estimate of the nominal size of the material.

AECOM

CORE LOGGING OF PAVEMENT MATERIAL

In Accordance with AECOM in House Procedures

Job Number :	**60485963**	Scheme :	**Stafford Depot : Telford**
Sample Number :	**T0824**	Notes:	**1. Core taken over the joint**
Core Number :	**38**		**2. Painted joint**
Cored / Logged By :	**RF / BM**		**3. Coin is placed on the unsupported edge side of the joint**
Date Cored / Logged :	**07-12-17 / 20-12-17**		
Nominal Diameter :	**150mm**		

Layer	Depth (mm)		Thickness (mm)	Material Description [1]	Suitable for NAT/CS Testing (Yes/No)	PAK-Marker [2]	Binder [3]	Aggregate	
	From	To						Size [4]	Type
1	0	30	30	Asphalt Surfacing (voided)	Yes	-ve	Bitumen	10	Crushed Rock
2	30	80	50	Asphalt Concrete (voided)	Yes	-ve	Bitumen	20	Crushed Rock
3	80	105	25	Asphalt Concrete	No	-ve	Bitumen	14	Crushed Rock

Notes : The scale is for guidance only. It does not necessarily reflect the actual thicknesses of individual layer(s).

Core Surface

Material Description [1]

The material description given (such as hot rolled asphalt or asphalt concrete) is generic only and is based upon a visual assessment of the material. Similarly, use of additional descriptive (such as voided) is based on visual assessment only and the relationship between air voids visually to the naked eye and degree of compaction is complex and materials specific.

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Binder [3]

The binder type is assessed based on visual and aromatic inspection. The PAK-Marker result is also considered.

Aggregate Size [4]

The sizes indicated are given as the best estimate of the nominal size of the material.

CORE LOGGING OF PAVEMENT MATERIAL

In Accordance with AECOM in House Procedures

Job Number :	**60485963**	Scheme :	**Stafford Depot : Telford**
Sample Number :	**T0824**	Notes:	**1. Core taken over the joint**
Core Number :	**39**		**2. Painted joint**
Cored / Logged By :	**RF / BM**		**3. Coin is placed on the unsupported edge side of the joint**
Date Cored / Logged :	**07-12-17 / 20-12-17**		
Nominal Diameter :	**150mm**		

Layer	Depth (mm)		Thickness (mm)	Material Description [1]	Suitable for NAT/CS Testing (Yes/No)	PAK-Marker [2]	Binder [3]	Aggregate	
	From	To						Size [4]	Type
1	0	35	35	Asphalt Surfacing (voided)	Yes	-ve	Bitumen	10	Crushed Rock
2	35	100	65	Asphalt Concrete (voided)	Yes	-ve	Bitumen	20	Crushed Rock
				Weakly Bound Material					

Notes : The scale is for guidance only. It does not necessarily reflect the actual thicknesses of individual layer(s).

Core Surface

Material Description [1]

The material description given (such as hot rolled asphalt or asphalt concrete) is generic only and is based upon a visual assessment of the material. Similarly, use of additional descriptive (such as voided) is based on visual assessment only and the relationship between air voids visually to the naked eye and degree of compaction is complex and materials specific.

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Binder [3]

The binder type is assessed based on visual and aromatic inspection. The PAK-Marker result is also considered.

Aggregate Size [4]

The sizes indicated are given as the best estimate of the nominal size of the material.

CORE LOGGING OF PAVEMENT MATERIAL

In Accordance with AECOM in House Procedures

Job Number :	**60485963**	Scheme :	**Stafford Depot : Telford**
Sample Number :	**T0824**	Notes:	**1. Core taken in central mat**
Core Number :	**40**		
Cored / Logged By :	**RF / BM**		
Date Cored / Logged :	**07-12-17 / 20-12-17**		
Nominal Diameter :	**150mm**		

Layer	Depth (mm)		Thickness (mm)	Material Description [1]	Suitable for NAT/CS Testing (Yes/No)	PAK-Marker [2]	Binder [3]	Aggregate	
	From	To						Size [4]	Type
1	0	40	40	Asphalt Surfacing	Yes	-ve	Bitumen	10	Crushed Rock
2	40	90	50	Asphalt Concrete (voided)	Yes	-ve	Bitumen	20	Crushed Rock
3	90	100	10	Asphalt Concrete (voided)	No	-ve	Bitumen	14	Crushed Rock

Notes : The scale is for guidance only. It does not necessarily reflect the actual thicknesses of individual layer(s).

Core Surface

Material Description [1]

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Binder [3]

The binder type is assessed based on visual and aromatic inspection. The PAK-Marker result is also considered.

Aggregate Size [4]

The sizes indicated are given as the best estimate of the nominal size of the material.

CORE LOGGING OF PAVEMENT MATERIAL

In Accordance with AECOM in House Procedures

Job Number :	**60485963**	Scheme :	**Stafford Depot : Telford**
Sample Number :	**T0824**	Notes:	**1. Core taken over joint**
Core Number :	**41**		**2. Coin placed on the heated side of the joint**
Cored / Logged By :	**RF / BM**		
Date Cored / Logged :	**07-12-17 / 20-12-17**		
Nominal Diameter :	**150mm**		

Layer	Depth (mm)		Thickness (mm)	Material Description [1]	Suitable for NAT/CS Testing (Yes/No)	PAK-Marker [2]	Binder [3]	Aggregate	
	From	To						Size [4]	Type
1	0	50	50	Asphalt Surfacing (voided)	Yes	-ve	Bitumen	10	Crushed Rock
2	50	60	10	Hot Rolled Asphalt	No	-ve	Bitumen	10	Gravel
3	60	110	50	Asphalt Concrete (voided)	Yes	-ve	Bitumen	20	Crushed Rock

Notes : The scale is for guidance only. It does not necessarily reflect the actual thicknesses of individual layer(s).

Core Surface

Material Description [1]

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Binder [3]

The binder type is assessed based on visual and aromatic inspection. The PAK-Marker result is also considered.

Aggregate Size [4]

The sizes indicated are given as the best estimate of the nominal size of the material.

CORE LOGGING OF PAVEMENT MATERIAL

In Accordance with AECOM in House Procedures

Job Number :	**60485963**	Scheme :	**Stafford Depot : Telford**
Sample Number :	**T0824**	Notes:	**1. Core taken over joint**
Core Number :	**42**		**2. Coin placed on the heated side of the joint**
Cored / Logged By :	**RF / BM**		
Date Cored / Logged :	**07-12-17 / 20-12-17**		
Nominal Diameter :	**150mm**		

Layer	Depth (mm)		Thickness (mm)	Material Description [1]	Suitable for NAT/CS Testing (Yes/No)	PAK-Marker [2]	Binder [3]	Aggregate	
	From	To						Size [4]	Type
1	0	40	40	Asphalt Surfacing (voided)	Yes	-ve	Bitumen	10	Crushed Rock
2	40	105	65	Asphalt Concrete (in half)	No	-ve	Bitumen	20	Crushed Rock

Notes : The scale is for guidance only. It does not necessarily reflect the actual thicknesses of individual layer(s).

Core Surface

Material Description [1]

The material description given (such as hot rolled asphalt or asphalt concrete) is generic only and is based upon a visual assessment of the material. Similarly, use of additional descriptive (such as voided) is based on visual assessment only and the relationship between air voids visually to the naked eye and degree of compaction is complex and materials specific.

PAK-Marker (PAH Spray) [2]

The Tar Spray Test is a rapid, qualitative indicator of the presence of polyaromatic compounds (PACs) typically found in tar. PACs also exist in other road construction materials (e.g. bitumen and cutbacks like kerosene), but at low concentrations. The probability of obtaining a false positive result in the tar spray test with such materials is low, and a positive result in the tar spray test is a strong (but not definitive) indicator of the presence of tar. For quantitative results, this test should be considered in conjunction with the results from other tests (i.e. Total Polynuclear Aromatic Hydrocarbons (PAH) by Gas Chromatography - Flame Ionisation Detection (GC-FID)).

Binder [3]

The binder type is assessed based on visual and aromatic inspection. The PAK-Marker result is also considered.

Aggregate Size [4]

The sizes indicated are given as the best estimate of the nominal size of the material.

CORE LOGGING OF PAVEMENT MATERIAL

In Accordance with AECOM in House Procedures

Job Number :	**60485963**	Scheme :	**Stafford Depot : Telford**
Sample Number :	**T0824**	Notes:	**1. Core taken over joint**
Core Number :	**43**		**2. Coin placed on the heated side of the joint**
Cored / Logged By :	**RF / BM**		
Date Cored / Logged :	**07-12-17 / 20-12-17**		
Nominal Diameter :	**150mm**		

Layer	Depth (mm)		Thickness (mm)	Material Description [1]	Suitable for NAT/CS Testing (Yes/No)	PAK-Marker [2]	Binder [3]	Aggregate	
	From	To						Size [4]	Type
1	0	45	45	Asphalt Surfacing (voided)	Yes	-ve	Bitumen	10	Crushed Rock
2	45	105	60	Asphalt Concrete (in half)	No	-ve	Bitumen	20	Crushed Rock

Notes : The scale is for guidance only. It does not necessarily reflect the actual thicknesses of individual layer(s).

Core Surface

Material Description [1]

The material description given (such as hot rolled asphalt or asphalt concrete) is generic only and is based upon a visual assessment of the material. Similarly, use of additional descriptive (such as voided) is based on visual assessment only and the relationship between air voids visually to the naked eye and degree of compaction is complex and materials specific.

PAK-Marker (PAH Spray) [2]

The Tar Spray Test is a rapid, qualitative indicator of the presence of polyaromatic compounds (PACs) typically found in tar. PACs also exist in other road construction materials (e.g. bitumen and cutbacks like kerosene), but at low concentrations. The probability of obtaining a false positive result in the tar spray test with such materials is low, and a positive result in the tar spray test is a strong (but not definitive) indicator of the presence of tar. For quantitative results, this test should be considered in conjunction with the results from other tests (i.e. Total Polynuclear Aromatic Hydrocarbons (PAH) by Gas Chromatography - Flame Ionisation Detection (GC-FID)).

Binder [3]

The binder type is assessed based on visual and aromatic inspection. The PAK-Marker result is also considered.

Aggregate Size [4]

The sizes indicated are given as the best estimate of the nominal size of the material.

CORE LOGGING OF PAVEMENT MATERIAL

In Accordance with AECOM in House Procedures

Job Number :	**60485963**	Scheme :	**Stafford Depot : Telford**
Sample Number :	**T0824**	Notes:	**1. Core taken over joint**
Core Number :	**44**		**2. Coin placed on the heated side of the joint**
Cored / Logged By :	**RF / BM**		
Date Cored / Logged :	**07-12-17 / 20-12-17**		
Nominal Diameter :	**150mm**		

Layer	Depth (mm)		Thickness (mm)	Material Description [1]	Suitable for NAT/CS Testing (Yes/No)	PAK-Marker [2]	Binder [3]	Aggregate	
	From	To						Size [4]	Type
1	0	45	45	Asphalt Surfacing (voided)	Yes	-ve	Bitumen	10	Crushed Rock

Notes : The scale is for guidance only. It does not necessarily reflect the actual thicknesses of individual layer(s).

Core Surface

Material Description [1]

The material description given (such as hot rolled asphalt or asphalt concrete) is generic only and is based upon a visual assessment of the material. Similarly, use of additional descriptive (such as voided) is based on visual assessment only and the relationship between air voids visually to the naked eye and degree of compaction is complex and materials specific.

PAK-Marker (PAH Spray) [2]

The Tar Spray Test is a rapid, qualitative indicator of the presence of polyaromatic compounds (PACs) typically found in tar. PACs also exist in other road construction materials (e.g. bitumen and cutbacks like kerosene), but at low concentrations. The probability of obtaining a false positive result in the tar spray test with such materials is low, and a positive result in the tar spray test is a strong (but not definitive) indicator of the presence of tar. For quantitative results, this test should be considered in conjunction with the results from other tests (i.e. Total Polynuclear Aromatic Hydrocarbons (PAH) by Gas Chromatography - Flame Ionisation Detection (GC-FID)).

Binder [3]

The binder type is assessed based on visual and aromatic inspection. The PAK-Marker result is also considered.

Aggregate Size [4]

The sizes indicated are given as the best estimate of the nominal size of the material.

CORE LOGGING OF PAVEMENT MATERIAL

In Accordance with AECOM in House Procedures

Job Number :	**60485963**	Scheme :	**Stafford Depot : Telford**
Sample Number :	**T0824**	Notes:	**1. Core taken over joint**
Core Number :	**45**		**2. Coin placed on the heated side of the joint**
Cored / Logged By :	**RF / BM**		
Date Cored / Logged :	**07-12-17 / 20-12-17**		
Nominal Diameter :	**150mm**		

Layer	Depth (mm)		Thickness (mm)	Material Description [1]	Suitable for NAT/CS Testing (Yes/No)	PAK-Marker [2]	Binder [3]	Aggregate	
	From	To						Size [4]	Type
1	0	50	50	Asphalt Surfacing (voided)	Yes	-ve	Bitumen	10	Crushed Rock

Notes : The scale is for guidance only. It does not necessarily reflect the actual thicknesses of individual layer(s).

Core Surface

Material Description [1]

The material description given (such as hot rolled asphalt or asphalt concrete) is generic only and is based upon a visual assessment of the material. Similarly, use of additional descriptive (such as voided) is based on visual assessment only and the relationship between air voids visually to the naked eye and degree of compaction is complex and materials specific.

PAK-Marker (PAH Spray) [2]

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Binder [3]

The binder type is assessed based on visual and aromatic inspection. The PAK-Marker result is also considered.

Aggregate Size [4]

The sizes indicated are given as the best estimate of the nominal size of the material.

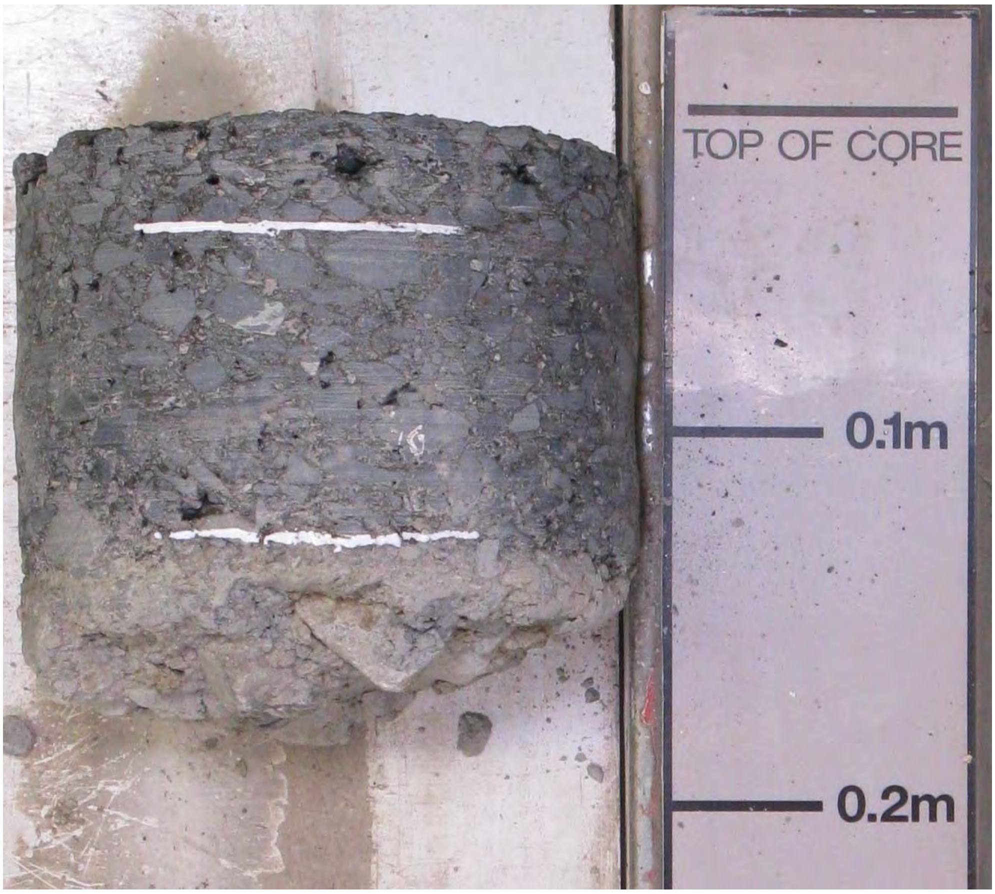
CORE LOGGING OF PAVEMENT MATERIAL

In Accordance with AECOM in House Procedures

Job Number :	**60485963**	Scheme :	**Stafford Depot : Telford**
Sample Number :	**T0824**	Notes:	**1. Core taken in central mat**
Core Number :	**46**		**2. Existing material**
Cored / Logged By :	**RF / BM**		
Date Cored / Logged :	**07-12-17 / 20-12-17**		
Nominal Diameter :	**150mm**		

Layer	Depth (mm)		Thickness (mm)	Material Description [1]	Suitable for NAT/CS Testing (Yes/No)	PAK-Marker [2]	Binder [3]	Aggregate	
	From	To						Size [4]	Type
1	0	30	30	Asphalt Surfacing (voided)	Yes	-ve	Bitumen	10	Crushed Rock
2	30	110	80	Asphalt Concrete (voided)	Yes	-ve	Bitumen	14	Crushed Rock
3	110	150	40	Weakly Bound Material					

Notes : The scale is for guidance only. It does not necessarily reflect the actual thicknesses of individual layer(s).



Core Surface

Material Description [1]

The material description given (such as hot rolled asphalt or asphalt concrete) is generic only and is based upon a visual assessment of the material. Similarly, use of additional descriptive (such as voided) is based on visual assessment only and the relationship between air voids visually to the naked eye and degree of compaction is complex and materials specific.

PAK-Marker (PAH Spray) [2]

The Tar Spray Test is a rapid, qualitative indicator of the presence of polyaromatic compounds (PACs) typically found in tar. PACs also exist in other road construction materials (e.g. bitumen and cutbacks like kerosene), but at low concentrations. The probability of obtaining a false positive result in the tar spray test with such materials is low, and a positive result in the tar spray test is a strong (but not definitive) indicator of the presence of tar. For quantitative results, this test should be considered in conjunction with the results from other tests (i.e. Total Polynuclear Aromatic Hydrocarbons (PAH) by Gas Chromatography - Flame Ionisation Detection (GC-FID)).

Binder [3]

The binder type is assessed based on visual and aromatic inspection. The PAK-Marker result is also considered.

Aggregate Size [4]

The sizes indicated are given as the best estimate of the nominal size of the material.

CORE LOGGING OF PAVEMENT MATERIAL

In Accordance with AECOM in House Procedures

Job Number :	**60485963**	Scheme :	**Stafford Depot : Telford**
Sample Number :	**T0824**	Notes:	**1. Core taken in central mat**
Core Number :	**47**		**2. Existing material**
Cored / Logged By :	**RF / BM**		
Date Cored / Logged :	**07-12-17 / 20-12-17**		
Nominal Diameter :	**150mm**		

Layer	Depth (mm)		Thickness (mm)	Material Description [1]	Suitable for NAT/CS Testing (Yes/No)	PAK-Marker [2]	Binder [3]	Aggregate	
	From	To						Size [4]	Type
1	0	25	25	Asphalt Surfacing (voided)	No	-ve	Bitumen	10	Crushed Rock
2	25	80	55	Asphalt Concrete (voided)	Yes	-ve	Bitumen	20	Crushed Rock
3	80	100	20	Asphalt Concrete (broken @ base)	No	-ve	Bitumen	14	Crushed Rock

Notes : The scale is for guidance only. It does not necessarily reflect the actual thicknesses of individual layer(s).

Core Surface

Material Description [1]

The material description given (such as hot rolled asphalt or asphalt concrete) is generic only and is based upon a visual assessment of the material. Similarly, use of additional descriptive (such as voided) is based on visual assessment only and the relationship between air voids visually to the naked eye and degree of compaction is complex and materials specific.

PAK-Marker (PAH Spray) [2]

The Tar Spray Test is a rapid, qualitative indicator of the presence of polyaromatic compounds (PACs) typically found in tar. PACs also exist in other road construction materials (e.g. bitumen and cutbacks like kerosene), but at low concentrations. The probability of obtaining a false positive result in the tar spray test with such materials is low, and a positive result in the tar spray test is a strong (but not definitive) indicator of the presence of tar. For quantitative results, this test should be considered in conjunction with the results from other tests (i.e. Total Polynuclear Aromatic Hydrocarbons (PAH) by Gas Chromatography - Flame Ionisation Detection (GC-FID)).

Binder [3]

The binder type is assessed based on visual and aromatic inspection. The PAK-Marker result is also considered.

Aggregate Size [4]

The sizes indicated are given as the best estimate of the nominal size of the material.

CORE LOGGING OF PAVEMENT MATERIAL

In Accordance with AECOM in House Procedures

Job Number :	**60485963**	Scheme :	**Stafford Depot : Telford**
Sample Number :	**T0824**	Notes:	**1. Core taken in central mat**
Core Number :	**48**		**2. Existing material**
Cored / Logged By :	**RF / BM**		
Date Cored / Logged :	**07-12-17 / 20-12-17**		
Nominal Diameter :	**150mm**		

Layer	Depth (mm)		Thickness (mm)	Material Description [1]	Suitable for NAT/CS Testing (Yes/No)	PAK-Marker [2]	Binder [3]	Aggregate	
	From	To						Size [4]	Type
1	0	25	25	Asphalt Surfacing (voided)	No	-ve	Bitumen	10	Crushed Rock
2	25	100	75	Asphalt Concrete (voided)	Yes	-ve	Bitumen	20	Crushed Rock
3	100	130	30	Asphalt Concrete (voided)	Yes	-ve	Bitumen	14	Crushed Rock

Notes : The scale is for guidance only. It does not necessarily reflect the actual thicknesses of individual layer(s).

Core Surface

Material Description [1]

The material description given (such as hot rolled asphalt or asphalt concrete) is generic only and is based upon a visual assessment of the material. Similarly, use of additional descriptive (such as voided) is based on visual assessment only and the relationship between air voids visually to the naked eye and degree of compaction is complex and materials specific.

PAK-Marker (PAH Spray) [2]

The Tar Spray Test is a rapid, qualitative indicator of the presence of polyaromatic compounds (PACs) typically found in tar. PACs also exist in other road construction materials (e.g. bitumen and cutbacks like kerosene), but at low concentrations. The probability of obtaining a false positive result in the tar spray test with such materials is low, and a positive result in the tar spray test is a strong (but not definitive) indicator of the presence of tar. For quantitative results, this test should be considered in conjunction with the results from other tests (i.e. Total Polynuclear Aromatic Hydrocarbons (PAH) by Gas Chromatography - Flame Ionisation Detection (GC-FID)).

Binder [3]

The binder type is assessed based on visual and aromatic inspection. The PAK-Marker result is also considered.

Aggregate Size [4]

The sizes indicated are given as the best estimate of the nominal size of the material.

CORE LOGGING OF PAVEMENT MATERIAL

In Accordance with AECOM in House Procedures

Job Number :	**60485963**	Scheme :	**Stafford Depot : Telford**
Sample Number :	**T0824**	Notes:	**1. Core taken over the joint**
Core Number :	**49**		**2. Painted joint**
Cored / Logged By :	**RF / BM**		
Date Cored / Logged :	**07-12-17 / 20-12-17**		
Nominal Diameter :	**150mm**		

Layer	Depth (mm)		Thickness (mm)	Material Description [1]	Suitable for NAT/CS Testing (Yes/No)	PAK-Marker [2]	Binder [3]	Aggregate	
	From	To						Size [4]	Type
1	0	50	50	Asphalt Surfacing	Yes	-ve	Bitumen	10	Crushed Rock

Notes : The scale is for guidance only. It does not necessarily reflect the actual thicknesses of individual layer(s).

Core Surface

Material Description [1]

The material description given (such as hot rolled asphalt or asphalt concrete) is generic only and is based upon a visual assessment of the material. Similarly, use of additional descriptive (such as voided) is based on visual assessment only and the relationship between air voids visually to the naked eye and degree of compaction is complex and materials specific.

PAK-Marker (PAH Spray) [2]

The Tar Spray Test is a rapid, qualitative indicator of the presence of polyaromatic compounds (PACs) typically found in tar. PACs also exist in other road construction materials (e.g. bitumen and cutbacks like kerosene), but at low concentrations. The probability of obtaining a false positive result in the tar spray test with such materials is low, and a positive result in the tar spray test is a strong (but not definitive) indicator of the presence of tar. For quantitative results, this test should be considered in conjunction with the results from other tests (i.e. Total Polynuclear Aromatic Hydrocarbons (PAH) by Gas Chromatography - Flame Ionisation Detection (GC-FID)).

Binder [3]

The binder type is assessed based on visual and aromatic inspection. The PAK-Marker result is also considered.

Aggregate Size [4]

The sizes indicated are given as the best estimate of the nominal size of the material.

