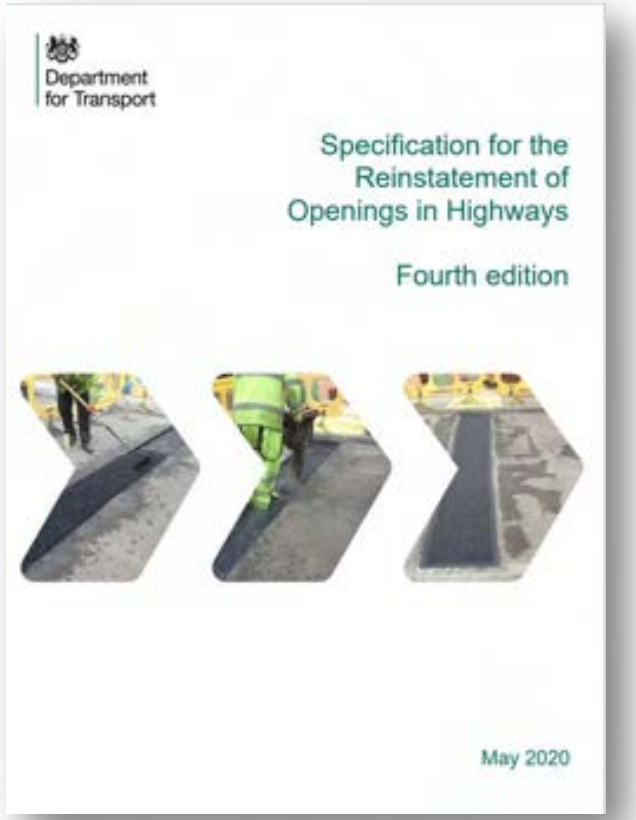
S10 – Compaction Requirements



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Introduction- SROH S10

This advisory document is designed to assist incoming and existing Inspectors as support and refresher material. It will be provided in simple language to aid in understanding and avoiding technical or descriptive explanation.

The current edition (Ed 4) of the Specification for Reinstatement of Openings in the Highway (SROH) has been updated to assist readers in understanding, and introduce new methods and developments within street-works.

Remember, the SROH applies to works undertaken on carriageway's, footway's and verge's maintained at public expense (not private roads or land).

You will now be taken through the key items within S10 which will enable you to have a better understanding of what to look for when monitoring compaction of materials.

Please note:
This presentation is simply to aid in understanding of the SROH and should not be used for any other purpose. The simplicity of language may detract from certain technical or descriptive requirements and, therefore, the SROH should be consulted for clarity.

S10 Compaction

What it says in the SROH - Equipment

S10.1.1 All compaction equipment covered by this Code must be checked, adjusted, maintained and operated in accordance with working practices, maintenance schedules, operating procedures and vibration frequencies recommended by the equipment manufacturer. Where available, relevant records must be provided to the authority on request within a reasonable period of time.

What it means

It is so important to ensure the correct compaction equipment is selected and is working properly. This means that compaction equipment must be serviced and checked regularly to ensure it does the job it is designed for.

You can see a general representation of different types of compaction equipment below. Always ensure the correct equipment is selected.


Hand rammer


Mechanical pole tamper


Vibrotamper


Vibrating plate


Single drum vibrating roller

Twin drum vibrating roller


S10 Compaction

Granular, cohesive & cement bound materials

What it says in the SROH

S10.2.1 For all materials, compaction must be carried out in accordance with the requirements of A2 or A8 immediately after the material has been placed.

What it means

The SROH states that compaction must be carried out to the prescribed methods as shown in appendices A2 and A8. This will describe what equipment can be used, the number of passes for a particular material and that it should be compacted after placement.
SROH - Appendix 2 (A2) = Key to materials
SROH - Appendix 8 (A8) = Compaction requirements

Table A8.1 will show what equipment can be used on granular, cohesive and cement bound materials

It will also show required layer thickness and how many times the compaction tool should pass over it.

Table A8.1 Compaction requirements for granular, cohesive and cement bound materials

Compaction plant and weight category	Cohesive material (less than 20% granular content) Minimum passes/lift for compacted lift thickness up to			Granular material (20% or more granular content including cement bound material) Minimum passes/lift for compacted lift thickness up to		
	100 mm	150 mm	200 mm	100 mm	150 mm	200 mm
Vibrotamper 50 kg minimum	4	8#	NP	4	8	NP
Single drum Vibrating roller						
600-1000 kg/m	NP	NP	NP	12	NP	NP
1000-2000 kg/m	8	NP	NP	6	NP	NP
2000-3500 kg/m	3	6	NP	3	5	7
Over 3500 kg/m	3	4	6#	3	4	6
Twin drum Vibrating roller						
600-1000 kg/m	NP	NP	NP	6	NP	NP
1000-2000 kg/m	4	8	NP	3	6	NP
Over 2000 kg/m	2	3	5#	2	3	4
Vibrating plate						
1400-1800 kg/m²	NP	NP	NP	5	NP	NP
Over 1800 kg/m²	3	6	NP	3	5	7
All above plant	For maximum and minimum compacted lift thickness see Table A2.6					
Compaction of small openings and narrow trenches must comply with S6.5.						
Vibrotamper 25 kg minimum	Minimum 6 compaction passes Maximum 100 mm compacted lift thickness					
Percussive rammer 10 kg minimum						

Notes:
1) NP = Not Permitted
PLEASE NOTE
2) # = Not Permitted on wholly cohesive material i.e. clay or silt with no particles > 0.063 mm
3) Single drum vibrating rollers are vibrating rollers providing vibration on only one drum
4) Twin drum