CORE LOGGING OF PAVEMENT MATERIAL

In Accordance with AECOM in House Procedures

Job Number :	**60485963**	Scheme :	**Stafford Depot : Telford**
Sample Number :	**T0824**	Notes:	**1. Core taken over the joint**
Core Number :	**50**		**2. Painted joint**
Cored / Logged By :	**RF / BM**		
Date Cored / Logged :	**07-12-17 / 20-12-17**		
Nominal Diameter :	**150mm**		

Layer	Depth (mm)		Thickness (mm)	Material Description [1]	Suitable for NAT/CS Testing (Yes/No)	PAK-Marker [2]	Binder [3]	Aggregate	
	From	To						Size [4]	Type
1	0	55	55	Asphalt Surfacing (voided)	Yes	-ve	Bitumen	10	Crushed Rock

Notes : The scale is for guidance only. It does not necessarily reflect the actual thicknesses of individual layer(s).

Core Surface

Material Description [1]

The material description given (such as hot rolled asphalt or asphalt concrete) is generic only and is based upon a visual assessment of the material. Similarly, use of additional descriptive (such as voided) is based on visual assessment only and the relationship between air voids visually to the naked eye and degree of compaction is complex and materials specific.

PAK-Marker (PAH Spray) [2]

The Tar Spray Test is a rapid, qualitative indicator of the presence of polyaromatic compounds (PACs) typically found in tar. PACs also exist in other road construction materials (e.g. bitumen and cutbacks like kerosene), but at low concentrations. The probability of obtaining a false positive result in the tar spray test with such materials is low, and a positive result in the tar spray test is a strong (but not definitive) indicator of the presence of tar. For quantitative results, this test should be considered in conjunction with the results from other tests (i.e. Total Polynuclear Aromatic Hydrocarbons (PAH) by Gas Chromatography - Flame Ionisation Detection (GC-FID)).

Binder [3]

The binder type is assessed based on visual and aromatic inspection. The PAK-Marker result is also considered.

Aggregate Size [4]

The sizes indicated are given as the best estimate of the nominal size of the material.

CORE LOGGING OF PAVEMENT MATERIAL

AECOM

In Accordance with AECOM in House Procedures

Job Number :	60485963	Scheme :	Stafford Depot : Telford
Sample Number :	T0824	Notes:	1. Core taken over the joint
Core Number :	51		2. Painted joint
Cored / Logged By :	RF / BM		
Date Cored / Logged :	07-12-17 / 20-12-17		
Nominal Diameter :	150mm		

Layer	Depth (mm)		Thickness (mm)	Material Description [1]	Suitable for NAT/CS Testing (Yes/No)	PAK-Marker [2]	Binder [3]	Aggregate	
	From	To						Size [4]	Type
1	0	50	50	Asphalt Surfacing (voided)	Yes	-ve	Bitumen	10	Crushed Rock

Notes : The scale is for guidance only. It does not necessarily reflect the actual thicknesses of individual layer(s).

Core Surface

Material Description [1]

The material description given (such as hot rolled asphalt or asphalt concrete) is generic only and is based upon a visual assessment of the material. Similarly, use of additional descriptive (such as voided) is based on visual assessment only and the relationship between air voids visually to the naked eye and degree of compaction is complex and materials specific.

PAK-Marker (PAH Spray) [2]

The Tar Spray Test is a rapid, qualitative indicator of the presence of polyaromatic compounds (PACs) typically found in tar. PACs also exist in other road construction materials (e.g. bitumen and cutbacks like kerosene), but at low concentrations. The probability of obtaining a false positive result in the tar spray test with such materials is low, and a positive result in the tar spray test is a strong (but not definitive) indicator of the presence of tar. For quantitative results, this test should be considered in conjunction with the results from other tests (i.e. Total Polynuclear Aromatic Hydrocarbons (PAH) by Gas Chromatography - Flame Ionisation Detection (GC-FID)).

Binder [3]

The binder type is assessed based on visual and aromatic inspection. The PAK-Marker result is also considered.

Aggregate Size [4]

The sizes indicated are given as the best estimate of the nominal size of the material.

CORE LOGGING OF PAVEMENT MATERIAL

In Accordance with AECOM in House Procedures

Job Number :	**60485963**	Scheme :	**Stafford Depot : Telford**
Sample Number :	**T0824**	Notes:	**1. Core taken over the joint**
Core Number :	**52**		**2. Painted joint**
Cored / Logged By :	**RF / BM**		
Date Cored / Logged :	**07-12-17 / 20-12-17**		
Nominal Diameter :	**150mm**		

Layer	Depth (mm)		Thickness (mm)	Material Description [1]	Suitable for NAT/CS Testing (Yes/No)	PAK-Marker [2]	Binder [3]	Aggregate	
	From	To						Size [4]	Type
1	0	50	50	Asphalt Surfacing	Yes	-ve	Bitumen	10	Crushed Rock

Notes : The scale is for guidance only. It does not necessarily reflect the actual thicknesses of individual layer(s).

Core Surface

Material Description [1]
The material description given (such as hot rolled asphalt or asphalt concrete) is generic only and is based upon a visual assessment of the material. Similarly, use of additional descriptive (such as voided) is based on visual assessment only and the relationship between air voids visually to the naked eye and degree of compaction is complex and materials specific.

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Binder [3]
The binder type is assessed based on visual and aromatic inspection. The PAK-Marker result is also considered.

Aggregate Size [4]
The sizes indicated are given as the best estimate of the nominal size of the material.

CORE LOGGING OF PAVEMENT MATERIAL

In Accordance with AECOM in House Procedures

Job Number :	**60485963**	Scheme :	**Stafford Depot : Telford**
Sample Number :	**T0824**	Notes:	**1. Core taken over the joint**
Core Number :	**53**		**2. Painted joint**
Cored / Logged By :	**RF / BM**		
Date Cored / Logged :	**07-12-17 / 20-12-17**		
Nominal Diameter :	**150mm**		

Layer	Depth (mm)		Thickness (mm)	Material Description [1]	Suitable for NAT/CS Testing (Yes/No)	PAK-Marker [2]	Binder [3]	Aggregate	
	From	To						Size [4]	Type
1	0	50	50	Asphalt Surfacing (in half)	No	-ve	Bitumen	10	Crushed Rock

Notes : The scale is for guidance only. It does not necessarily reflect the actual thicknesses of individual layer(s).

Core Surface

Material Description [1]

The material description given (such as hot rolled asphalt or asphalt concrete) is generic only and is based upon a visual assessment of the material. Similarly, use of additional descriptive (such as voided) is based on visual assessment only and the relationship between air voids visually to the naked eye and degree of compaction is complex and materials specific.

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Binder [3]

The binder type is assessed based on visual and aromatic inspection. The PAK-Marker result is also considered.

Aggregate Size [4]

The sizes indicated are given as the best estimate of the nominal size of the material.

CORE LOGGING OF PAVEMENT MATERIAL

In Accordance with AECOM in House Procedures

Job Number :	**60485963**	Scheme :	**Stafford Depot : Telford**
Sample Number :	**T0824**	Notes:	**1. Core taken over joint**
Core Number :	**54**		**2. Coin placed on the heated side of the joint**
Cored / Logged By :	**RF / BM**		
Date Cored / Logged :	**07-12-17 / 20-12-17**		
Nominal Diameter :	**150mm**		

Layer	Depth (mm)		Thickness (mm)	Material Description [1]	Suitable for NAT/CS Testing (Yes/No)	PAK-Marker [2]	Binder [3]	Aggregate	
	From	To						Size [4]	Type
1	0	40	40	Asphalt Surfacing (voided)	Yes	-ve	Bitumen	10	Crushed Rock
2	40	100	60	Asphalt Concrete (voided)	Yes	-ve	Bitumen	20	Crushed Rock
3	100	145	45	Weakly Bound Material					

Notes : The scale is for guidance only. It does not necessarily reflect the actual thicknesses of individual layer(s).

Core Surface

Material Description [1]

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Binder [3]

The binder type is assessed based on visual and aromatic inspection. The PAK-Marker result is also considered.

Aggregate Size [4]

The sizes indicated are given as the best estimate of the nominal size of the material.

CORE LOGGING OF PAVEMENT MATERIAL

In Accordance with AECOM in House Procedures

Job Number :	**60485963**	Scheme :	**Stafford Depot : Telford**
Sample Number :	**T0824**	Notes:	**1. Core taken over joint**
Core Number :	**55**		**2. Coin placed on the heated side of the joint**
Cored / Logged By :	**RF / BM**		
Date Cored / Logged :	**07-12-17 / 20-12-17**		
Nominal Diameter :	**150mm**		

Layer	Depth (mm)		Thickness (mm)	Material Description [1]	Suitable for NAT/CS Testing (Yes/No)	PAK-Marker [2]	Binder [3]	Aggregate	
	From	To						Size [4]	Type
1	0	45	45	Asphalt Surfacing (voided)(Offset)	Yes	-ve	Bitumen	10	Crushed Rock
2	45	110	65	Asphalt Concrete	Yes	-ve	Bitumen	20	Crushed Rock

Notes : The scale is for guidance only. It does not necessarily reflect the actual thicknesses of individual layer(s).

Core Surface

Material Description [1]

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Binder [3]

The binder type is assessed based on visual and aromatic inspection. The PAK-Marker result is also considered.

Aggregate Size [4]

The sizes indicated are given as the best estimate of the nominal size of the material.

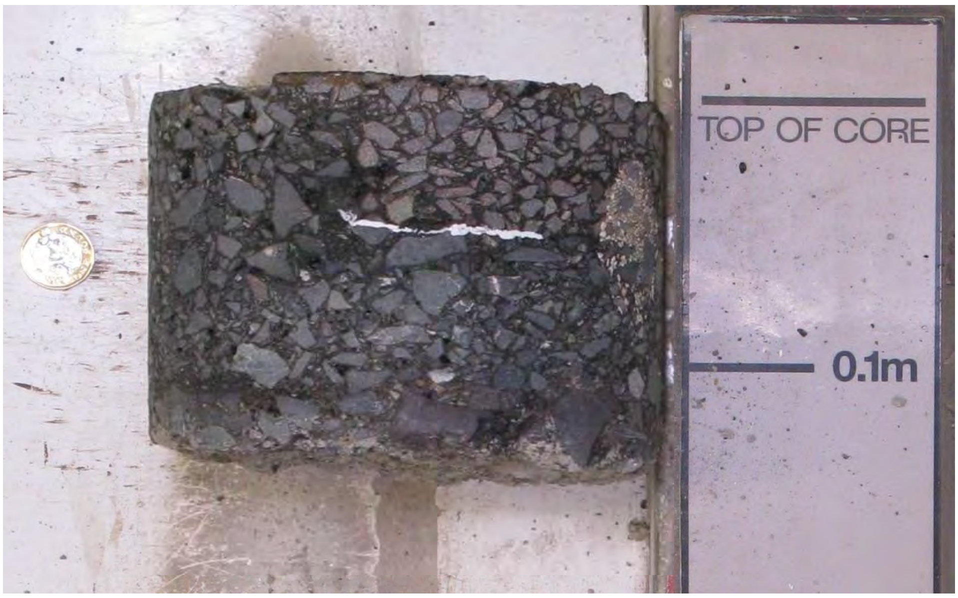
CORE LOGGING OF PAVEMENT MATERIAL

In Accordance with AECOM in House Procedures

Job Number :	**60485963**	Scheme :	**Stafford Depot : Telford**
Sample Number :	**T0824**	Notes:	**1. Core taken over joint**
Core Number :	**56**		**2. Coin placed on the heated side of the joint**
Cored / Logged By :	**RF / BM**		
Date Cored / Logged :	**07-12-17 / 20-12-17**		
Nominal Diameter :	**150mm**		

Layer	Depth (mm)		Thickness (mm)	Material Description [1]	Suitable for NAT/CS Testing (Yes/No)	PAK-Marker [2]	Binder [3]	Aggregate	
	From	To						Size [4]	Type
1	0	50	50	Asphalt Surfacing	Yes	-ve	Bitumen	10	Crushed Rock
2	50	120	70	Asphalt Concrete (voided)	Yes	-ve	Bitumen	20	Crushed Rock

Notes : The scale is for guidance only. It does not necessarily reflect the actual thicknesses of individual layer(s).



Core Surface

Material Description [1]

The material description given (such as hot rolled asphalt or asphalt concrete) is generic only and is based upon a visual assessment of the material. Similarly, use of additional descriptive (such as voided) is based on visual assessment only and the relationship between air voids visually to the naked eye and degree of compaction is complex and materials specific.

PAK-Marker (PAH Spray) [2]

The Tar Spray Test is a rapid, qualitative indicator of the presence of polyaromatic compounds (PACs) typically found in tar. PACs also exist in other road construction materials (e.g. bitumen and cutbacks like kerosene), but at low concentrations. The probability of obtaining a false positive result in the tar spray test with such materials is low, and a positive result in the tar spray test is a strong (but not definitive) indicator of the presence of tar. For quantitative results, this test should be considered in conjunction with the results from other tests (i.e. Total Polynuclear Aromatic Hydrocarbons (PAH) by Gas Chromatography - Flame Ionisation Detection (GC-FID)).

Binder [3]

The binder type is assessed based on visual and aromatic inspection. The PAK-Marker result is also considered.

Aggregate Size [4]

The sizes indicated are given as the best estimate of the nominal size of the material.

AECOM

CORE LOGGING OF PAVEMENT MATERIAL

In Accordance with AECOM in House Procedures

Job Number :	**60485963**	Scheme :	**Stafford Depot : Telford**
Sample Number :	**T0824**	Notes:	**1. Core taken over joint**
Core Number :	**57**		**2. Coin placed on the heated side of the joint**
Cored / Logged By :	**RF / BM**		
Date Cored / Logged :	**07-12-17 / 20-12-17**		
Nominal Diameter :	**150mm**		

Layer	Depth (mm)		Thickness (mm)	Material Description [1]	Suitable for NAT/CS Testing (Yes/No)	PAK-Marker [2]	Binder [3]	Aggregate	
	From	To						Size [4]	Type
1	0	45	45	Asphalt Surfacing	Yes	-ve	Bitumen	10	Crushed Rock
2	45	110	65	Asphalt Concrete (voided)	Yes	-ve	Bitumen	20	Crushed Rock

Notes : The scale is for guidance only. It does not necessarily reflect the actual thicknesses of individual layer(s).

Core Surface

Material Description [1]

The material description given (such as hot rolled asphalt or asphalt concrete) is generic only and is based upon a visual assessment of the material. Similarly, use of additional descriptive (such as voided) is based on visual assessment only and the relationship between air voids visually to the naked eye and degree of compaction is complex and materials specific.

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Binder [3]

The binder type is assessed based on visual and aromatic inspection. The PAK-Marker result is also considered.

Aggregate Size [4]

The sizes indicated are given as the best estimate of the nominal size of the material.

CORE LOGGING OF PAVEMENT MATERIAL

In Accordance with AECOM in House Procedures

Job Number :	60485963	Scheme :	Stafford Depot : Telford
Sample Number :	T0824	Notes:	1. Core taken over joint
Core Number :	58		2. Coin placed on the heated side of the joint
Cored / Logged By :	RF / BM		
Date Cored / Logged :	07-12-17 / 20-12-17		
Nominal Diameter :	150mm		

Layer	Depth (mm)		Thickness (mm)	Material Description [1]	Suitable for NAT/CS Testing (Yes/No)	PAK-Marker [2]	Binder [3]	Aggregate	
	From	To						Size [4]	Type
1	0	45	45	Asphalt Surfacing	Yes	-ve	Bitumen	10	Crushed Rock
2	45	110	65	Asphalt Concrete	Yes	-ve	Bitumen	20	Crushed Rock

Notes : The scale is for guidance only. It does not necessarily reflect the actual thicknesses of individual layer(s).

Core Surface

Material Description [1]

The material description given (such as hot rolled asphalt or asphalt concrete) is generic only and is based upon a visual assessment of the material. Similarly, use of additional descriptive (such as voided) is based on visual assessment only and the relationship between air voids visually to the naked eye and degree of compaction is complex and materials specific.

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Binder [3]

The binder type is assessed based on visual and aromatic inspection. The PAK-Marker result is also considered.

Aggregate Size [4]

The sizes indicated are given as the best estimate of the nominal size of the material.

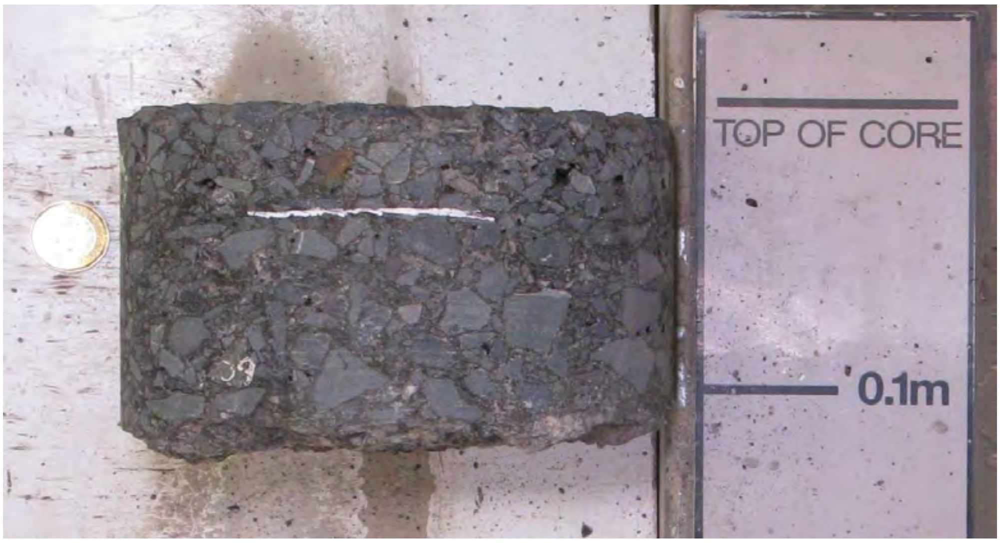
CORE LOGGING OF PAVEMENT MATERIAL

In Accordance with AECOM in House Procedures

Job Number :	**60485963**	Scheme :	**Stafford Depot : Telford**
Sample Number :	**T0824**	Notes:	**1. Edge core**
Core Number :	**59**		**2. Coin is placed on the edge closest to the joint**
Cored / Logged By :	**RF / BM**		**3. Existing material**
Date Cored / Logged :	**07-12-17 / 20-12-17**		
Nominal Diameter :	**150mm**		**Notes: N/A**

Layer	Depth (mm)		Thickness (mm)	Material Description [1]	Suitable for NAT/CS Testing (Yes/No)	PAK-Marker [2]	Binder [3]	Aggregate	
	From	To						Size [4]	Type
1	0	30	30	Asphalt Surfacing (voided)(Left of Rip)	Yes	-ve	Bitumen	10	Crushed Rock
2	30	100	70	Asphalt Concrete	Yes	-ve	Bitumen	20	Crushed Rock

Notes : The scale is for guidance only. It does not necessarily reflect the actual thicknesses of individual layer(s).



Core Surface

Material Description [1]

The material description given (such as hot rolled asphalt or asphalt concrete) is generic only and is based upon a visual assessment of the material. Similarly, use of additional descriptive (such as voided) is based on visual assessment only and the relationship between air voids visually to the naked eye and degree of compaction is complex and materials specific.

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The Tar Spray Test is a rapid, qualitative indicator of the presence of polyaromatic compounds (PACs) typically found in tar. PACs also exist in other road construction materials (e.g. bitumen and cutbacks like kerosene), but at low concentrations. The probability of obtaining a false positive result in the tar spray test with such materials is low, and a positive result in the tar spray test is a strong (but not definitive) indicator of the presence of tar. For quantitative results, this test should be considered in conjunction with the results from other tests (i.e. Total Polynuclear Aromatic Hydrocarbons (PAH) by Gas Chromatography - Flame Ionisation Detection (GC-FID)).

Binder [3]

The binder type is assessed based on visual and aromatic inspection. The PAK-Marker result is also considered.

Aggregate Size [4]

The sizes indicated are given as the best estimate of the nominal size of the material.

AECOM

CORE LOGGING OF PAVEMENT MATERIAL

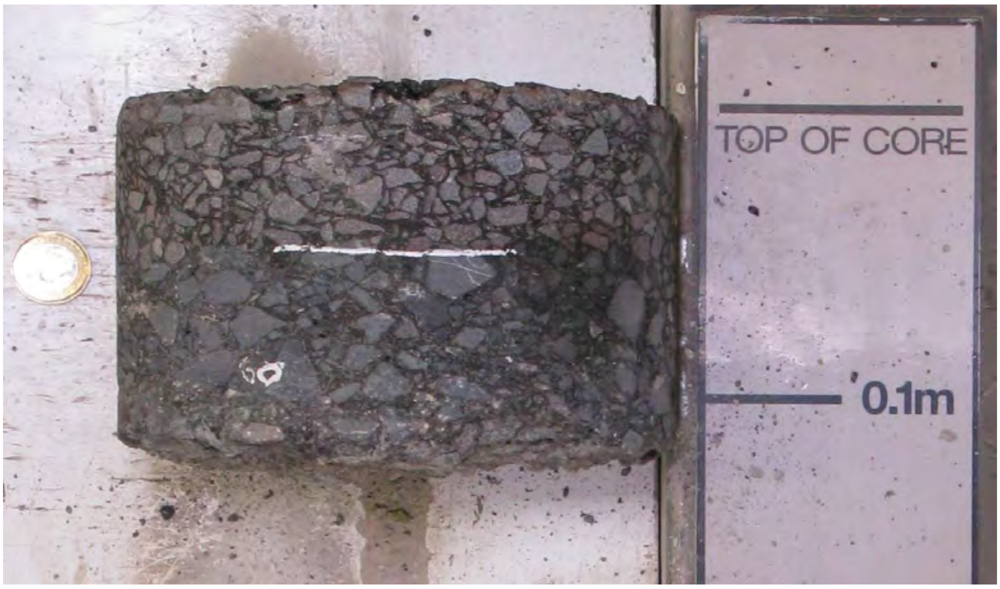
In Accordance with AECOM in House Procedures

Job Number :	**60485963**	Scheme :	**Stafford Depot : Telford**
Sample Number :	**T0824**	Notes:	**1. Edge core**
Core Number :	**60**		**2. Coin is placed on the edge closest to the joint**
Cored / Logged By :	**RF / BM**		
Date Cored / Logged :	**07-12-17 / 20-12-17**		
Nominal Diameter :	**150mm**		**Notes: N/A**

Layer	Depth (mm)		Thickness (mm)	Material Description [1]	Suitable for NAT/CS Testing (Yes/No)	PAK-Marker [2]	Binder [3]	Aggregate	
	From	To						Size [4]	Type
1	0	50	50	Asphalt Surfacing	Yes	-ve	Bitumen	10	Crushed Rock
2	50	105	55	Asphalt Concrete	Yes	-ve	Bitumen	20	Crushed Rock

Notes : The scale is for guidance only. It does not necessarily reflect the actual thicknesses of individual layer(s).

Core Surface



Material Description [1]

The material description given (such as hot rolled asphalt or asphalt concrete) is generic only and is based upon a visual assessment of the material. Similarly, use of additional descriptive (such as voided) is based on visual assessment only and the relationship between air voids visually to the naked eye and degree of compaction is complex and materials specific.

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Binder [3]

The binder type is assessed based on visual and aromatic inspection. The PAK-Marker result is also considered.

Aggregate Size [4]

The sizes indicated are given as the best estimate of the nominal size of the material.

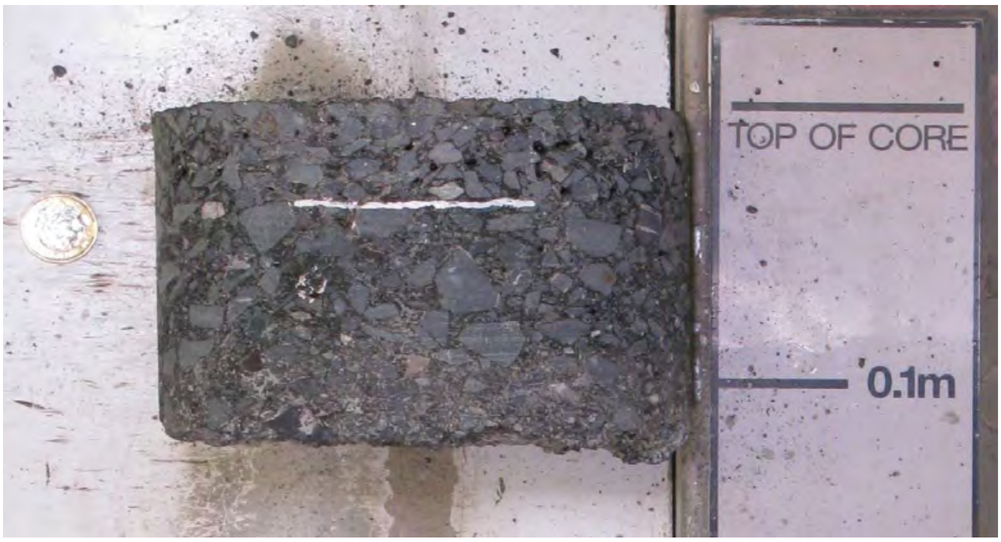
CORE LOGGING OF PAVEMENT MATERIAL

In Accordance with AECOM in House Procedures

Job Number :	60485963	Scheme :	Stafford Depot : Telford
Sample Number :	T0824	Notes:	1. Edge core
Core Number :	61		2. Coin is placed on the edge closest to the joint
Cored / Logged By :	RF / BM		3. Existing material
Date Cored / Logged :	07-12-17 / 20-12-17		
Nominal Diameter :	150mm		Notes: N/A

Layer	Depth (mm)		Thickness (mm)	Material Description [1]	Suitable for NAT/CS Testing (Yes/No)	PAK-Marker [2]	Binder [3]	Aggregate	
	From	To						Size [4]	Type
1	0	30	30	Asphalt Surfacing (voided)	Yes	-ve	Bitumen	10	Crushed Rock
2	30	105	75	Asphalt Concrete	Yes	-ve	Bitumen	20	Crushed Rock

Notes : The scale is for guidance only. It does not necessarily reflect the actual thicknesses of individual layer(s).



Core Surface

Material Description [1]

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Binder [3]

The binder type is assessed based on visual and aromatic inspection. The PAK-Marker result is also considered.

Aggregate Size [4]

The sizes indicated are given as the best estimate of the nominal size of the material.

CORE LOGGING OF PAVEMENT MATERIAL

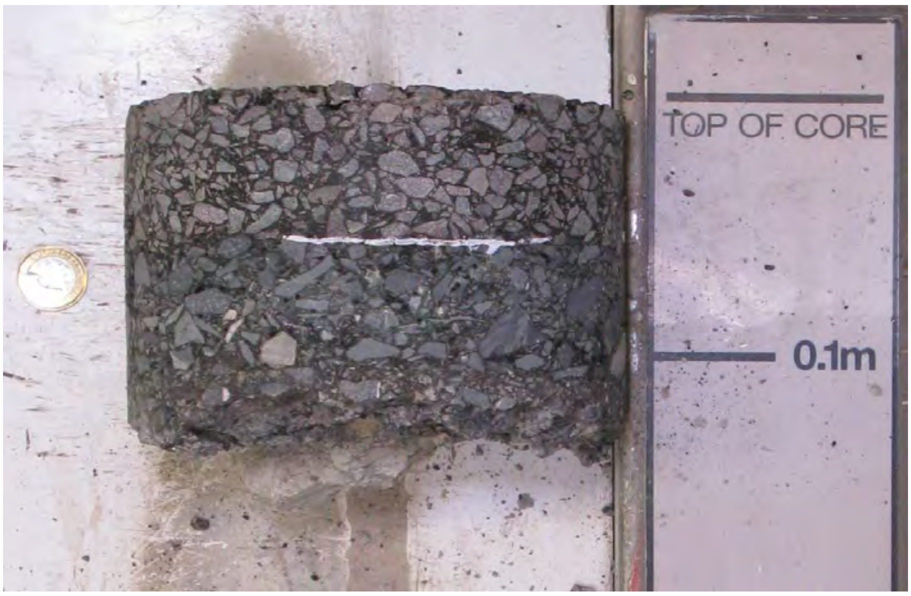
In Accordance with AECOM in House Procedures

Job Number :	**60485963**	Scheme :	**Stafford Depot : Telford**
Sample Number :	**T0824**	Notes:	**1. Edge core**
Core Number :	**62**		**2. Coin is placed on the edge closest to the joint**
Cored / Logged By :	**RF / BM**		
Date Cored / Logged :	**07-12-17 / 20-12-17**		
Nominal Diameter :	**150mm**		**Notes: N/A**

Layer	Depth (mm)		Thickness (mm)	Material Description [1]	Suitable for NAT/CS Testing (Yes/No)	PAK-Marker [2]	Binder [3]	Aggregate	
	From	To						Size [4]	Type
1	0	50	50	Asphalt Surfacing (voided)	Yes	-ve	Bitumen	10	Crushed Rock
2	50	110	60	Asphalt Concrete (voided)	Yes	-ve	Bitumen	20	Crushed Rock

Notes : The scale is for guidance only. It does not necessarily reflect the actual thicknesses of individual layer(s).

Core Surface



Material Description [1]

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Binder [3]

The binder type is assessed based on visual and aromatic inspection. The PAK-Marker result is also considered.

Aggregate Size [4]

The sizes indicated are given as the best estimate of the nominal size of the material.

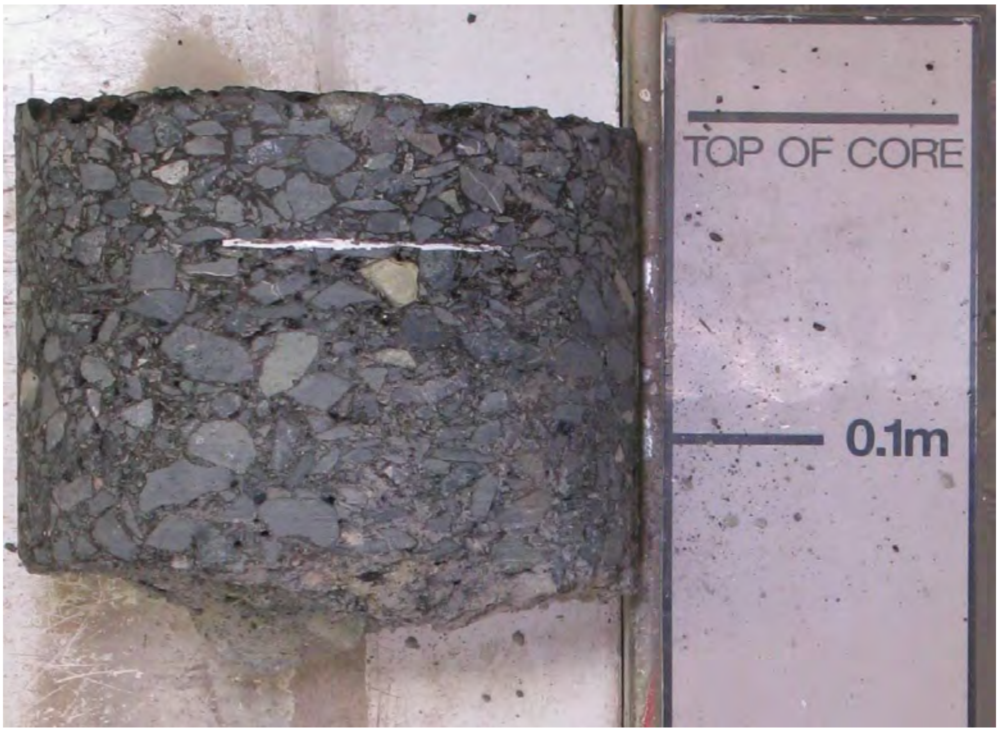
CORE LOGGING OF PAVEMENT MATERIAL

In Accordance with AECOM in House Procedures

Job Number :	60485963	Scheme :	Stafford Depot : Telford
Sample Number :	T0824	Notes:	1. Core taken in central mat
Core Number :	63		2. Existing material
Cored / Logged By :	RF / BM		
Date Cored / Logged :	07-12-17 / 20-12-17		
Nominal Diameter :	150mm		

Layer	Depth (mm)		Thickness (mm)	Material Description [1]	Suitable for NAT/CS Testing (Yes/No)	PAK-Marker [2]	Binder [3]	Aggregate	
	From	To						Size [4]	Type
1	0	40	40	Asphalt Surfacing	Yes	-ve	Bitumen	10	Crushed Rock
2	40	135	95	Asphalt Concrete (voided)	Yes	-ve	Bitumen	14	Crushed Rock

Notes : The scale is for guidance only. It does not necessarily reflect the actual thicknesses of individual layer(s).



Core Surface

Material Description [1]

The material description given (such as hot rolled asphalt or asphalt concrete) is generic only and is based upon a visual assessment of the material. Similarly, use of additional descriptive (such as voided) is based on visual assessment only and the relationship between air voids visually to the naked eye and degree of compaction is complex and materials specific.

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Binder [3]

The binder type is assessed based on visual and aromatic inspection. The PAK-Marker result is also considered.

Aggregate Size [4]

The sizes indicated are given as the best estimate of the nominal size of the material.

CORE LOGGING OF PAVEMENT MATERIAL

In Accordance with AECOM in House Procedures

Job Number :	**60485963**	Scheme :	**Stafford Depot : Telford**
Sample Number :	**T0824**	Notes:	**1. Core taken in central mat**
Core Number :	**64**		**2. Existing material**
Cored / Logged By :	**RF / BM**		
Date Cored / Logged :	**07-12-17 / 20-12-17**		
Nominal Diameter :	**150mm**		

Layer	Depth (mm)		Thickness (mm)	Material Description [1]	Suitable for NAT/CS Testing (Yes/No)	PAK-Marker [2]	Binder [3]	Aggregate	
	From	To						Size [4]	Type
1	0	45	45	Asphalt Surfacing	Yes	-ve	Bitumen	10	Crushed Rock
2	45	120	75	Asphalt Concrete	Yes	-ve	Bitumen	14	Crushed Rock

Notes : The scale is for guidance only. It does not necessarily reflect the actual thicknesses of individual layer(s).

Core Surface

Material Description [1]
The material description given (such as hot rolled asphalt or asphalt concrete) is generic only and is based upon a visual assessment of the material. Similarly, use of additional descriptive (such as voided) is based on visual assessment only and the relationship between air voids visually to the naked eye and degree of compaction is complex and materials specific.

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Binder [3]
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Aggregate Size [4]
The sizes indicated are given as the best estimate of the nominal size of the material.

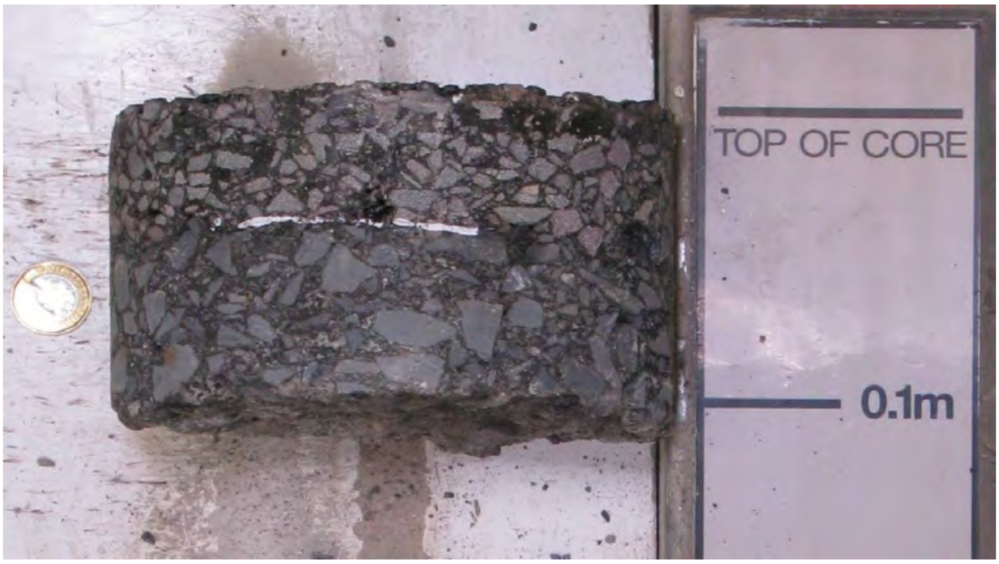
CORE LOGGING OF PAVEMENT MATERIAL

In Accordance with AECOM in House Procedures

Job Number :	**60485963**	Scheme :	**Stafford Depot : Telford**
Sample Number :	**T0824**	Notes:	**1. Core taken in central mat**
Core Number :	**65**		**2. Existing material**
Cored / Logged By :	**RF / BM**		
Date Cored / Logged :	**07-12-17 / 20-12-17**		
Nominal Diameter :	**150mm**		

Layer	Depth (mm)		Thickness (mm)	Material Description [1]	Suitable for NAT/CS Testing (Yes/No)	PAK-Marker [2]	Binder [3]	Aggregate	
	From	To						Size [4]	Type
1	0	35	35	Asphalt Surfacing	Yes	-ve	Bitumen	10	Crushed Rock
2	35	110	75	Asphalt Concrete	Yes	-ve	Bitumen	14	Crushed Rock

Notes : The scale is for guidance only. It does not necessarily reflect the actual thicknesses of individual layer(s).



Core Surface

Material Description [1]

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Binder [3]

The binder type is assessed based on visual and aromatic inspection. The PAK-Marker result is also considered.

Aggregate Size [4]

The sizes indicated are given as the best estimate of the nominal size of the material.

Appendix D Laboratory test instruction

LABORATORY TEST INSTRUCTION

Project Title :	**Area 9 joint heater trials**	Created By :	**JT**
Job Number :	**60485963**	Checked By :	**NAL**
Cost Code :	**JHT**	Date of Issue :	**22 December 2017**
Location of Creation :	**AECOM Nottingham, NG9 6RZ**	Project Deadline :	**31 January 2018**

Core	Layer	2. Air Voids Using Density Method B	3. Air Voids Using Density Method C	Maximum density (bulk sample)	Permeability BS EN 12697-19 constant head	ITST @ 20oC. Joint vertical through sample	Develop pull test equipment	Bespoke pull test	4. Binder Recover BS EN 12697-3, Followed by DSR for Equivalent PEN &SP	Maximum density (cores)			
		15	3	0	6	11	1	6	3	0			
		Book to: 60485963.JHT (up to £4745)					60526556.SPT3 (up to £5k)						
1	1	x											
2	1	x											
3	1	x											
4	1	x											
5	1					x							
6	1					x							
7	1					x							
8	1				x			x					
9	1				x			x					
10	1	x											
11	1	x											
12	1	x											
13	1	x											
14	1				x			x					
15	1					x			x				
16	1					x			x	combine heated side for single test			
17	1					x			x				
18	1				x			x					
19	1	x	x			x			x				
20	1	x	x										
21	1	x											
22	1	x											
23	1	x											
24	1	x											
25	1					x			x				
26	1				x			x		combine heated side for single test			
27	1					x			x				
28	1					x			x				
29	1				x			x					
30	1	x	x			x							

Checked by: - **NAL**	Date: - **22 December 2017**

AECOM

LABORATORY TEST INSTRUCTION

Project Title :	**Area 9 joint heater trials**	Created By :	**JT**
Job Number :	**60485963**	Checked By :	**NAL**
Cost Code :	**JHT**	Date of Issue :	**22 December 2017**
Location of Creation :	**AECOM Nottingham, NG9 6RZ**	Project Deadline :	**31 January 2018**

Page 2 of 3

Core	Layer	2. Air Voids Using Density Method B	3. Air Voids Using Density Method C	Maximum density (bulk sample)	Permeability BS EN 12697-19 constant head	ITST @ 20oC. Joint vertical through sample	Develop shear test equipment	Bespoke pull test	4. Binder Recover BS EN 12697-3, Followed by DSR for Equivalent PEN &SP	Maximum density (cores)			
		29	1	0	8	15	0	8	3	1			
31	1	x											
32	1	x											
33	1	x											
34	1	x											
35	1	x			x			x					
36	1	x				x			x				
37	1	x				x			x	combine dotted side for single test			
38	1	x				x			x				
39	1	x			x			x					
40	1	x	x			x			x				
41	1	x				x							
42	1	x				x							
43	1	x			x			x					
44	1	x			x			x					
45	1	x				x							
46	1	x				x							
47	1	x				x							
48	1	x				x				x			
49	1	x			x			x					
50	1	x			x			x					
51	1	x				x							
52	1	x				x							
53	No test												
54	1	x				x			x				
55	1	x				x			x	combine heated side for single test			
56	1	x				x			x				
57	1	x			x			x					
58	1	x			x			x					
59	1	x											
60	1	x											

Checked by: - **Jessica Tuck**	Date: - **22 December 2017**

AECOM

LABORATORY TEST INSTRUCTION

Project Title :	**60485963**	Created By :	**JT**
Job Number :	**JHT**	Checked By :	**NAL**
Location of Creation :	**AECOM Nottingham, NG9 6RZ**	Project dealine:	**31 January 2018**

Core	Layer	2. Air Voids Using Density Method B	3. Air Voids Using Density Method C	Maximum density (bulk sample)	Permeability BS EN 12697-19 constant head	ITST @ 20oC. Joint vertical through sample	Develop shear test equipment	Bespoke pull test	4. Binder Recover BS EN 12697-3, Followed by DSR for Equivalent PEN &SP	Maximum density (cores)			
		5	0	1	0	3	0	0	1	1			
61	1	x											
62	1	x											
63	1	x				x				x			
64	1	x				x			x				
65	1	x				x							
Bulk sample				x									
Manual tot up		ALL (64)	4	1	14	29	1	14	7	2			

Checked by: -	**NAL**	Date: -	**22 December 2017**

Appendix E Laboratory results summary table

APPENDIX

Location	Heated/ painted joint ref.	Core ref	Chainage	Core type	Uconfined or confined edge	Heated?	Air Voids (% v/v)	Average Air Voids (% v/v)	Maximum Density (kg/m^3)	Bulk Density (kg/m^3)	Average Bulk Density kg/m3	Indirect tensile strength / kPa	Average ITS (kPa)	Permeability Kv (m/s)	Average Permeability K_v (m/s)	Direct Tension Test, peak force (kN)	Average DTT peak force (kN)	DTT peak Stress (N/mm2)	Average DTT Peak Stress (N/mm2)	Penetration grade (dmm) [heated side]	Penetration Index (IP)	G* at 0.4Hz & 25ºC (Pa)
Joint between Rip 1 and Rip 3	Heated Joint B	14	21m	Over joint			13	12.8	2508	2182	2186.4		485	6.58E-04	0.000647	0.72	0.77	0.15	0.15	60	0.4	2.74E+05
		15	22m	Over joint			13.5		2508	2170		534										
		16	25m	Over joint			12.1		2508	2203		458										
		17	27m	Over joint			12.8		2508	2187		463										
		18	27m	Over joint			12.7		2508	2190				6.36E-04		0.81		0.14				
		10	18m	Edge	Unconfined (Rip 1)	Y	13.9	13.2	2508	2159	2178.5											
		12	20m	Edge	Unconfined (Rip 1)	Y	12.4		2508	2198												
		11	18m	Edge	Confined (Rip 3)	N	10	10.0	2508	2256	2258.5											
		13	20m	Edge	Confined (Rip 3)	N	9.9		2508	2261												
Joint between Rip 3 and Rip 4	Heated Joint C	25	22m	Over joint			10.6	13.0	2508	2241	2181.6	465	396		0.001135		0.53		0.10	75	1.9	1.82E+05
		26	22m	Over joint			13.2		2508	2177				1.06E-03		0.53		0.11				
		27	25m	Over joint			14		2508	2156		279										
		28	26m	Over joint			12.3		2508	2199		443										
		29	26m	Over joint			14.9		2508	2135				1.21E-03		0.52		0.09				
		21	15m	Edge	Unconfined (Rip 3)	Y	13.8	13.6	2508	2162	2167.5											
		23	16m	Edge	Unconfined (Rip 3)	Y	13.3		2508	2173												
		22	15m	Edge	Confined (Rip 4)	N	6.1	6.1	2508	2354	2354.5											
		24	16m	Edge	Confined (Rip 4)	N	6.1		2508	2355												
Joint between Rip 2 and Rip 4	Painted Joint D	35	22m	Over joint			11	11.5	2508	2231	2218.2		381	5.17E-04	0.000387	0.95	0.80	0.15	0.13	68	0.2	2.20E+05
		36	22m	Over joint			11		2508	2231		402										
		37	26m	Over joint			13.7		2508	2163		326										
		38	26m	Over joint			10.2		2508	2251		414										
		39	27m	Over joint			11.7		2508	2215				2.57E-04		0.64		0.12				
		31	15m	Edge	Unconfined (Rip 2)	N/A	12.9	13.2	2508	2183	2175.5											
		33	16m	Edge	Unconfined (Rip 2)	N/A	13.5		2508	2168												
		32	15m	Edge	Confined (Rip 4)	N/A	6.9	6.7	2508	2335	2341.5											
		34	16m	Edge	Confined (Rip 4)	N/A	6.4		2508	2348												
Joint between Rip 1 & Existing	Heated Joint A	41	8m	Over joint			0	0.0	0	2321	2336.4	641	721		0.000229		0.87		0.12			
		42	9m	Over joint			0		0	2359		739										
		43	10m	Over joint			0		0	2323				2.11E-04		0.87		0.12				
		44	13m	Over joint			0		0	2341				2.47E-04		Not valid						
		45	15m	Over joint			0		0	2338		784										
Joint between Rip 2 & Existing	Painted Joint E	49	5m*	Over joint			0	0.0	0	2251	2329.5		355	-	0.000141		0.44		0.07			
		50	6m*	Over joint			0		0	2495				1.41E-04		0.44		0.07				
		51	6m*	Over joint			0		0	2266		296										
		52	7m*	Over joint			0		0	2306		414										
		53	7m*	Over joint																		
Joint between Rip 1 & Existing	Painted Joint A	5	29m	Over joint			8	7.9	2523.5	2321	2325.0	659	659		0.0002795		0.79		0.13			
		6	28m	Over joint			7.2		2523.5	2341		794										
		7	27m	Over joint			7.2		2523.5	2343				2.97E-04		0.80		0.14				
		8	26m	Over joint			7.8		2523.5	2326				2.62E-04		0.78		0.13				
		9	25m	Over joint			9.1		2523.5	2294		523										
		2	31m	Edge	Confined (Rip 1)	N/A	8.9	8.7	2508	2284	2508.0											
		4	30m	Edge	Confined (Rip 1)	N/A	8.5		2508	2296												
		1	31m	Edge	Existing material	N/A	10.5	11.8	2529	2273	2239.5											
		3	30m	Edge	Existing material	N/A	13.1		2539	2206												
Joint between Rip 2 & Existing	Heated Joint E	54	28m*	Over joint			7.1	7.2	2518.5	2339	2337.6	637	655		0.0003385		1.27		0.20	21	0.7	1.83E+06
		55	28m*	Over joint			7.5		2518.5	2329		439										
		56	28m*	Over joint			6.5		2518.5	2355		889										
		57	29m*	Over joint			7.1		2518.5	2339				3.38E-04		1.40		0.20				
		58	29m*	Over joint			7.6		2518.5	2326				3.39E-04		1.13		0.19				
		60	29m*	Edge	Confined (Rip 2)		7.2	7.6	2508	2326	2316											
		62	30m*	Edge	Confined (Rip 2)		8		2508	2306												

Joints between newly installed materials

Joints between new and existing

		59	29m*	Edge	Existing material		6.4	6.65	2529	2366	2359.5												
		61	30m*	Edge	Existing material		6.9		2529	2353													
Rip 1 TSCS		19	16m	Central mat			8.1	7.1	2508	2304	2330.8	658	743							64	0.7	2.43E+05	New material
Rip 2 TSCS		40	30m	Central mat			6.3		2508	2349		757								72	1.0	1.94E+05	
Rip 3 TSCS		20	11m	Central mat			6.1		2508	2355													
Rip 4 TSCS		30	28m	Central mat			7.7		2508	2315		814											
Existing material B (adjacent to Joint A)		46	31m	Central mat			6	6.3	2539	2386	2377.7	769	821										Existing material
		47	31m	Central mat			6		2539	2386		814											
		48	48m	Central mat			7		2539	2361		879											
Existing material B (adjacent to Joint E)		63	30m*	Central mat			2.4	3.4	2529	2467	2443.3	1160	1207										
		64	30m*	Central mat			4		2529	2427		1220								30	0.9	9.21E+05	
		65	31m*	Central mat			3.7		2529	2436		1240											

*estimated

Estimated max D, assuming 50% new material and 50% existing material max density

Appendix F Laboratory test certificates

AECOM

MAXIMUM DENSITY & AIR VOIDS

BS EN 12697-5 : 2009 - Procedure A & BS EN 12697-8 : 2003

UKAS TESTING 4410

Project Title :	**Area 9 joint heater trials**	Tested By :	**NAL**
Job Number :	**60485963**	Reported By :	**NAL**
Ticket Number :	**T0824**	Checked By :	**MK**
Location of Testing :	**AECOM Laboratory, NG9 6RZ**	Date of Issue :	**31 January 2018**

Sample Reference	Date of Test	Bulk Density Method	Bulk Density (kg/m³)	Maximum Density Test Temperature (˚C)		**Maximum Density (kg/m³)***	**Air Voids (% v/v)**
01L1	04-Jan-18	B	2273	20.2		2539	**10.5**
02L1	04-Jan-18	B	2284	20.2		2508	**8.9**
03L1	04-Jan-18	B	2206	20.2		2539	**13.1**
04L1	04-Jan-18	B	2296	20.2		2508	**8.5**
05L1	04-Jan-18	B	2321	20.2		2523	**8.0**
06L1	04-Jan-18	B	2341	20.2		2523	**7.2**
07L1	04-Jan-18	B	2343	20.2		2523	**7.2**
08L1	04-Jan-18	B	2326	20.2		2523	**7.8**
09L1	04-Jan-18	B	2294	20.2		2523	**9.1**
10L1	04-Jan-18	B	2159	20.2		2508	**13.9**
11L1	04-Jan-18	B	2256	20.2		2508	**10.0**
12L1	04-Jan-18	B	2198	20.2		2508	**12.4**
13L1	04-Jan-18	B	2261	20.2		2508	**9.9**
14L1	04-Jan-18	B	2182	20.2		2508	**13.0**
15L1	04-Jan-18	B	2170	20.2		2508	**13.5**
16L1	04-Jan-18	B	2203	20.2		2508	**12.1**
17L1	04-Jan-18	B	2187	20.2		2508	**12.8**
18L1	04-Jan-18	B	2190	20.2		2508	**12.7**
19L1	04-Jan-18	B	2304	20.2		2508	**8.1**
20L1	04-Jan-18	B	2355	20.2		2508	**6.1**
21L1	04-Jan-18	B	2162	20.2		2508	**13.8**
22L1	04-Jan-18	B	2354	20.2		2508	**6.1**
23L1	04-Jan-18	B	2173	20.2		2508	**13.3**
24L1	04-Jan-18	B	2355	20.2		2508	**6.1**
25L1	04-Jan-18	B	2241	20.2		2508	**10.6**
26L1	04-Jan-18	B	2177	20.2		2508	**13.2**
27L1	04-Jan-18	B	2156	20.2		2508	**14.0**
28L1	04-Jan-18	B	2199	20.2		2508	**12.3**
29L1	04-Jan-18	B	2135	20.2		2508	**14.9**
30L1	04-Jan-18	B	2315	20.2		2508	**7.7**

Comments and Deviations:

m_1= mass of pyknometer (g), m_2= m_1 and sample (g), m_3= m_2 and filled with water (g), Vp= volume of pyknometer (m³)

ρw= density of water (mg/m³), ρmv= sample maximum density (mg/m³) * x10⁻³ Mg/m³

$$\rho w = 1.00025205 + \frac{7.59t - 5.32t^2}{10^6} \qquad \rho mv = \frac{(m_2 - m_1)}{10^6 x Vp - (m_3 - m_2)/\rho w}$$

Origin of Specimen : Extracted from Site

Underlined values are estimated assuming 50:50 TSCS:existing material

Checked by: - MKozicz

Date: - **31 January 2018**

AECOM

MAXIMUM DENSITY & AIR VOIDS

BS EN 12697-5 : 2009 - Procedure A & BS EN 12697-8 : 2003

UKAS TESTING 4410

Project Title :	**Area 9 joint heater trials**	Tested By :	**NAL**
Job Number :	**60485963**	Reported By :	**NAL**
Ticket Number :	**T0824**	Checked By :	**MK**
Location of Testing :	**AECOM Laboratory, NG9 6RZ**	Date of Issue :	**31 January 2018**

Sample Reference	Date of Test	Bulk Density Method	Bulk Density (kg/m³)	Maximum Density Test Temperature (˚C)		**Maximum Density (kg/m³)***	**Air Voids (% v/v)**
31L1	04-Jan-18	B	2183	20.2		2508	**12.9**
32L1	04-Jan-18	B	2335	20.2		2508	**6.9**
33L1	04-Jan-18	B	2168	20.2		2508	**13.5**
34L1	04-Jan-18	B	2348	19.6		2508	**6.4**
35L1	04-Jan-18	B	2231	20.2		2508	**11.0**
36L1	04-Jan-18	B	2231	20.2		2508	**11.0**
37L1	04-Jan-18	B	2163	20.2		2508	**13.7**
38L1	04-Jan-18	B	2251	19.5		2508	**10.2**
39L1	04-Jan-18	B	2215	19.5		2508	**11.7**
40L1	04-Jan-18	B	2349	19.5		2508	**6.3**
41L1	04-Jan-18	B	2321	19.5			
42L1	04-Jan-18	B	2359	19.5			
43L1	04-Jan-18	B	2323	19.5			
44L1	04-Jan-18	B	2341	19.5			
45L1	04-Jan-18	B	2338	19.5			
46L1	04-Jan-18	B	2386	19.5		2539	**6.0**
47L1	04-Jan-18	B	2386	19.5		2539	**6.0**
48L1	04-Jan-18	B	2361	19.5		2539	**7.0**
49L1	04-Jan-18	B	2251	19.5			
50L1	04-Jan-18	B	2495	19.5			
51L1	04-Jan-18	B	2266	19.5			
52L1	04-Jan-18	B	2306	19.5			
54L1	04-Jan-18	B	2339	19.5		<u>2518</u>	**7.1**
55L1	04-Jan-18	B	2329	19.5		<u>2518</u>	**7.5**
56L1	04-Jan-18	B	2355	19.5		<u>2518</u>	**6.5**
57L1	04-Jan-18	B	2339	19.5		<u>2518</u>	**7.1**
58L1	04-Jan-18	B	2326	19.5		<u>2518</u>	**7.6**
59L1	04-Jan-18	B	2366	19.5		2529	**6.4**
60L1	04-Jan-18	B	2326	19.5		2508	**7.2**
61L1	04-Jan-18	B	2353	19.5		2529	**6.9**

Comments and Deviations:

m_1= mass of pyknometer (g), m_2= m_1 and sample (g), m_3= m_2 and filled with water (g), Vp= volume of pyknometer (m³)

ρw= density of water (mg/m³), ρmv= sample maximum density (mg/m³) * x10⁻³ Mg/m³

$$\rho w = 1.00025205 + \frac{7.59t-5.32t^2}{10^6} \qquad \rho mv = \frac{(m_2-m_1)}{10^6 x Vp - (m_3-m_2)/\rho w}$$

Origin of Specimen : Extracted from Site

Underlined values are estimated assuming 50:50 TSCS:existing material

Checked by: - MKozicz

Date: - **31 January 2018**

MAXIMUM DENSITY & AIR VOIDS

BS EN 12697-5 : 2009 - Procedure A & BS EN 12697-8 : 2003

Project Title :	**Area 9 joint heater trials**	Tested By :	**NAL**
Job Number :	**60485963**	Reported By :	**NAL**
Ticket Number :	**T0824**	Checked By :	**MK**
Location of Testing :	**AECOM Laboratory, NG9 6RZ**	Date of Issue :	**31 January 2018**

Sample Reference	Date of Test	Bulk Density Method	Bulk Density (kg/m³)	Maximum Density Test Temperature (˚C)		**Maximum Density (kg/m³)***	**Air Voids (% v/v)**
62L1	04-Jan-18	B	2306	19.5		2508	**8.0**
63L1	04-Jan-18	B	2467	19.5		2529	**2.4**
64L1	04-Jan-18	B	2427	19.5		2529	**4.0**
65L1	04-Jan-18	B	2436	19.5		2529	**3.7**

Comments and Deviations:

m_1= mass of pyknometer (g), m_2= m_1 and sample (g), m_3= m_2 and filled with water (g), Vp= volume of pyknometer (m³)

ρw= density of water (mg/m³), ρmv= sample maximum density (mg/m³) * x10⁻³ Mg/m³

$$\rho w = 1.00025205 + \frac{7.59t-5.32t^2}{10^6} \qquad \rho mv = \frac{(m_2-m_1)}{10^6 x Vp - (m_3-m_2)/\rho w}$$

Origin of Specimen : Extracted from Site

Checked by: -	MKozicz	Date: -	**31 January 2018**

MAXIMUM DENSITY & AIR VOIDS

BS EN 12697-5 : 2009 - Procedure A & BS EN 12697-8 : 2003

UKAS TESTING 4410

Project Title :	**Area 9 joint heater trials**	Tested By :	**NAL**
Job Number :	**60485963**	Reported By :	**NAL**
Ticket Number :	**T0824**	Checked By :	**MK**
Location of Testing :	**AECOM Laboratory, NG9 6RZ**	Date of Issue :	**31 January 2018**

Sample Reference	Date of Test	Bulk Density Method	Bulk Density (kg/m³)	Maximum Density Test Temperature (˚C)		**Maximum Density (kg/m³)***	**Air Voids (% v/v)**
19L1	04-Jan-18	C	2253	20.2		2508	**10.2**
20L1	04-Jan-18	C	2306	20.2		2508	**8.0**
30L1	04-Jan-18	C	2266	20.2		2508	**9.6**
40L1	17-Jan-18	C	2288	19.5		2508	**9.5**

Comments and Deviations:

m_1= mass of pyknometer (g), m_2= m_1 and sample (g), m_3= m_2 and filled with water (g), Vp= volume of pyknometer (m³)

ρw= density of water (mg/m³), ρmv= sample maximum density (mg/m³) * x10⁻³ Mg/m³

$$\rho w = 1.00025205 + \frac{7.59t - 5.32t^2}{10^6} \qquad \rho mv = \frac{(m_2 - m_1)}{10^6 x Vp - (m_3 - m_2)/\rho w}$$

Origin of Specimen : Extracted from Site

Checked by: -	MKozicz	Date: -	**31 January 2018**

Permeability of Specimen (Vertical)

BS EN 12697-19:2012

Project Title :	**Area 9 joint heater trials**	Tested By :	**NAL**
Job Number :	**60485963**	Reported By :	**NAL**
Ticket Number :	**T0824**	Checked By :	**LK**
Location of Testing :	**AECOM Laboratory, NG9 6RZ**	Date of Issue :	**31 January 2018**

Sample Reference	Date of Test	Thickness (mm)	Diameter (mm)		Time Taken (sec)	Qv (m3/s)	K_v (m/s)
07L1	18-Jan-18	49.2	151.6	Test 1	74	2.93E-05	2.66E-04
				Test 2	79	3.60E-05	3.27E-04
					Mean:	**3.26E-05**	**2.97E-04**
08L1	18-Jan-18	38.5	151.8	Test 1	71	4.86E-05	3.45E-04
				Test 2	75	2.53E-05	1.79E-04
					Mean:	**3.70E-05**	**2.62E-04**
14L1	18-Jan-18	32	152.9	Test 1	75	1.12E-04	6.51E-04
				Test 2	82	1.14E-04	6.64E-04
					Mean:	**1.13E-04**	**6.58E-04**
18L1	18-Jan-18	36.7	152.5	Test 1	85	9.67E-05	6.47E-04
				Test 2	86	9.33E-05	6.25E-04
					Mean:	**9.50E-05**	**6.36E-04**
26L1	18-Jan-18	41.2	153.0	Test 1	82	1.40E-04	1.05E-03
				Test 2	80	1.42E-04	1.06E-03
					Mean:	**1.41E-04**	**1.06E-03**
29L1	18-Jan-18	43.6	153.1	Test 1	74	1.57E-04	1.24E-03
				Test 2	79	1.49E-04	1.18E-03
					Mean:	**1.53E-04**	**1.21E-03**
35L1	18-Jan-18	45.7	152.9	Test 1	68	6.08E-05	5.04E-04
				Test 2	72	6.38E-05	5.30E-04
					Mean:	**6.23E-05**	**5.17E-04**

Calculations :-

$$Qv = \frac{m2 - m1}{t} \times 10\text{-}6 \text{ (m3/s)}$$

$$kv = \frac{4 \times Qv \times l}{h \times p \times D^2} \text{ (m/s)}$$

Qv is the vertical flow (m3/s)
m2 is the mass of the filled collector (g)
t is the time of collecting the water (s)
Kv is the vertical permeability (m/s)
l is the thickness of the specimen (m)
h is the height of the water column (m)
D is the diameter of the specimen (m)

Comments and Deviations:

Water Temperature ºC :

Origin of Specimen : Extracted from Site

h will always be set to 0.3m unless otherwise stated.

* Sample broke during conditioning.

Checked by: - Kozica Lukas

Date: - **31 January 2018**

AECOM

Permeability of Specimen (Vertical)

BS EN 12697-19:2012

Project Title :	**Area 9 joint heater trials**	Tested By :	**NAL**
Job Number :	**60485963**	Reported By :	**NAL**
Ticket Number :	**T0824**	Checked By :	**LK**
Location of Testing :	**AECOM Laboratory, NG9 6RZ**	Date of Issue :	**31 January 2018**

Sample Reference	Date of Test	Thickness (mm)	Diameter (mm)		Time Taken (sec)	Qv (m3/s)	K_v (m/s)
39L1	18-Jan-18	37.4	152.8	Test 1	73	3.74E-05	2.54E-04
				Test 2	77	3.82E-05	2.60E-04
					Mean:	**3.78E-05**	**2.57E-04**
43L1	18-Jan-18	46.0	153.0	Test 1	74	2.79E-05	2.33E-04
				Test 2	72	2.27E-05	1.89E-04
					Mean:	**2.53E-05**	**2.11E-04**
44L1	18-Jan-18	40.9	152.8	Test 1	76	2.59E-05	1.93E-04
				Test 2	71	4.05E-05	3.01E-04
					Mean:	**3.32E-05**	**2.47E-04**
49L1*	18-Jan-18	51.2	152.9	Test 1			
				Test 2			
					Mean:		
50L1	18-Jan-18	42.9	152.7	Test 1	69	1.90E-05	1.48E-04
				Test 2	70	1.72E-05	1.34E-04
					Mean:	**1.81E-05**	**1.41E-04**
57L1	18-Jan-18	46.0	152.4	Test 1	75	4.44E-05	3.73E-04
				Test 2	78	3.60E-05	3.02E-04
					Mean:	**4.02E-05**	**3.38E-04**
58L1	18-Jan-18	38.3	152.5	Test 1	76	4.67E-05	3.26E-04
				Test 2	73	5.03E-05	3.51E-04
					Mean:	**4.85E-05**	**3.39E-04**

Calculations :-

$$Qv = \frac{m2 - m1}{t} \times 10\text{-}6 \text{ (m3/s)}$$

$$kv = \frac{4 \times Qv \times l}{h \times p \times D^2} \text{ (m/s)}$$

Qv is the vertical flow (m3/s)
m2 is the mass of the filled collector (g)
t is the time of collecting the water (s)
Kv is the vertical permeability (m/s)
l is the thickness of the specimen (m)
h is the height of the water column (m)
D is the diameter of the specimen (m)

Comments and Deviations:

Water Temperature ºC :

Origin of Specimen : Extracted from Site

h will always be set to 0.3m unless otherwise stated.

* Sample broke during conditioning.

Checked by: - Kozica Lukas

Date: - **31 January 2018**

INDIRECT TENSLE STRENGTH TEST

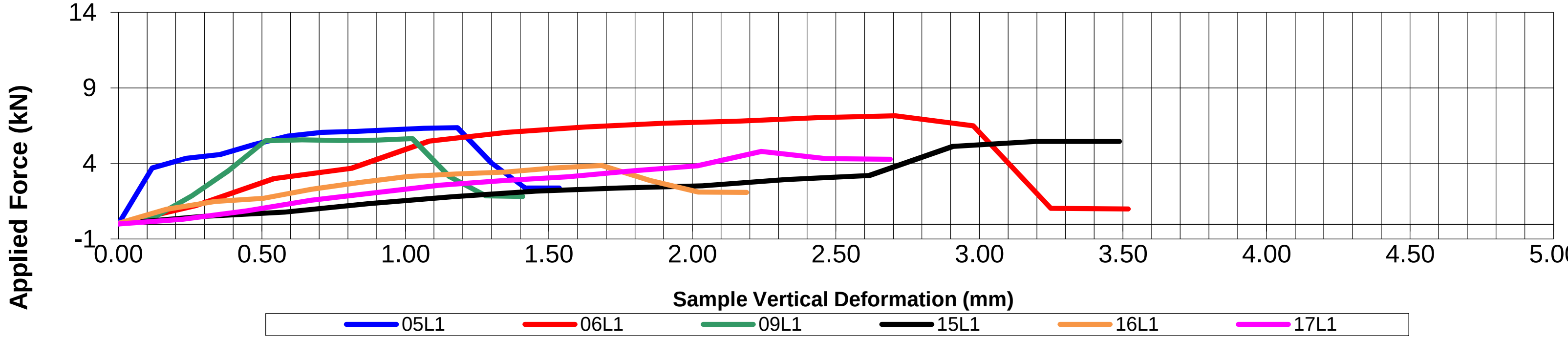
BS EN 12697-23:2003

Project Title :	**Area 9 joint heater trials**	Location of Testing :	**Aecom, Nottingham, NG9 6RZ**	Reported By :	**NAL**
Job Number :	**60485963**	Date of Issue :	**31 January 2018**	Checked By :	**LK**
Bulk Reference :	**T0824**	Tested By :	**NAL**		

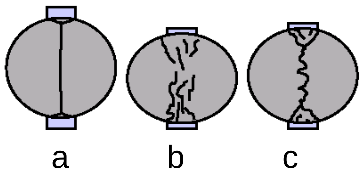
Sample ID	Test Temperature (°C)	Bulk Density (kg/m^3)	Thickness (mm)	Diameter (mm)	Peak Load (kN)	ITST (GPa)	Failure Mode	Broken Aggregate
05L1	20.0	2321	40.4	152.6	6.4	6.59E-04	a	Yes
06L1	20.0	2341	39.8	152.3	7.6	7.94E-04	c	Yes
09L1	20.0	2294	45.3	151.6	5.6	5.23E-04	c	Yes
15L1	20.0	2170	42.6	153.3	5.5	5.34E-04	c	No
16L1	20.0	2203	36.7	152.5	4.0	4.58E-04	c	No
17L1	20.0	2187	43.5	153.4	4.9	4.63E-04	c	No

Calculations: $ITST = \frac{2P}{\pi DH}$

ITST = Indirect Tensile Strength (GPa)
P = Peak Load (kN)
D = Specimen Diameter (mm)
H = Specimen Thickness (mm)



* Failure Types
a:- clear tensile break
b:- deformation
c:- combination



Comments and Deviations:

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b: - "deformation" - Specimen without a clearly visible tensile break line -
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Checked by: - Kozica Lukas

Date: - **31 January 2018**

Indirect Tensile Strength Test

BS EN 12697-23:2003

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Job Number :	**60485963**	Date of Issue :	**31 January 2018**	Checked By :	**LK**
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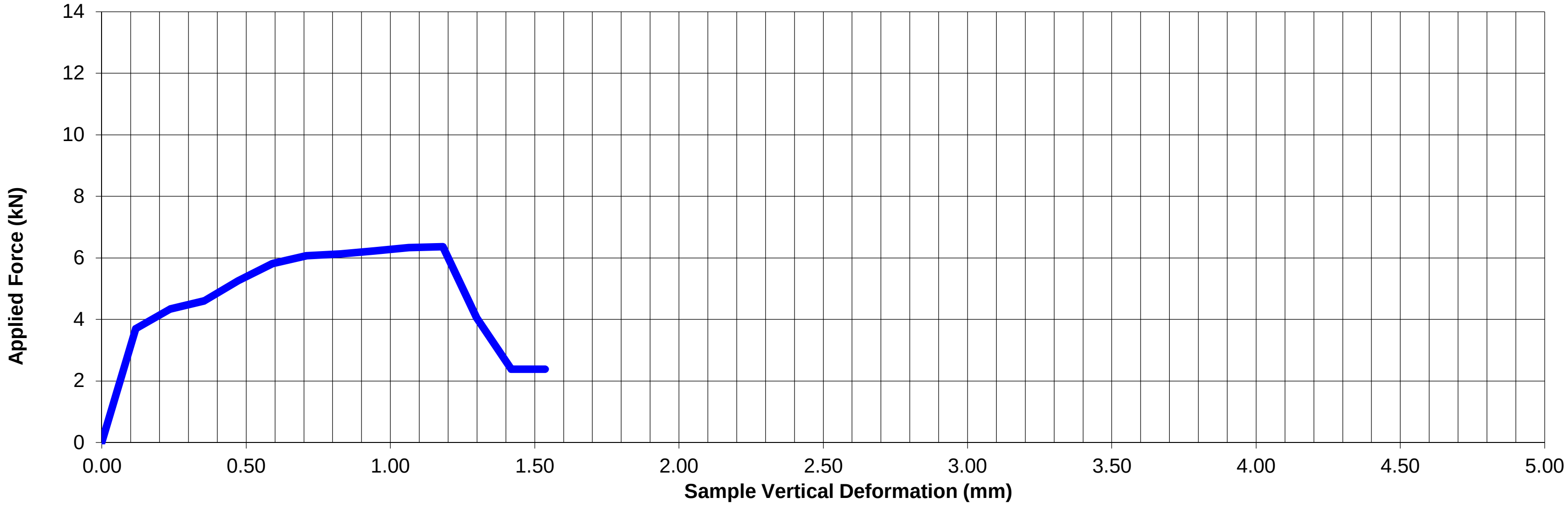
Sample ID	Test Temperature (^oC)	Conditioned in :	Bulk Density (kg/m^3)	Thickness (mm)	Diameter (mm)	Peak Load (kN)	ITST (GPa)	Type of Failure*	Broken Aggregate
05L1	20.0	Air	2321	40.4	152.6	6.4	6.59E-04	a	Yes



Calculations: $ITST = \frac{2P}{\pi DH}$

ITST = Indirect Tensile Strength (GPa)

P = Peak Load (kN)

D = Specimen Diameter (mm)

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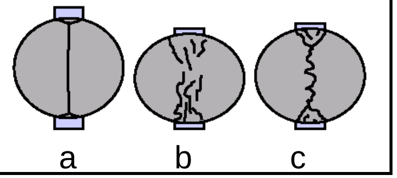

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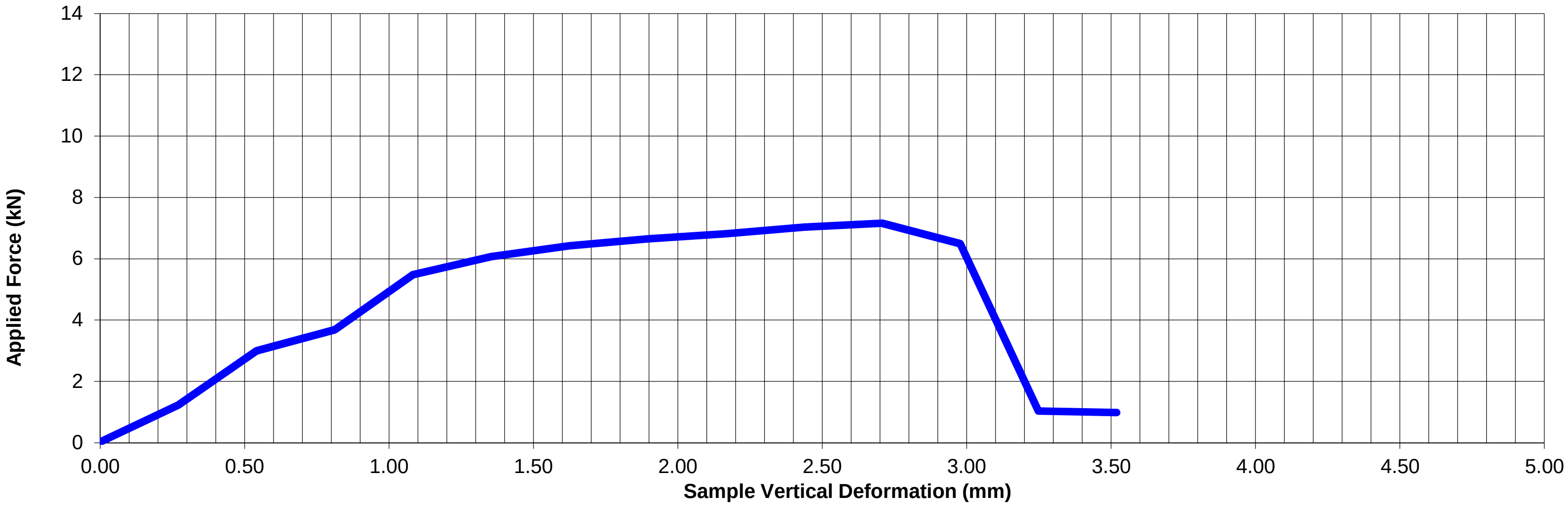
06L1	20.0	Air	2341	39.8	152.3	7.6	7.94E-04	c	Yes



Calculations:

$$ITST = \frac{2P}{\pi DH}$$

ITST = Indirect Tensile Strength (GPa)

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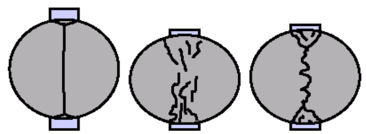

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Checked by: - Kozica Lukas

Date: - **31 January 2018**

AECOM

Indirect Tensile Strength Test

BS EN 12697-23:2003

Project Title :	**Area 9 joint heater trials**	Location of Testing :	**Aecom, Nottingham, NG9 6RZ**	Reported By :	**NAL**
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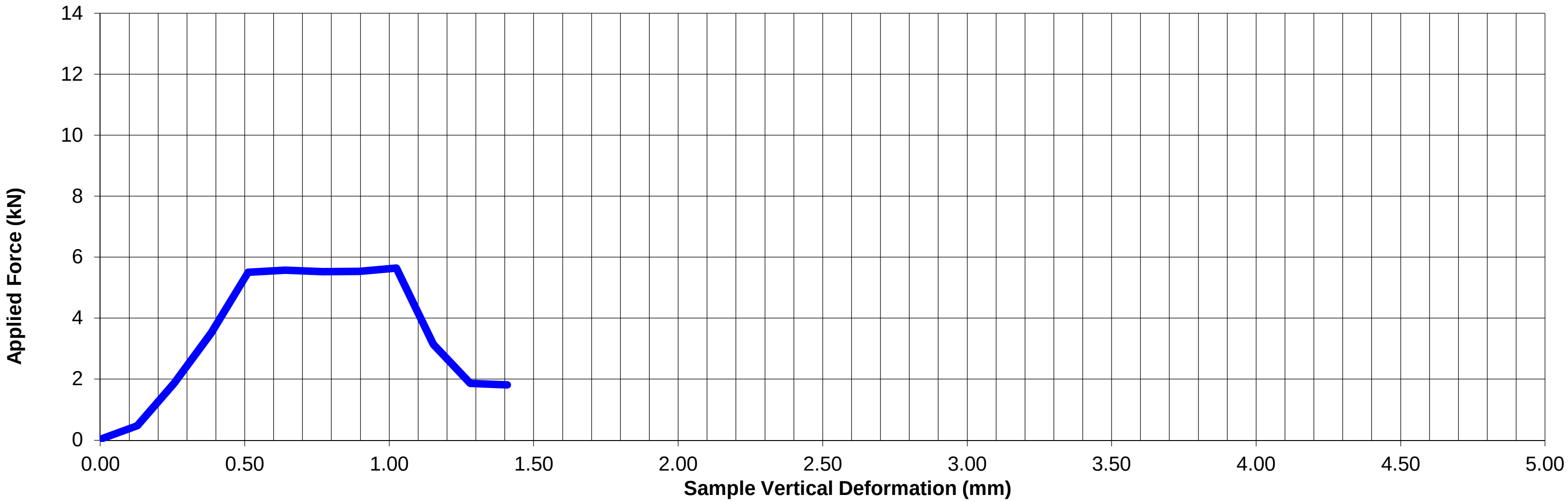
Bulk Reference :	**T0824**	Tested By :	**NAL**		

Sample ID	Test Temperature (^{o}C)	Conditioned in :	Bulk Density (kg/m^3)	Thickness (mm)	Diameter (mm)	Peak Load (kN)	ITST (GPa)	Type of Failure*	Broken Aggregate
09L1	20.0	Air	2294	45.3	151.6	5.6	5.23E-04	c	Yes



Calculations: $$ITST = \frac{2P}{\pi DH}$$

ITST = Indirect Tensile Strength (GPa)

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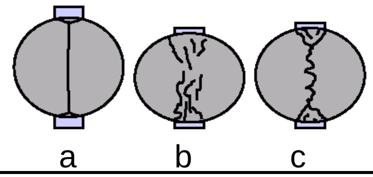

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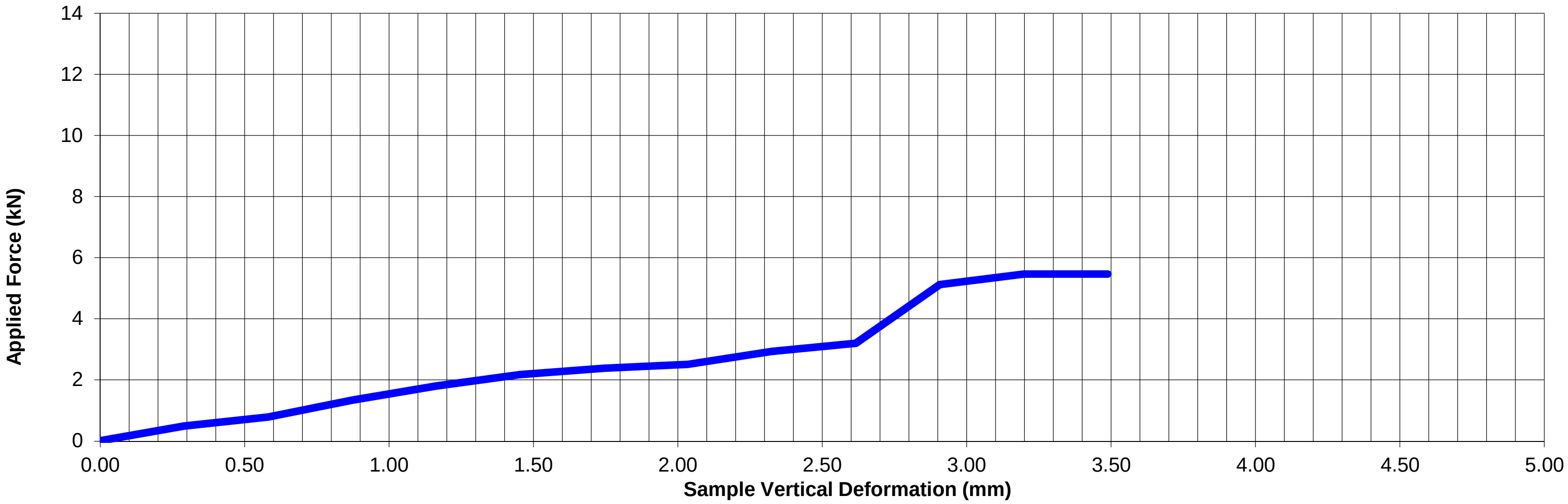
15L1	20.0	Air	2170	42.6	153.3	5.5	5.34E-04	c	No



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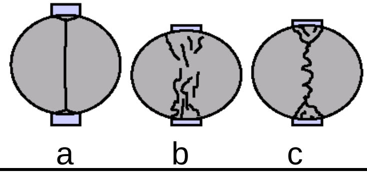

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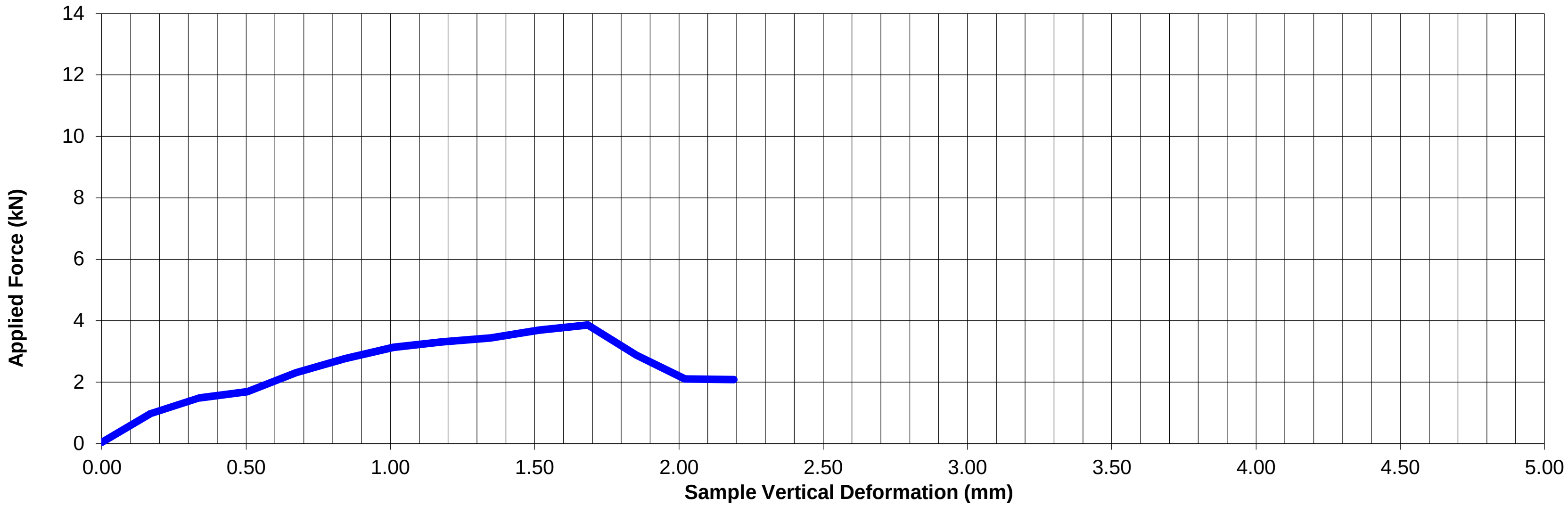
16L1	20.0	Air	2203	36.7	152.5	4.0	4.58E-04	c	No



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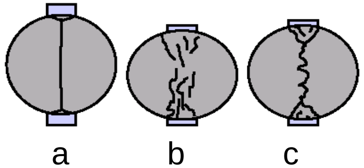

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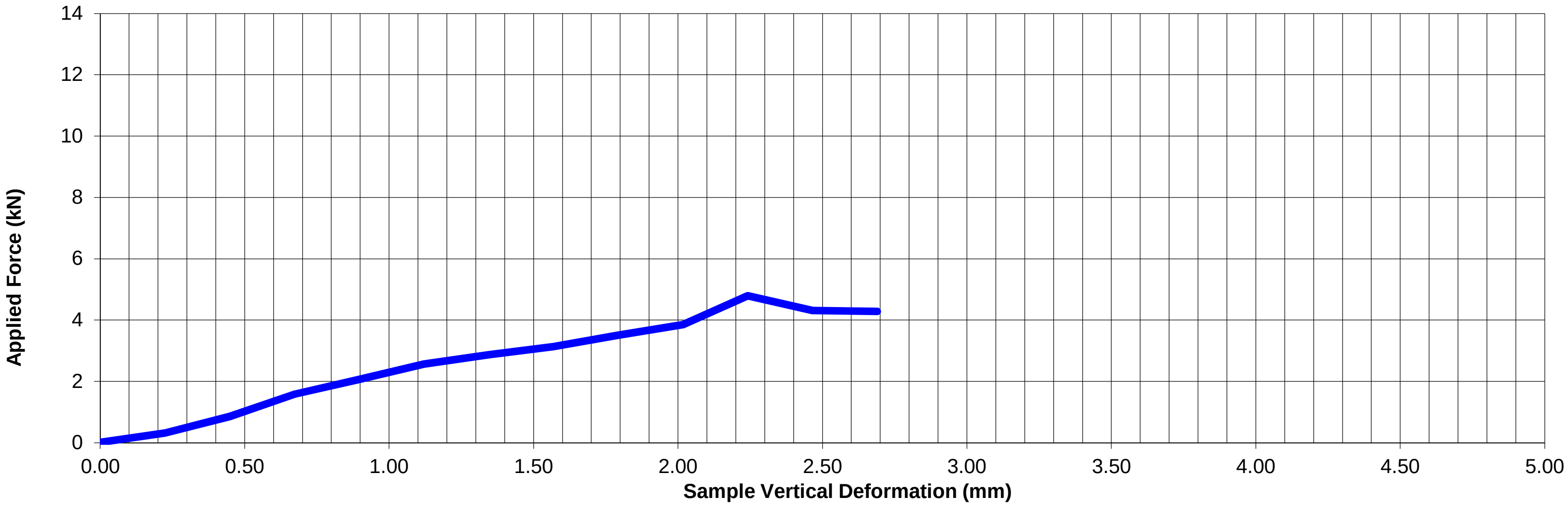
17L1	20.0	Air	2187	43.5	153.4	4.9	4.63E-04	c	No



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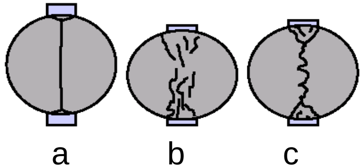

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19L1	20.0	2304	50.5	152.5	8.0	6.58E-04	c	Yes
25L1	20.0	2241	49.7	153.2	5.6	4.65E-04	c	Yes
27L1	20.0	2156	44.2	153.4	3.0	2.79E-04	c	Yes
28L1	20.0	2199	46.0	153.0	4.9	4.43E-04	c	Yes
30L1	20.0	2315	46.1	152.6	9.0	8.14E-04	c	Yes
36L1	20.0	2231	39.4	153.0	3.8	4.02E-04	c	Yes

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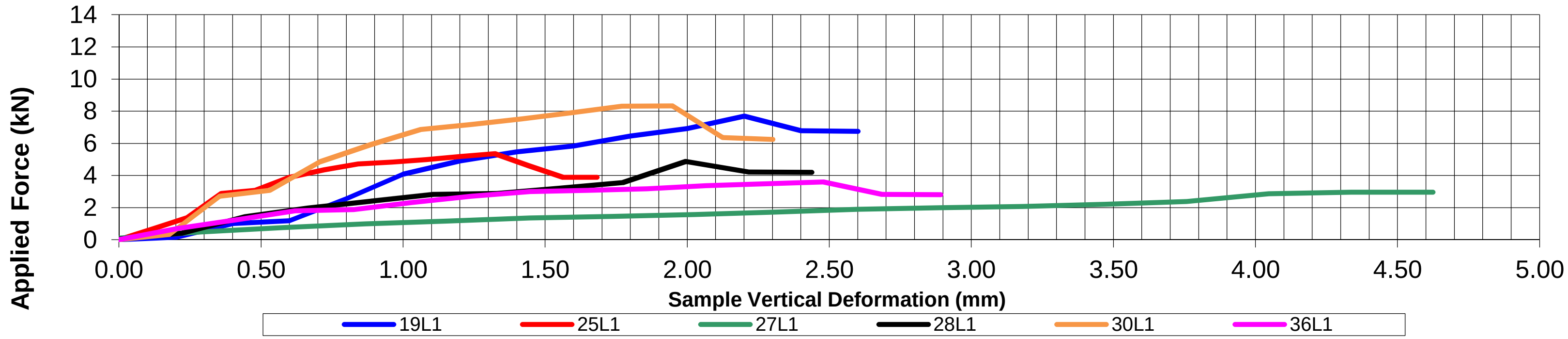

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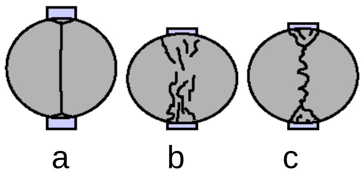

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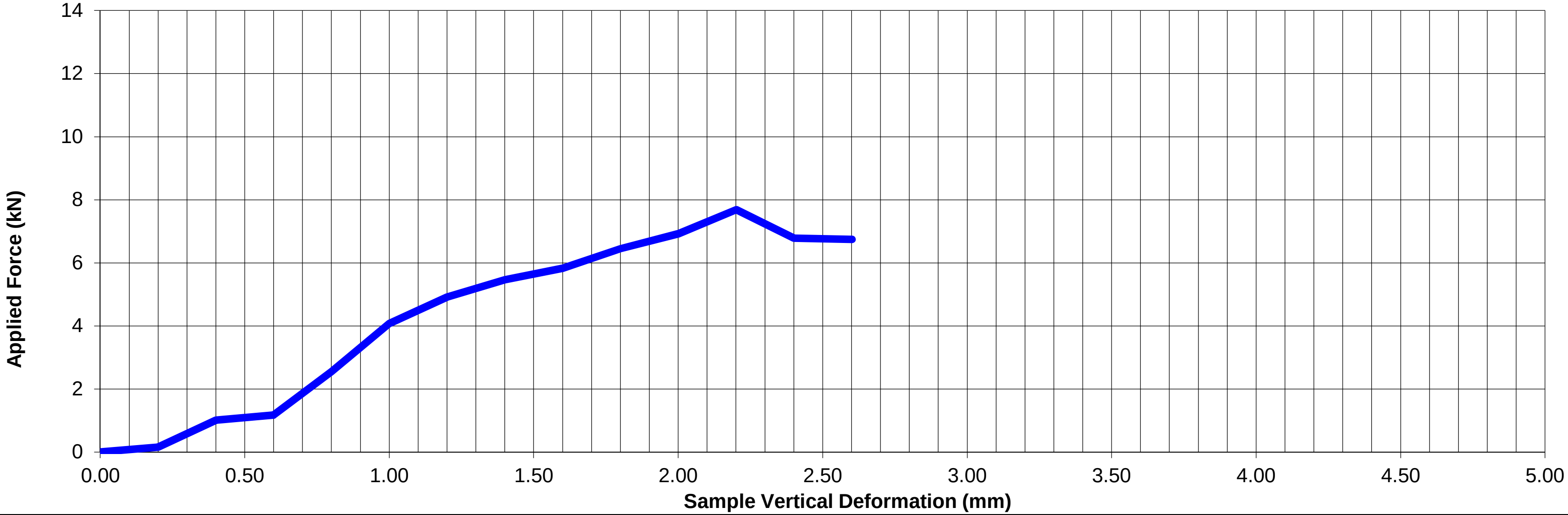

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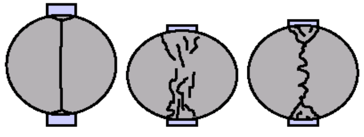

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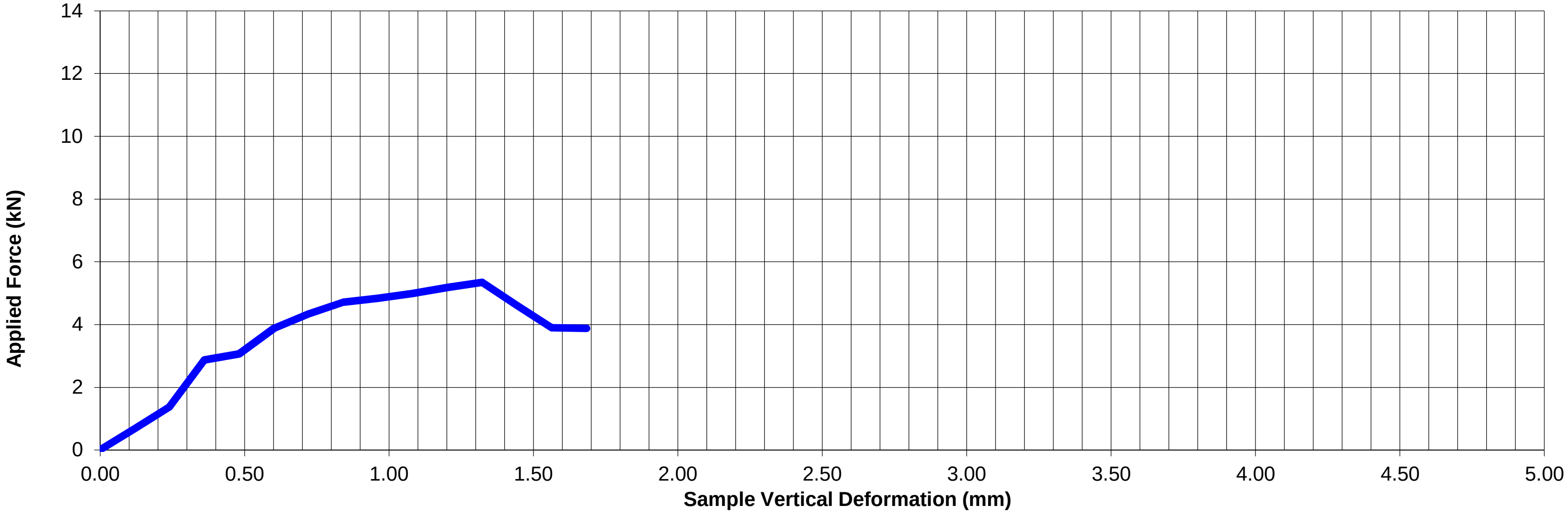

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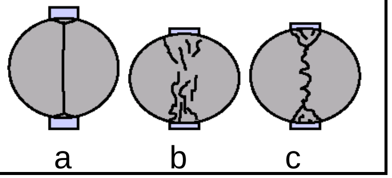

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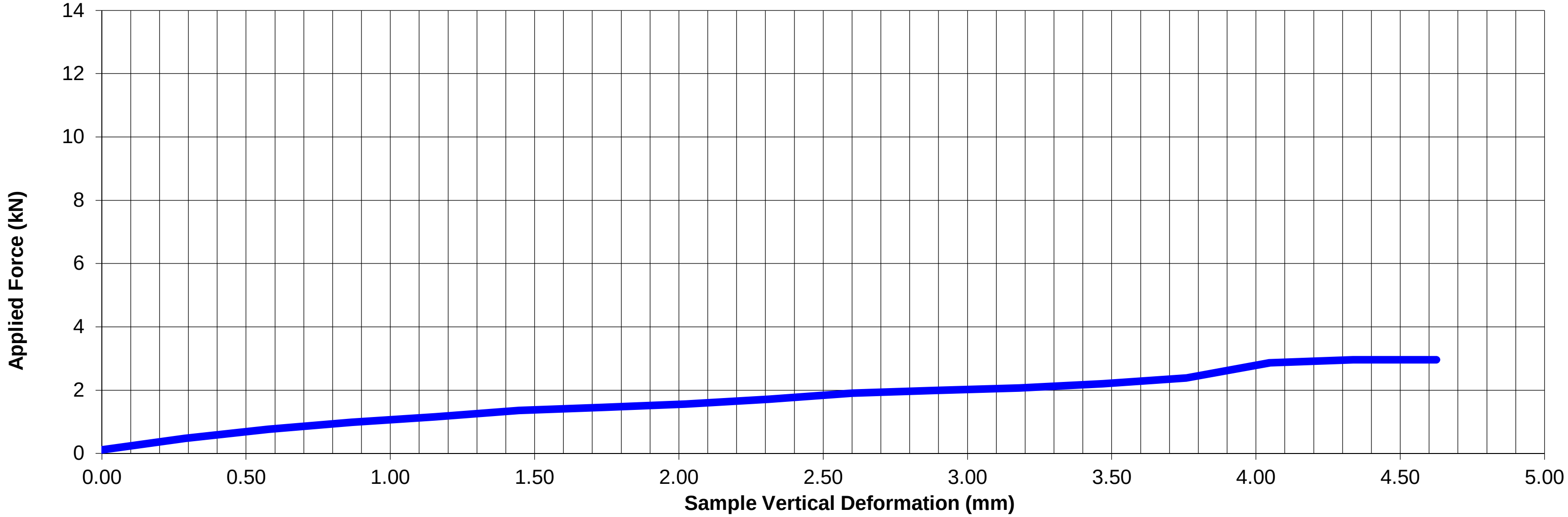

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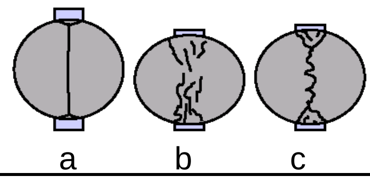

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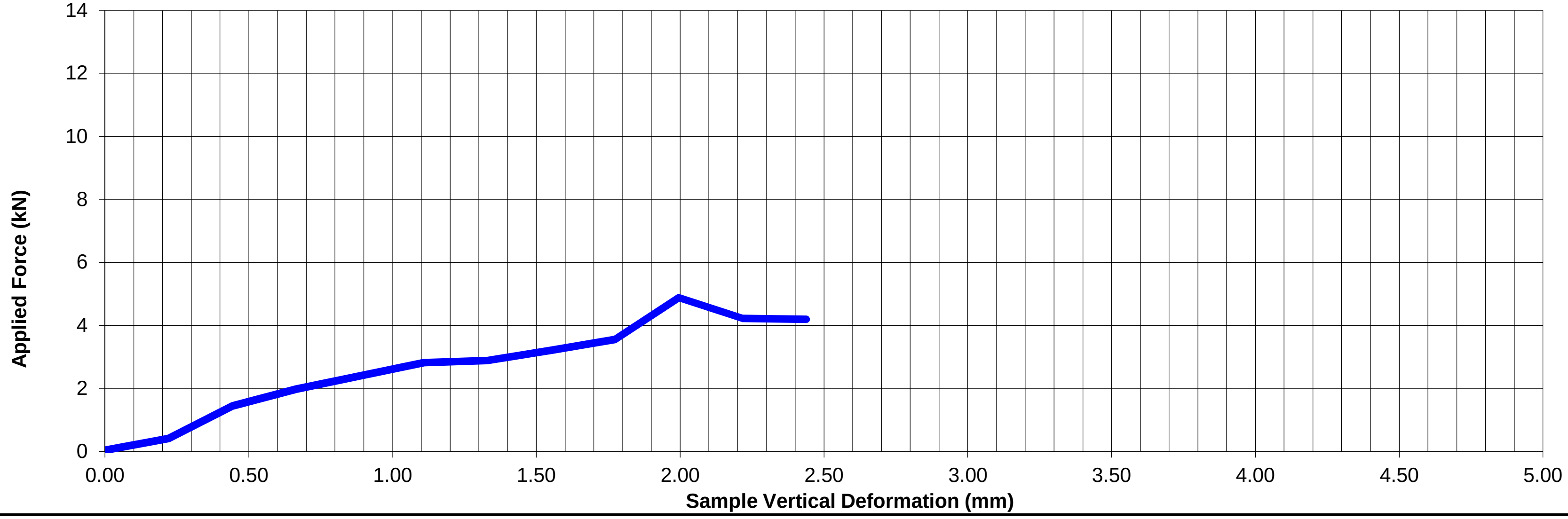

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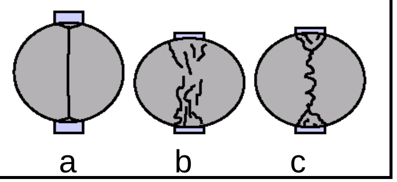

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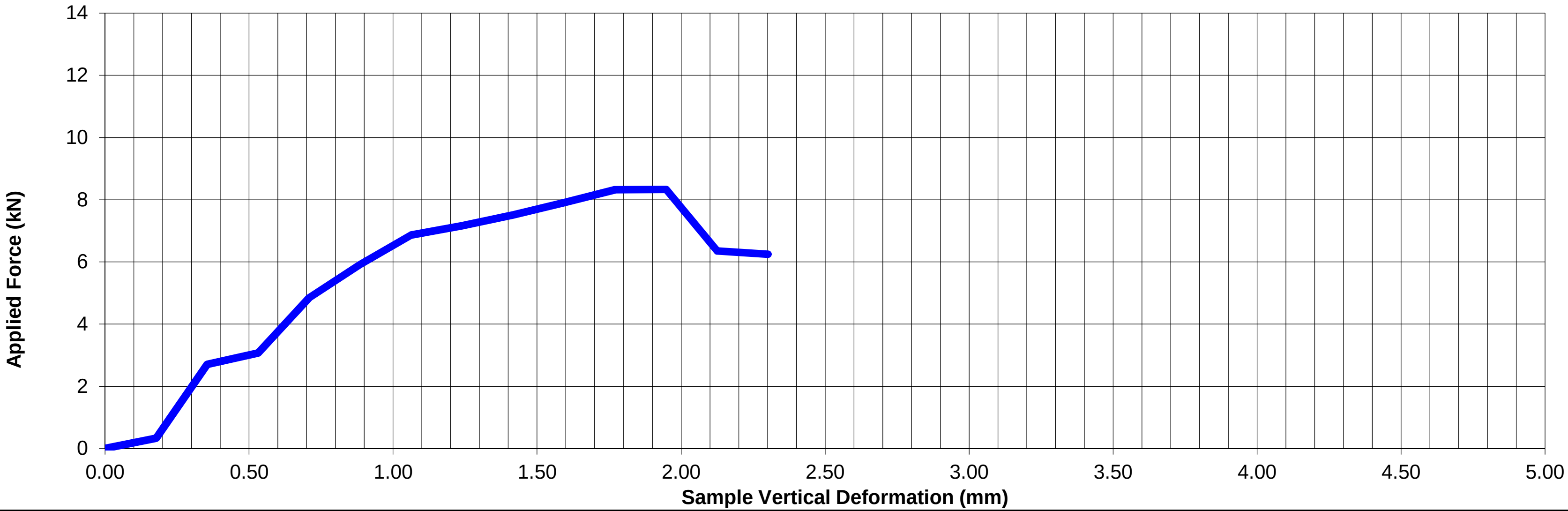
BS EN 12697-23:2003

Project Title :	**Area 9 joint heater trials**	Location of Testing :	**Aecom, Nottingham, NG9 6RZ**	Reported By :	**NAL**
Job Number :	**60485963**	Date of Issue :	**31 January 2018**	Checked By :	**LK**
Bulk Reference :	**T0824**	Tested By :	**NAL**		

Sample ID	Test Temperature (^oC)	Conditioned in :	Bulk Density (kg/m^3)	Thickness (mm)	Diameter (mm)	Peak Load (kN)	ITST (GPa)	Type of Failure*	Broken Aggregate
30L1	20.0	Air	2315	46.1	152.6	9.0	8.14E-04	c	Yes



Calculations: $ITST = \frac{2P}{\pi DH}$

ITST = Indirect Tensile Strength (GPa)

P = Peak Load (kN)

D = Specimen Diameter (mm)

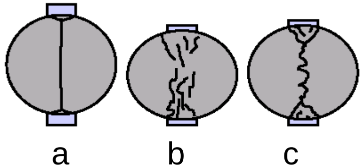
H = Specimen Thickness (mm)

* Failure Types

a:- clear tensile break

b:- deformation

c:- combination



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Checked by: - Kozica Lukas

Date: - **31 January 2018**

Indirect Tensile Strength Test

BS EN 12697-23:2003

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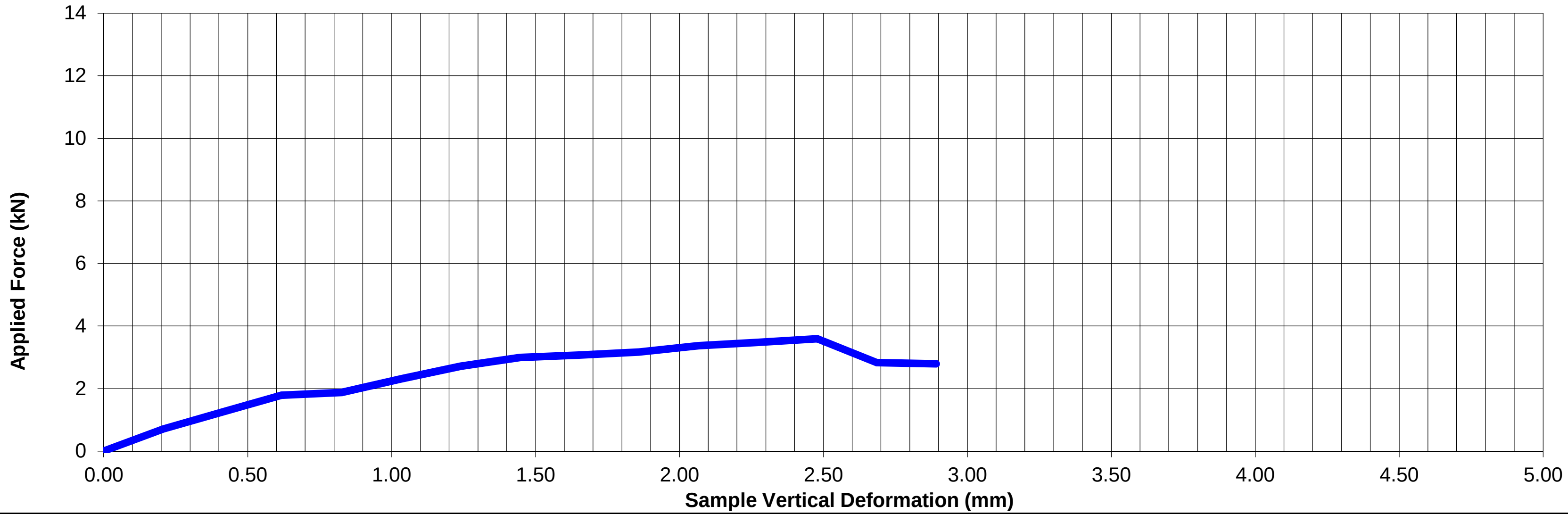
36L1	20.0	Air	2231	39.4	153.0	3.8	4.02E-04	c	Yes



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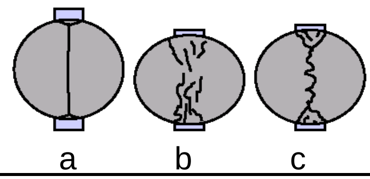

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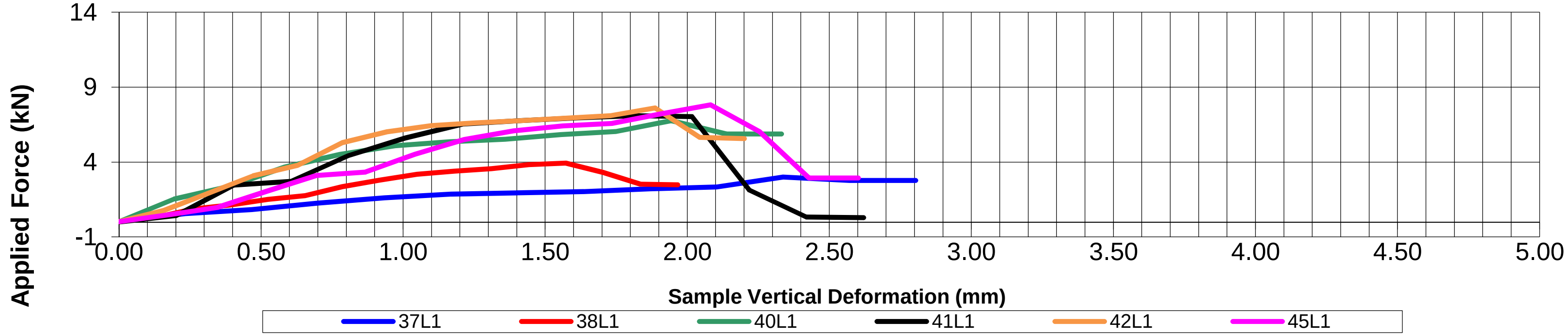
37L1	20.0	2163	38.5	152.6	3.0	3.26E-04	c	Yes
38L1	20.0	2251	40.3	152.7	4.0	4.14E-04	b	Yes
40L1	20.0	2349	38.1	153.0	6.9	7.57E-04	c	Yes
41L1	20.0	2321	46.2	152.7	7.1	6.41E-04	a	Yes
42L1	20.0	2359	45.6	153.3	8.1	7.39E-04	c	Yes
45L1	20.0	2338	44.2	152.7	8.3	7.84E-04	c	Yes



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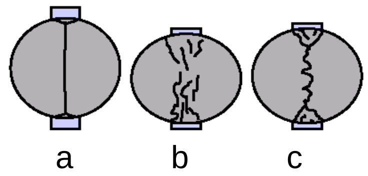

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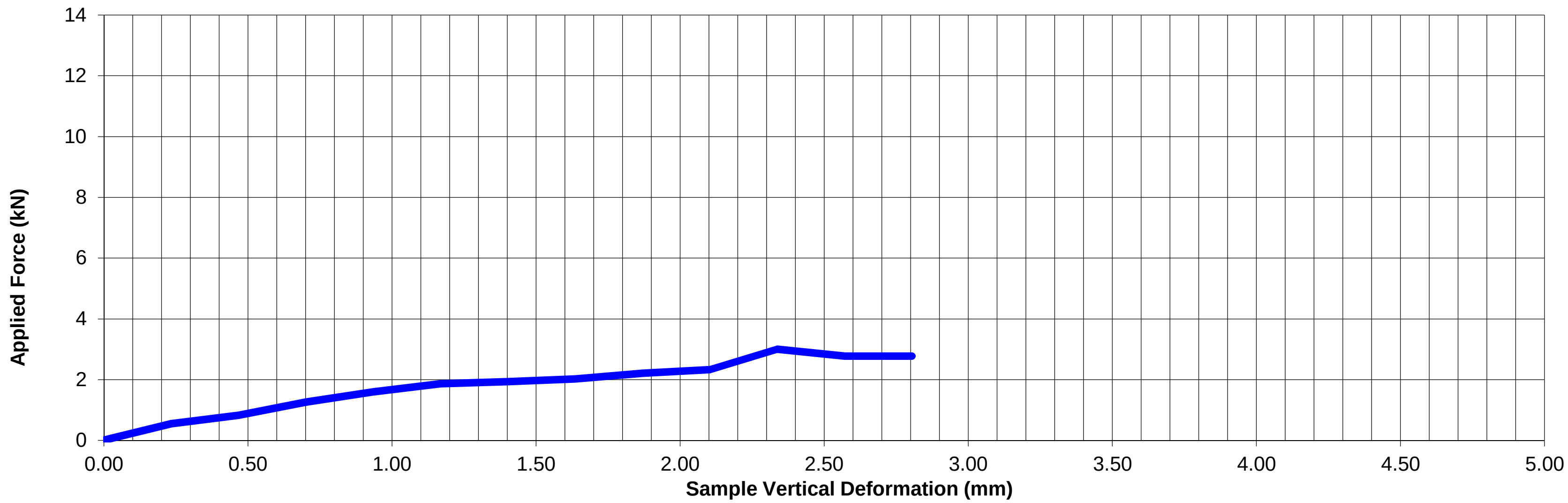
37L1	20.0	Air	2163	38.5	152.6	3.0	3.26E-04	c	Yes



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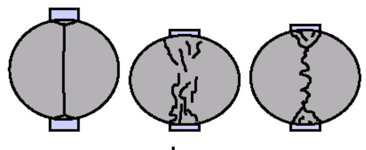

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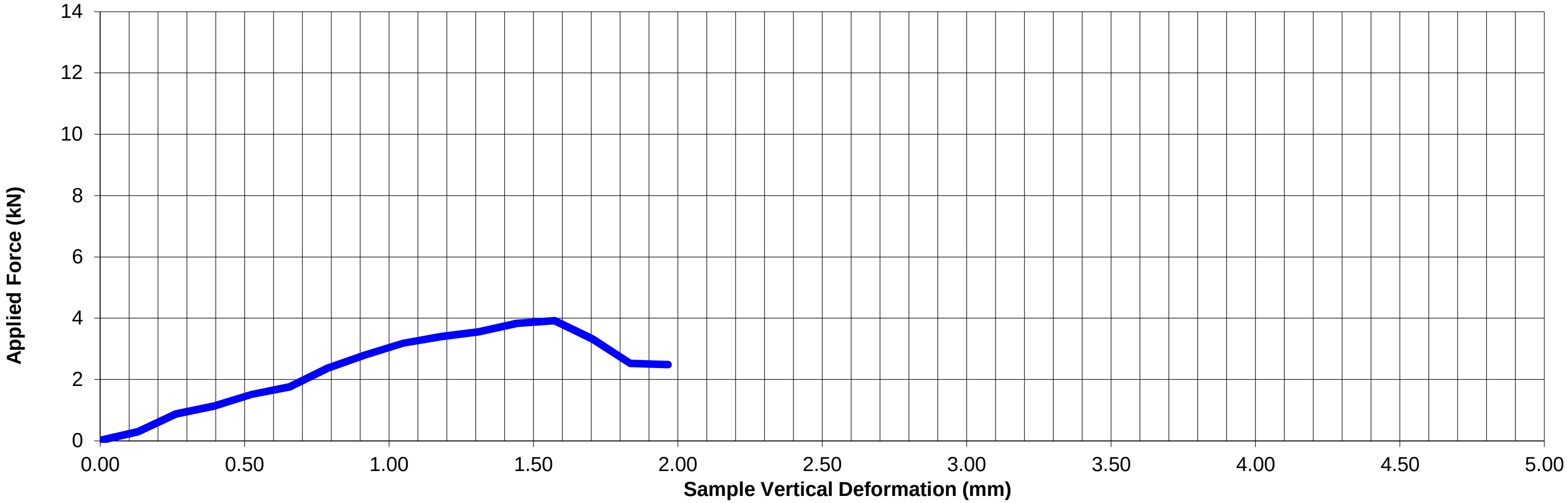
38L1	20.0	Air	2251	40.3	152.7	4.0	4.14E-04	b	Yes



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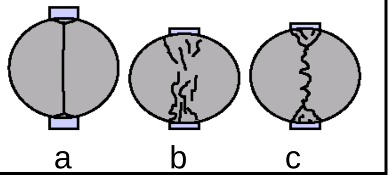

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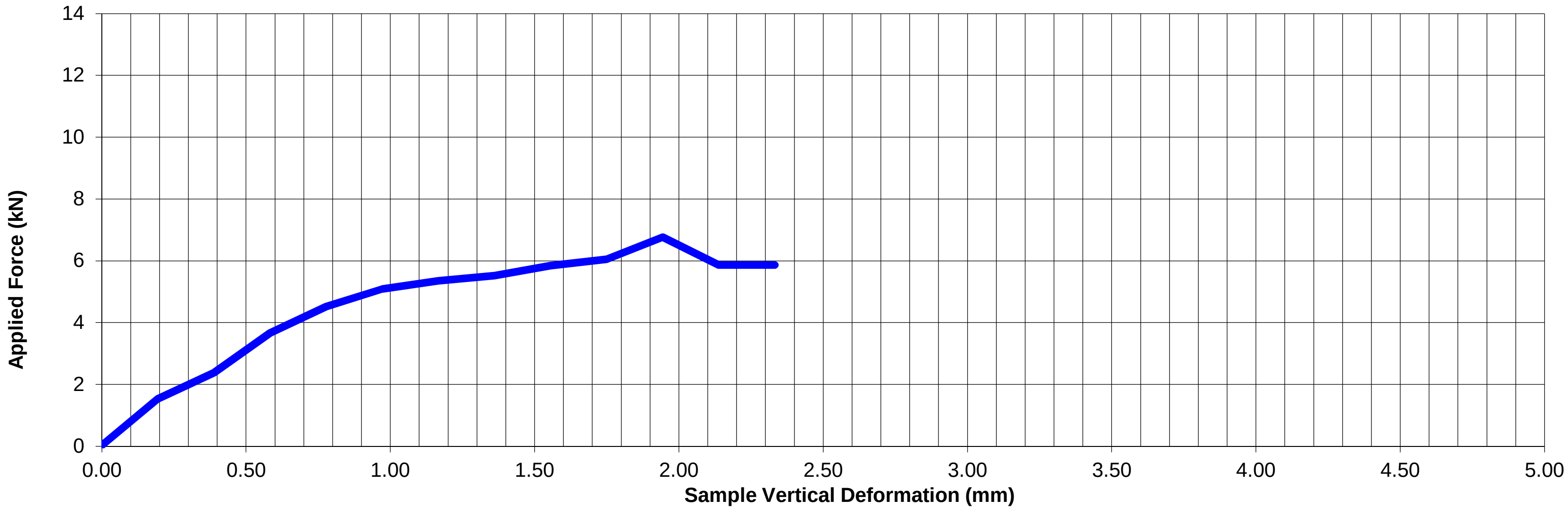
40L1	20.0	Air	2349	38.1	153.0	6.9	7.57E-04	c	Yes



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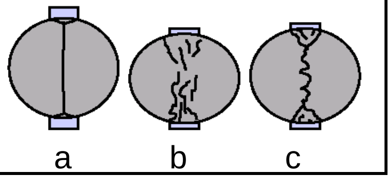

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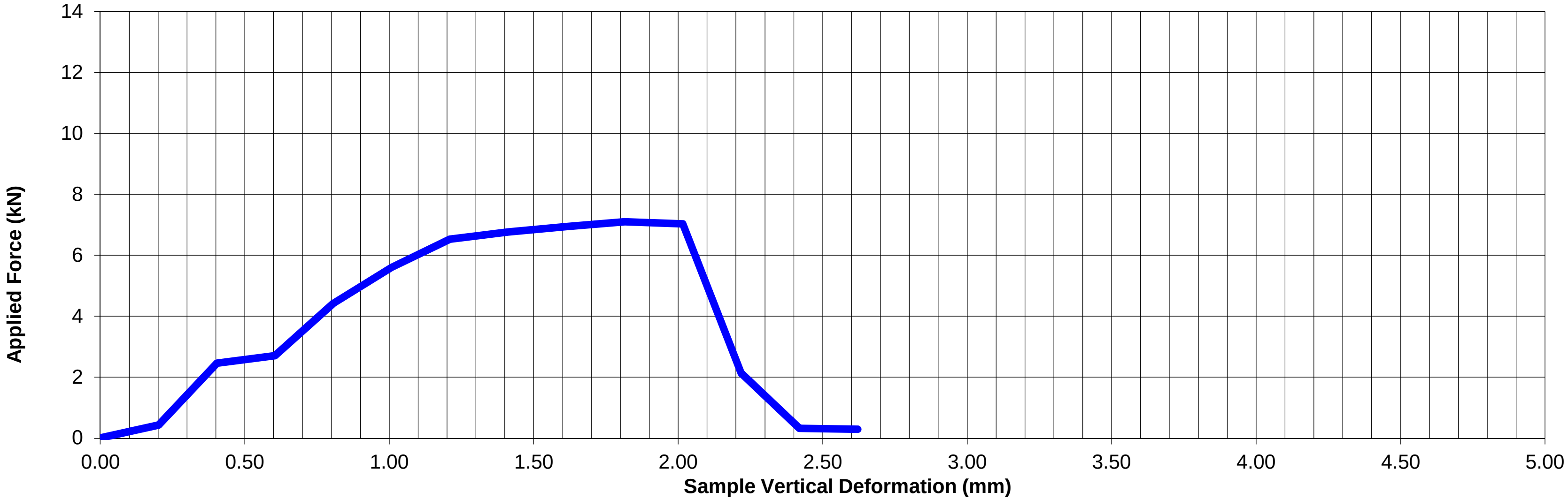
41L1	20.0	Air	2321	46.2	152.7	7.1	6.41E-04	a	Yes



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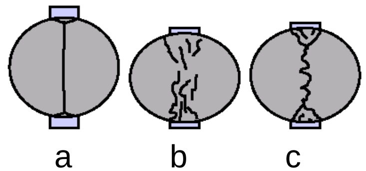

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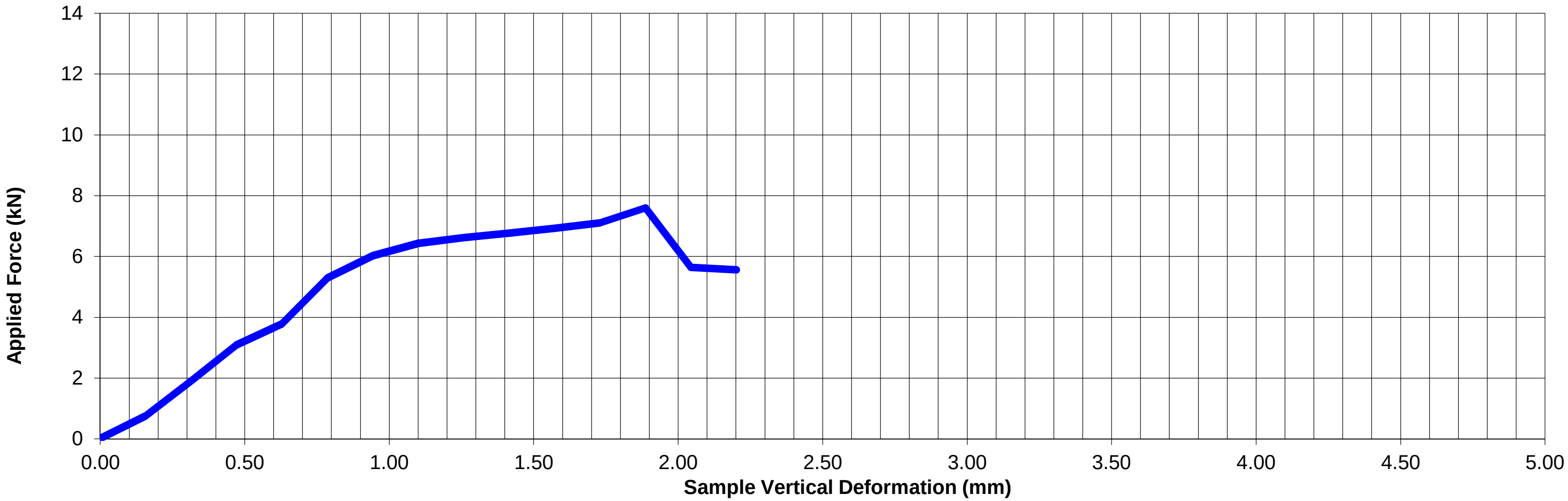
42L1	20.0	Air	2359	45.6	153.3	8.1	7.39E-04	c	Yes



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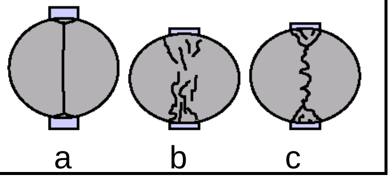

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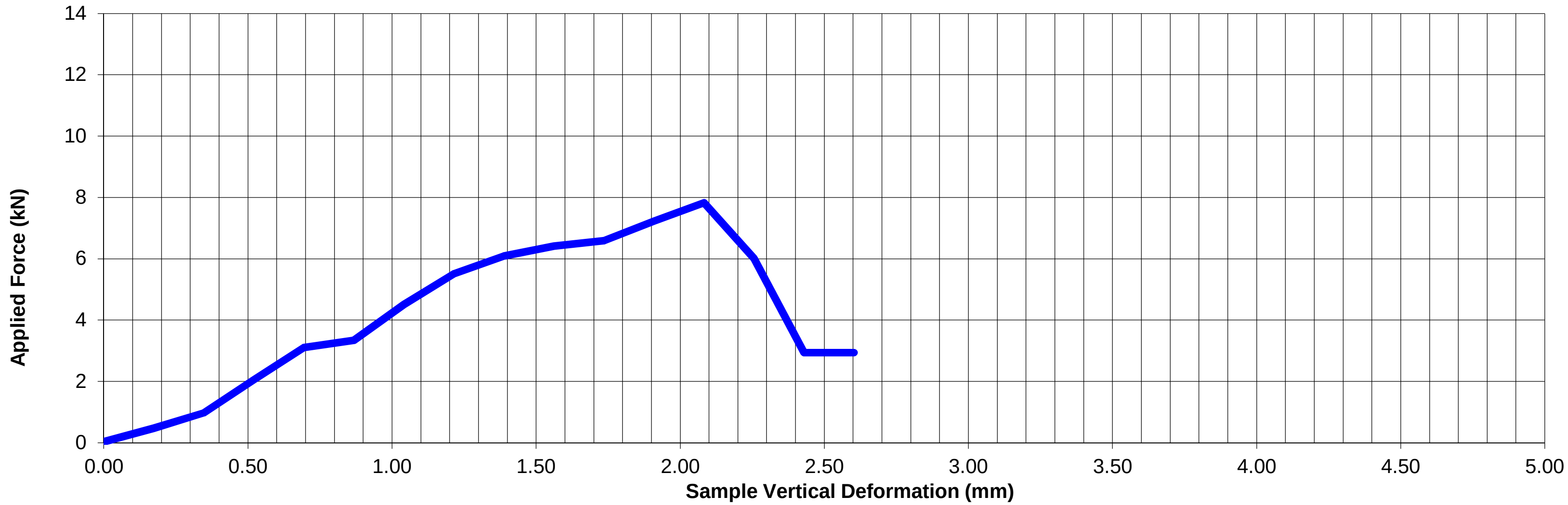

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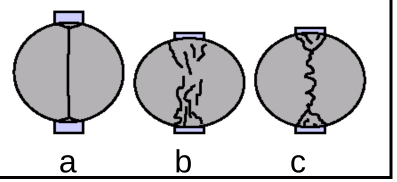

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47L1	20.0	2386	23.3	152.4	4.5	8.14E-04	b	Yes
48L1	20.0	2361	31.7	152.4	6.7	8.79E-04	a	Yes
51L1	20.0	2266	43.0	152.0	3.0	2.96E-04	a	Yes
52L1	20.0	2306	44.4	152.6	4.4	4.14E-04	c	Yes
54L1	20.0	2339	39.8	152.5	6.1	6.37E-04	a	Yes

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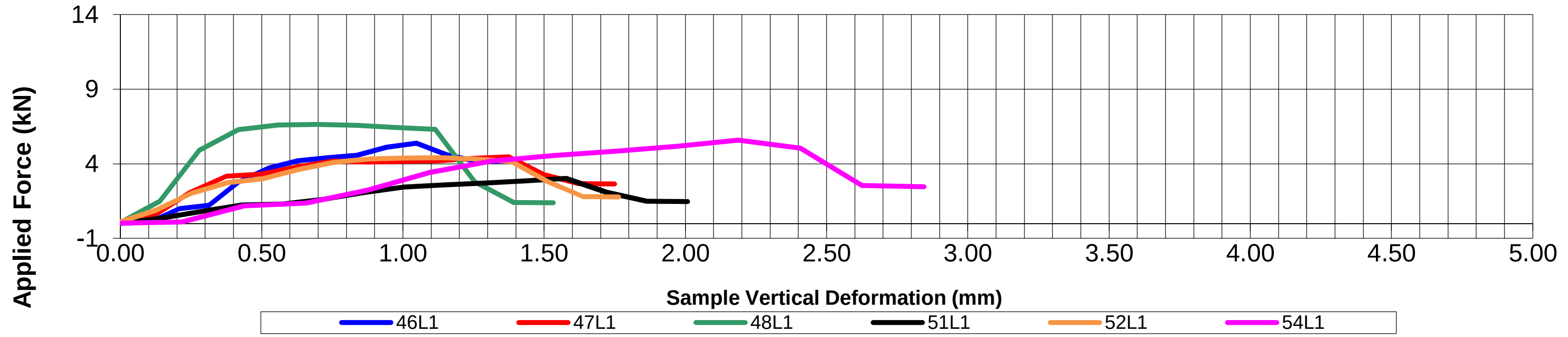

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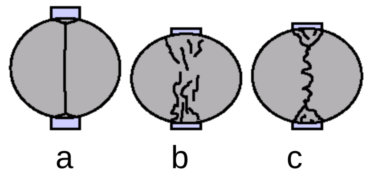

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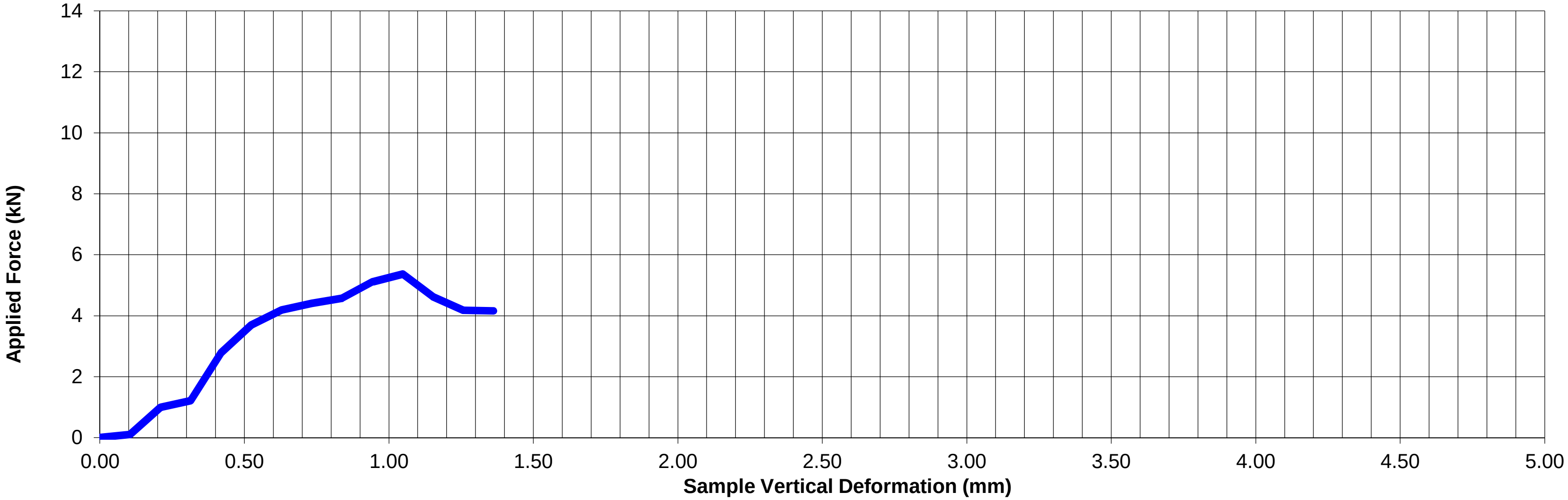

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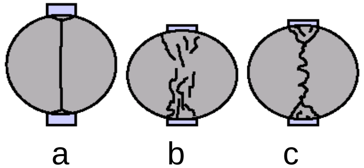

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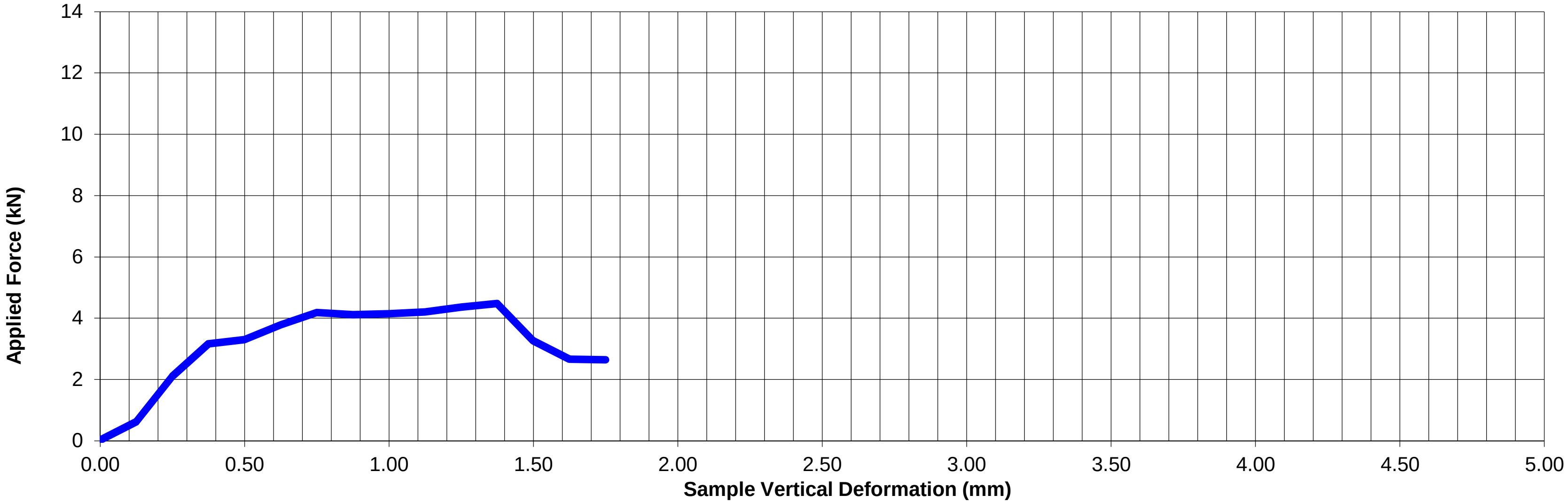

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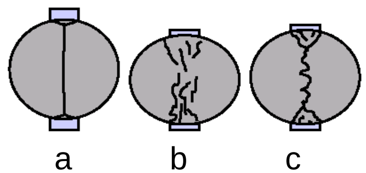

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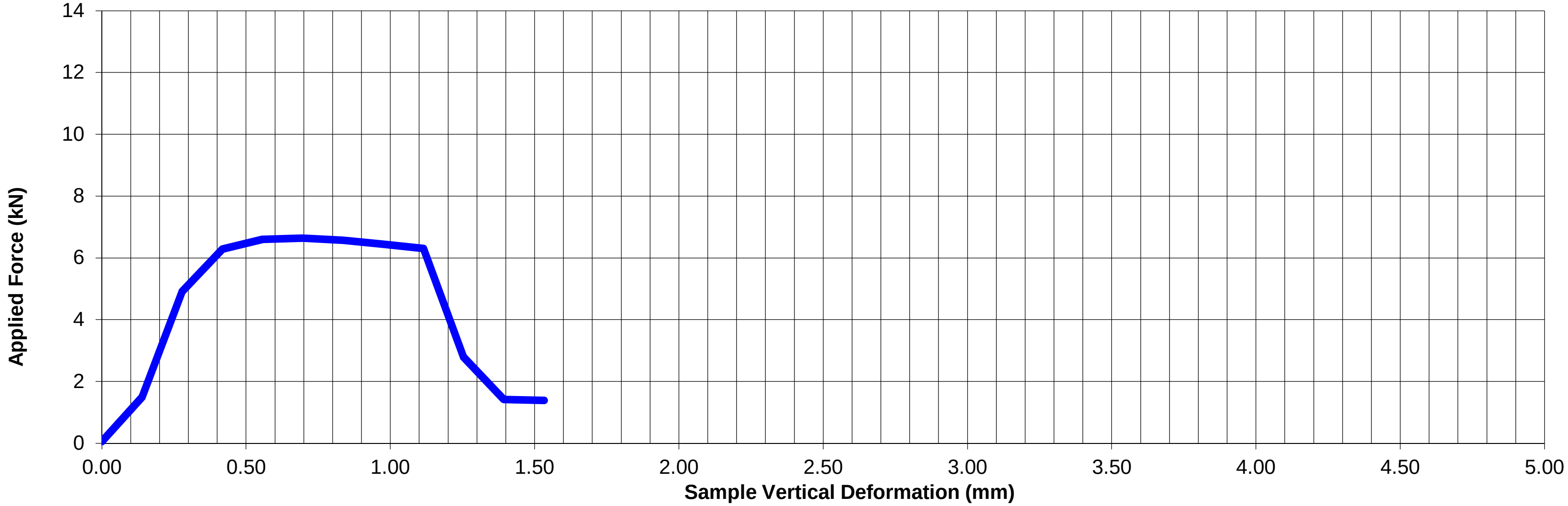

Calculations:

$$ITST = \frac{2P}{\pi DH}$$

ITST = Indirect Tensile Strength (GPa)
P = Peak Load (kN)
D = Specimen Diameter (mm)
H = Specimen Thickness (mm)

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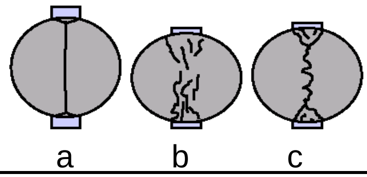

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Checked by: - Kozica Lukas

Date: - **31 January 2018**

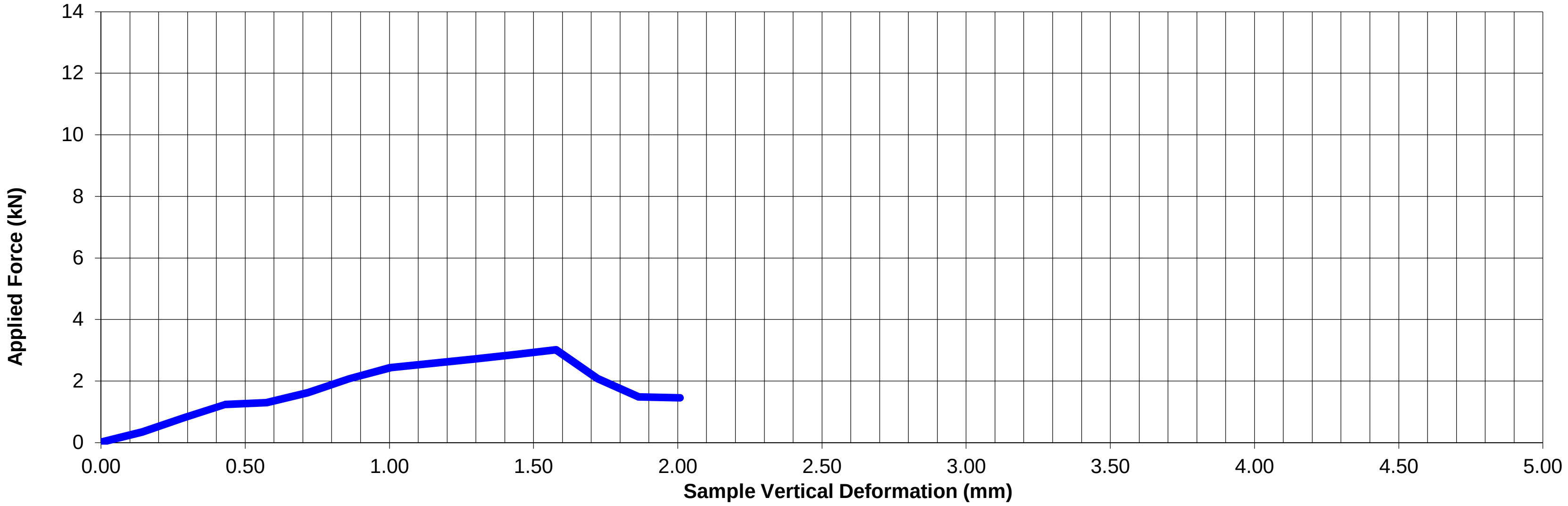
AECOM

Indirect Tensile Strength Test

BS EN 12697-23:2003

Project Title :	**Area 9 joint heater trials**	Location of Testing :	**Aecom, Nottingham, NG9 6RZ**	Reported By :	**NAL**
Job Number :	**60485963**	Date of Issue :	**31 January 2018**	Checked By :	**LK**
Bulk Reference :	**T0824**	Tested By :	**NAL**		

Sample ID	Test Temperature (^oC)	Conditioned in :	Bulk Density (kg/m^3)	Thickness (mm)	Diameter (mm)	Peak Load (kN)	ITST (GPa)	Type of Failure*	Broken Aggregate
51L1	20.0	Air	2266	43.0	152.0	3.0	2.96E-04	a	Yes



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ITST = Indirect Tensile Strength (GPa)

P = Peak Load (kN)

D = Specimen Diameter (mm)

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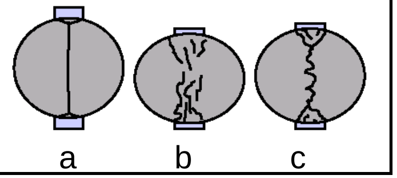

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Checked by: - Kozicz Lukas

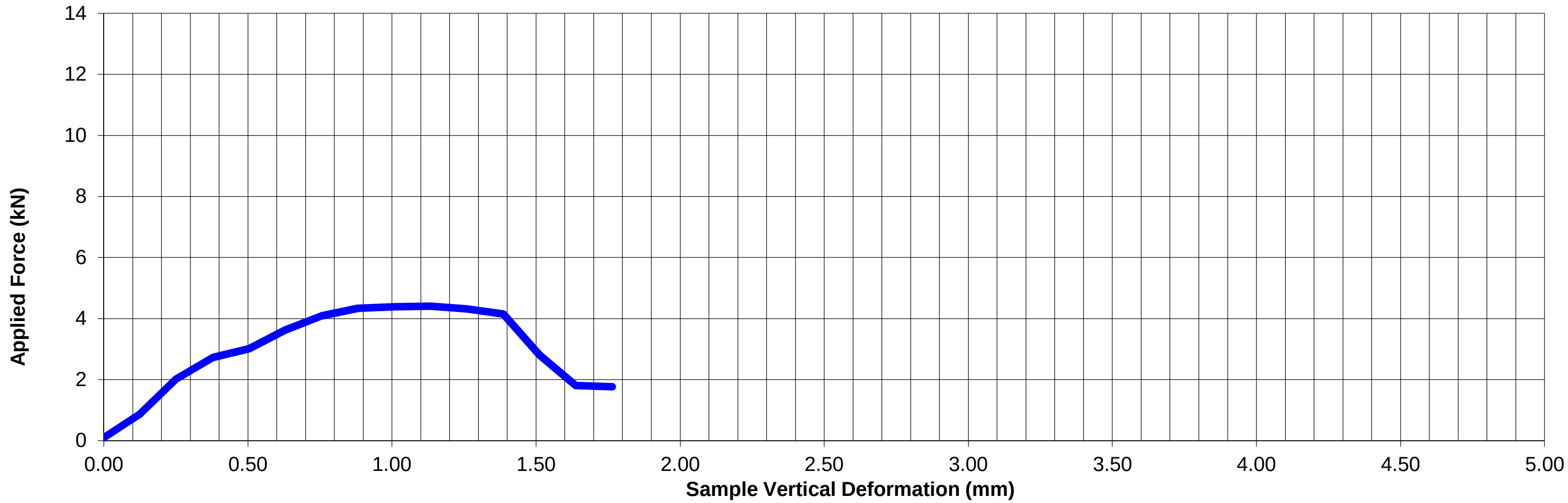
Date: - **31 January 2018**

Indirect Tensile Strength Test

BS EN 12697-23:2003

Project Title :	**Area 9 joint heater trials**	Location of Testing :	**Aecom, Nottingham, NG9 6RZ**	Reported By :	**NAL**
Job Number :	**60485963**	Date of Issue :	**31 January 2018**	Checked By :	**LK**
Bulk Reference :	**T0824**	Tested By :	**NAL**		

Sample ID	Test Temperature (^{o}C)	Conditioned in :	Bulk Density (kg/m^3)	Thickness (mm)	Diameter (mm)	Peak Load (kN)	ITST (GPa)	Type of Failure*	Broken Aggregate
52L1	20.0	Air	2306	44.4	152.6	4.4	4.14E-04	c	Yes



Calculations: $$ITST = \frac{2P}{\pi DH}$$

ITST = Indirect Tensile Strength (GPa)
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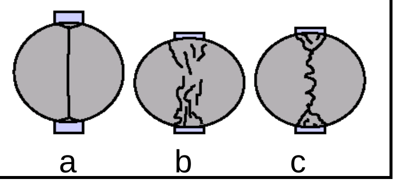

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Checked by: - Kozica Lukas

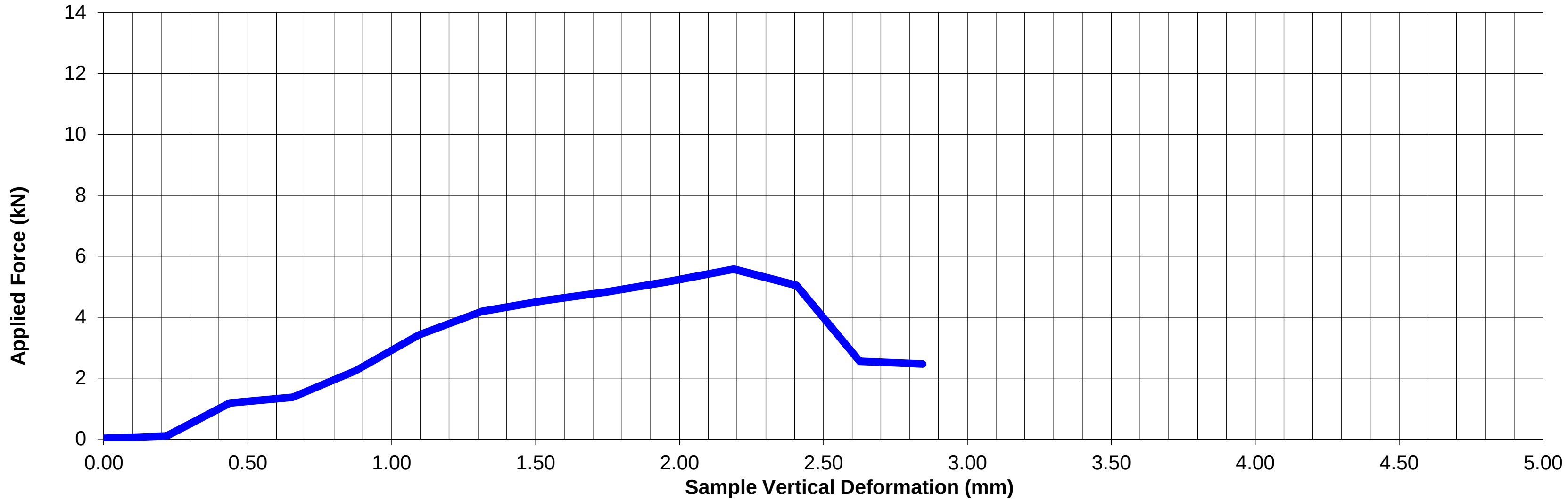
Date: - **31 January 2018**

Indirect Tensile Strength Test

BS EN 12697-23:2003

Project Title :	**Area 9 joint heater trials**	Location of Testing :	**Aecom, Nottingham, NG9 6RZ**	Reported By :	**NAL**
Job Number :	**60485963**	Date of Issue :	**31 January 2018**	Checked By :	**LK**
Bulk Reference :	**T0824**	Tested By :	**NAL**		

Sample ID	Test Temperature (^{o}C)	Conditioned in :	Bulk Density (kg/m^3)	Thickness (mm)	Diameter (mm)	Peak Load (kN)	ITST (GPa)	Type of Failure*	Broken Aggregate
54L1	20.0	Air	2339	39.8	152.5	6.1	6.37E-04	a	Yes



Calculations: $$ITST = \frac{2P}{\pi DH}$$

ITST = Indirect Tensile Strength (GPa)

P = Peak Load (kN)

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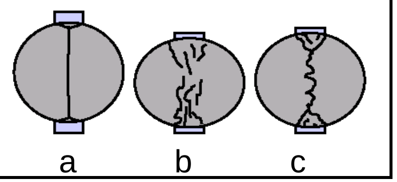

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Checked by: - Kozica Lukas

Date: - **31 January 2018**

INDIRECT TENSLE STRENGTH TEST

BS EN 12697-23:2003

Project Title :	**Area 9 joint heater trials**	Location of Testing :	**Aecom, Nottingham, NG9 6RZ**	Reported By :	**NAL**
Job Number :	**60485963**	Date of Issue :	**31 January 2018**	Checked By :	**LK**
Bulk Reference :	**T0824**	Tested By :	**NAL**		

Sample ID	Test Temperature (°C)	Bulk Density (kg/m^3)	Thickness (mm)	Diameter (mm)	Peak Load (kN)	ITST (GPa)	Failure Mode	Broken Aggregate
55L1	20.0	2329	47.3	152.3	5.0	4.39E-04	a	Yes
56L1	20.0	2355	47.2	152.5	10.1	8.89E-04	a	Yes
63L1	20.0	2467	38.1	152.8	10.6	1.16E-03	c	Yes
64L1	20.0	2427	43.7	152.4	12.7	1.22E-03	a	Yes
65L1	20.0	2436	42.3	152.2	12.5	1.24E-03	c	Yes

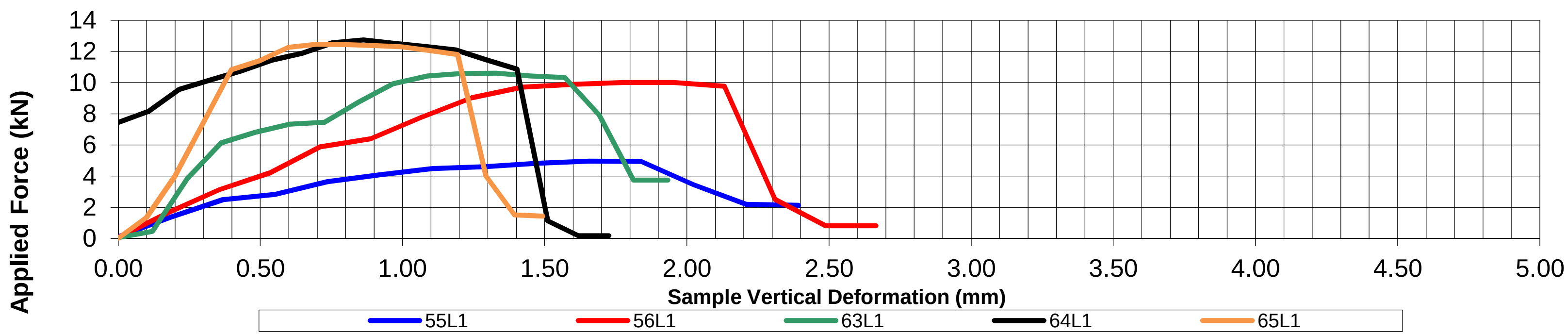
Calculations: $ITST = \frac{2P}{\pi DH}$

ITST = Indirect Tensile Strength (GPa)

P = Peak Load (kN)

D = Specimen Diameter (mm)

H = Specimen Thickness (mm)



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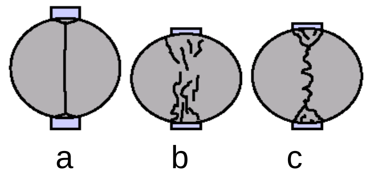

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Checked by: - Kozica Lukas

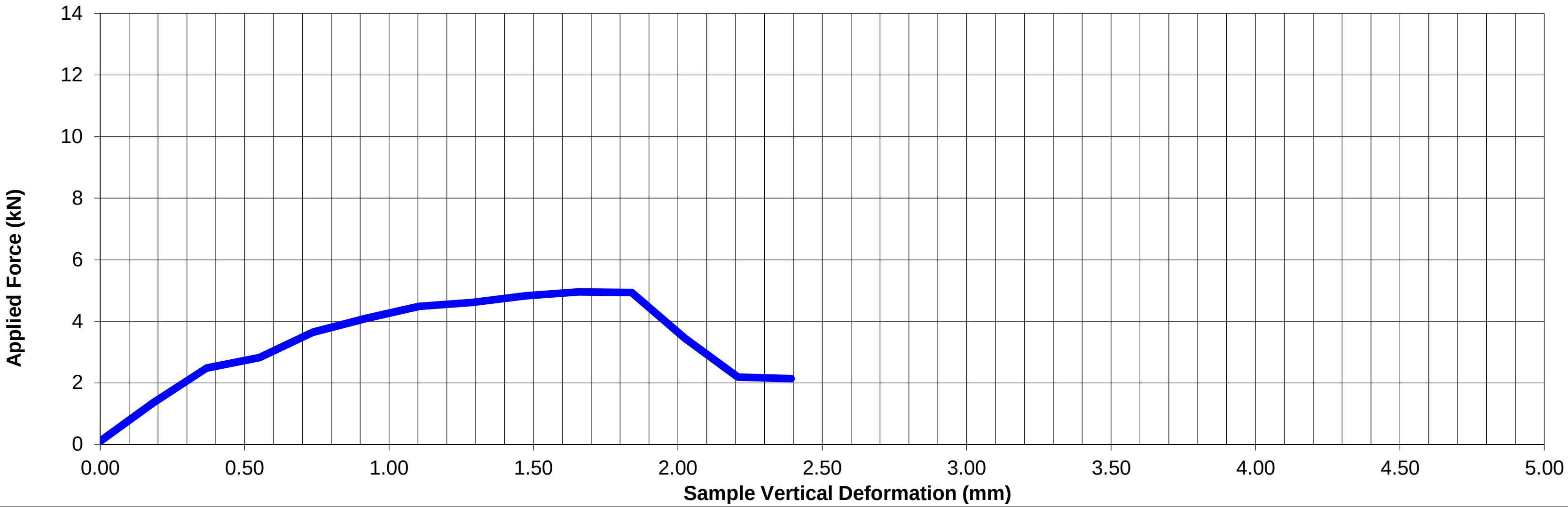
Date: - **31 January 2018**

Indirect Tensile Strength Test

BS EN 12697-23:2003

Project Title :	**Area 9 joint heater trials**	Location of Testing :	**Aecom, Nottingham, NG9 6RZ**	Reported By :	**NAL**
Job Number :	**60485963**	Date of Issue :	**31 January 2018**	Checked By :	**LK**
Bulk Reference :	**T0824**	Tested By :	**NAL**		

Sample ID	Test Temperature (^oC)	Conditioned in :	Bulk Density (kg/m^3)	Thickness (mm)	Diameter (mm)	Peak Load (kN)	ITST (GPa)	Type of Failure*	Broken Aggregate
55L1	20.0	Air	2329	47.3	152.3	5.0	4.39E-04	a	Yes



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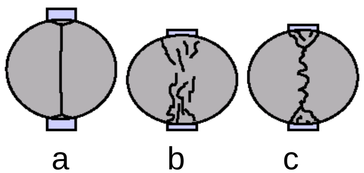

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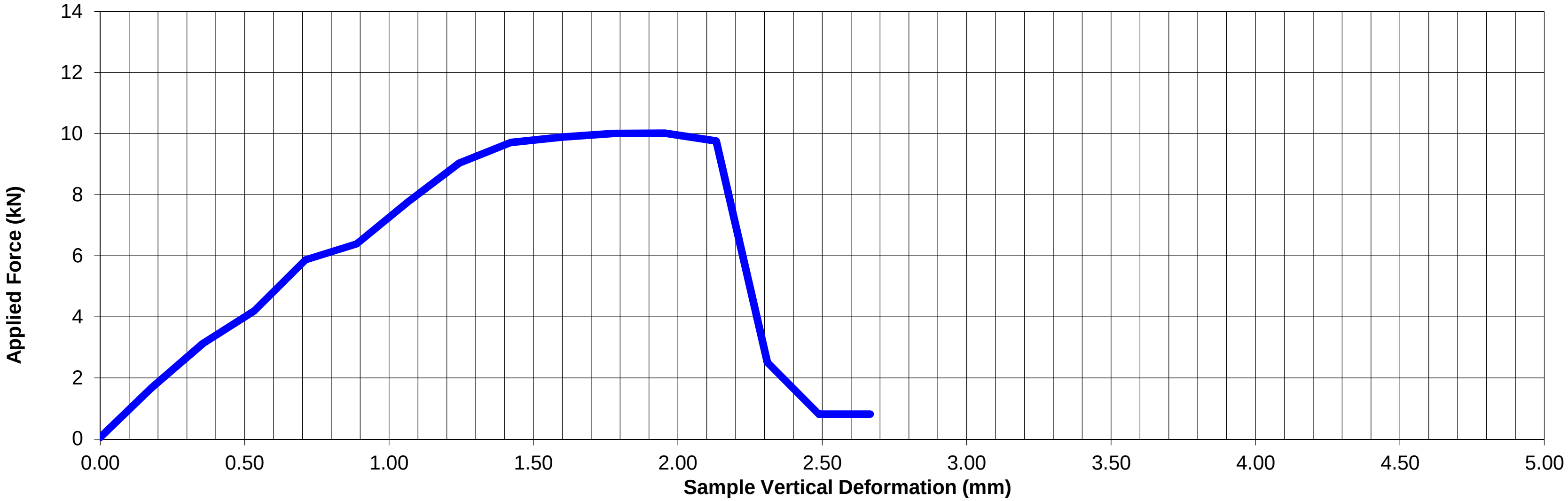
Bulk Reference :	**T0824**	Tested By :	**NAL**		

Sample ID	Test Temperature (^oC)	Conditioned in :	Bulk Density (kg/m^3)	Thickness (mm)	Diameter (mm)	Peak Load (kN)	ITST (GPa)	Type of Failure*	Broken Aggregate
56L1	20.0	Air	2355	47.2	152.5	10.1	8.89E-04	a	Yes



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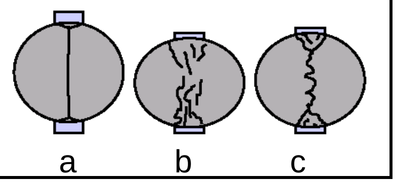

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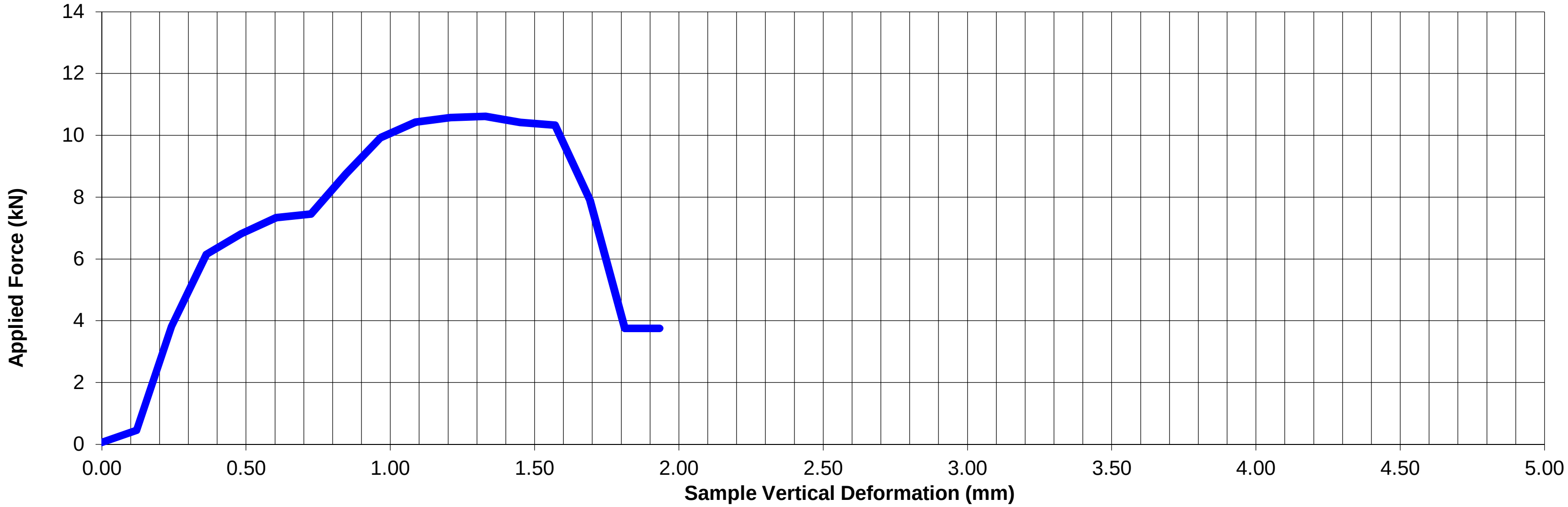
Bulk Reference :	**T0824**	Tested By :	**NAL**		

Sample ID	Test Temperature (^oC)	Conditioned in :	Bulk Density (kg/m^3)	Thickness (mm)	Diameter (mm)	Peak Load (kN)	ITST (GPa)	Type of Failure*	Broken Aggregate
63L1	20.0	Air	2467	38.1	152.8	10.6	1.16E-03	c	Yes



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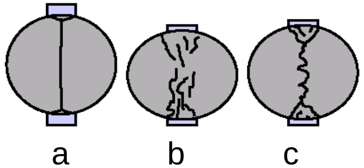

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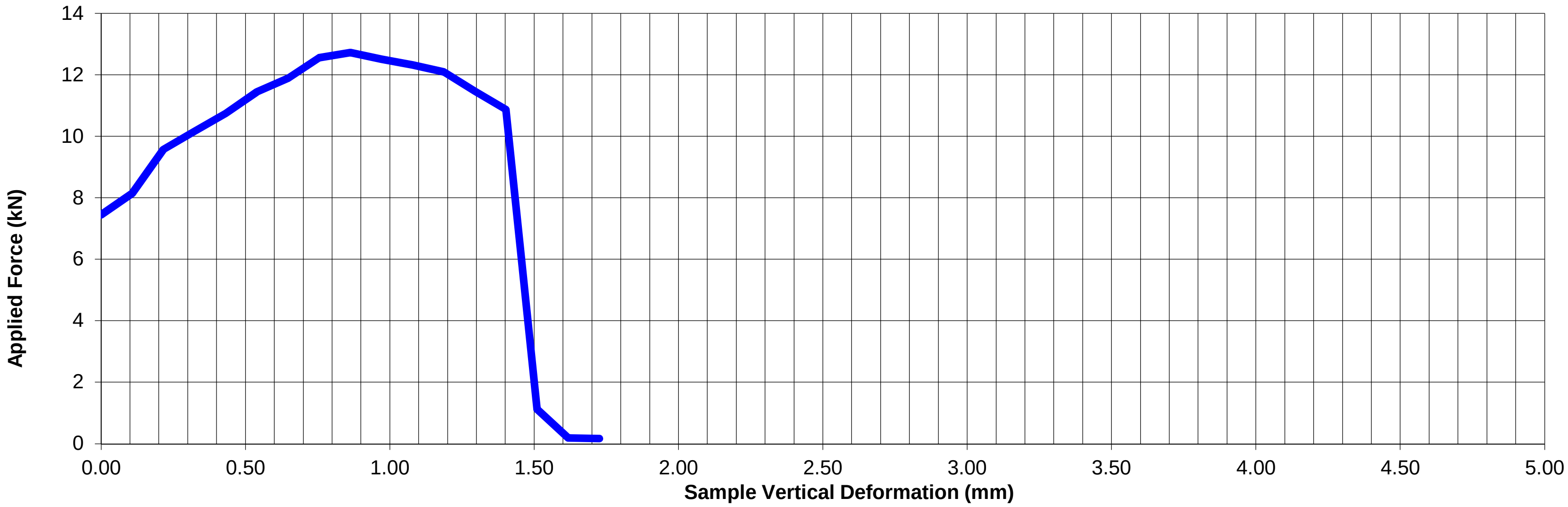
64L1	20.0	Air	2427	43.7	152.4	12.7	1.22E-03	a	Yes



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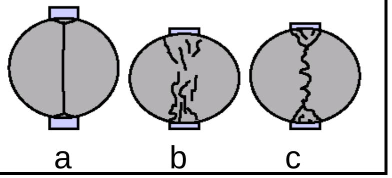

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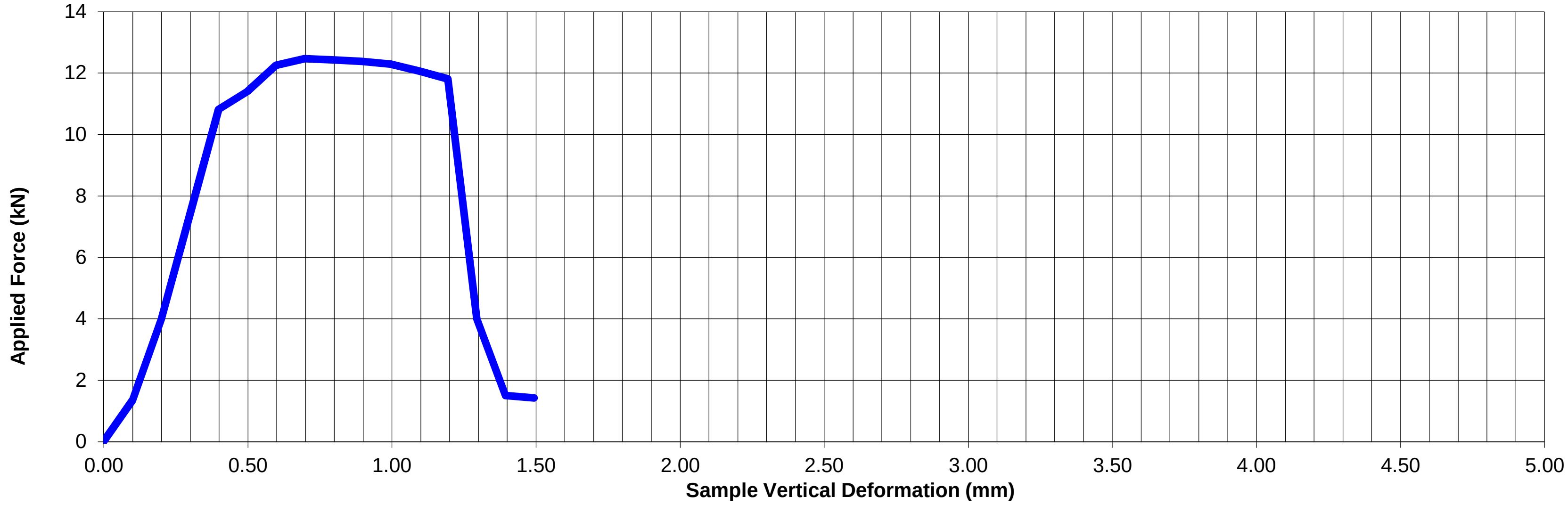

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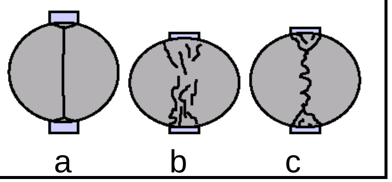

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Checked by: - Kozica Lukas

Date: - **31 January 2018**

AECOM

EQUIVALENT PENETRATION AND SOFTENING POINT USING THE DYNAMIC SHEAR RHEOMETER

In House AECOM Working Procedure

UKAS TESTING 4410

Project Title :	**Area 9 joint heater trials**	Tested By :	**LK**
Job Number :	**60485963**	Reported By :	**LK**
Bulk Reference :	**T0824**	Checked By :	**NAL**
Location of Testing :	**AECOM Laboratory, NG9 6RZ**	Date of Issue :	**02 February 2018**

Binder (Sample reference)	G* (Pa) at 0.4Hz & 25ºC	Penetration Indices (IP)	Calculated Values	
			Penetration (dmm) at 25ºC	Softening Point (ºC)
151617L1	2.74E+05	0.4	60	53.6
19L1	2.43E+05	0.7	64	54.0
252728L1	1.82E+05	1.9	75	57.4
363738L1	2.20E+05	0.2	68	51.4
40L1	1.94E+05	1.0	72	53.6
545556L1	1.83E+06	0.7	21	67.4
64L1	9.21E+05	0.9	30	64.0

Comments and Deviations:

In accordance with In house AECOM Working Procedure and the supporting data, it has been found that the calculated equivalent penetration and softening point using the VdP calculation will give values which fall in the below ranges when using the Dynamic Shear Rheometer: Supporting data will be supplied on request in graphical form only.

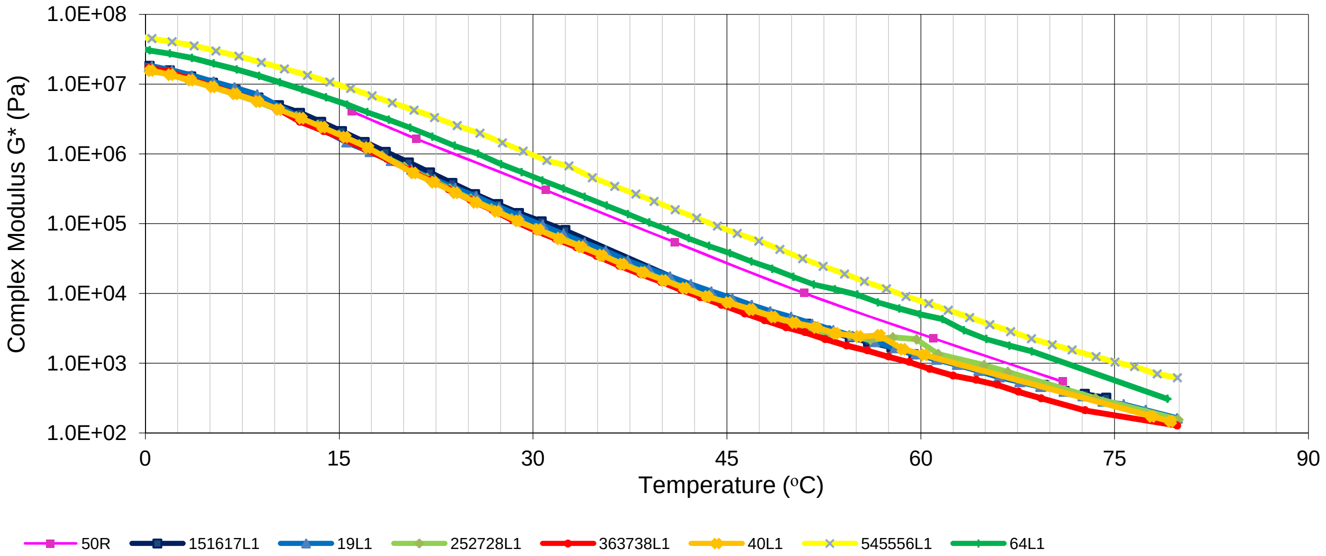
Checked by: - NAL [signature] Date: - **02 February 2018**

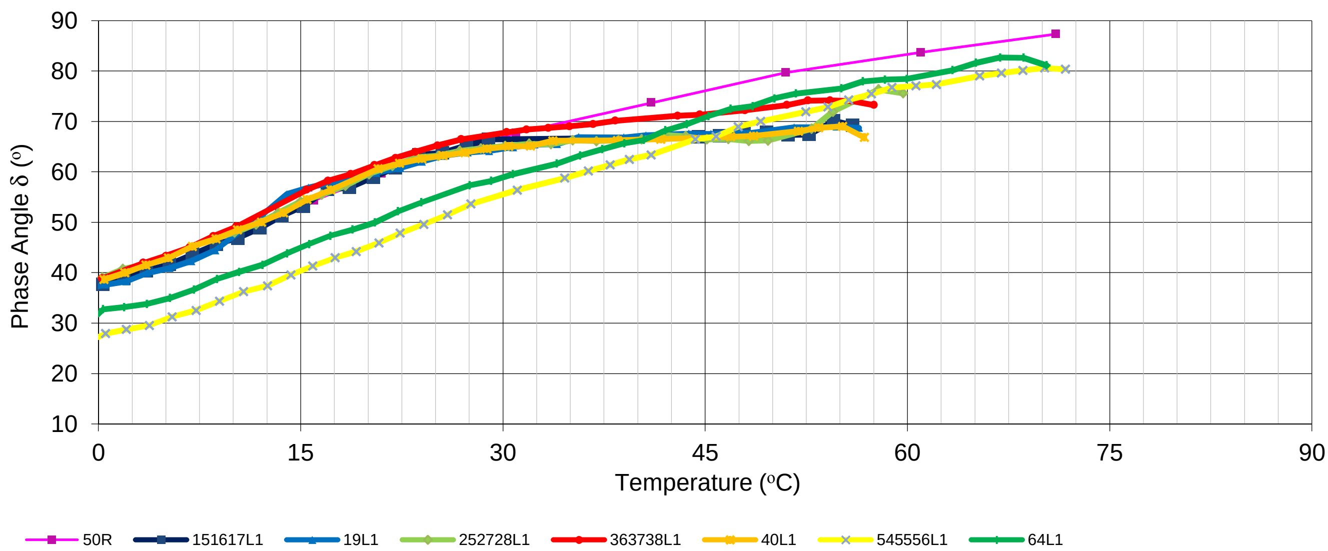
EQUIVALENT PENETRATION AND SOFTENING POINT USING THE DYNAMIC SHEAR RHEOMETER

In House AECOM Working Procedure

UKAS TESTING 4410

Project Title :	**Area 9 joint heater trials**	Tested By :	**LK**
Job Number :	**60485963**	Reported By :	**LK**
Bulk Reference :	**T0824**	Checked By :	**NAL**
Location of Testing :	**AECOM Laboratory, NG9 6RZ**	Date of Issue :	**02 February 2018**





Comments and Deviations:

In accordance with In house AECOM Working Procedure and the supporting data, it has been found that the calculated equivalent penetration and softening point using the VdP calculation will give values which fall in the below ranges when using the Dynamic Shear Rheometer:
Supporting data will be supplied on request in graphical form only.

Checked by: - NA [signature]

Date: - **02 February 2018**

Jessica Tuck
Associate
T: 0115 907700
E: jessica.tuck@aecom.com

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12 Regan Way
Chetwynd Business Park
Nottingham NG9 6RZ
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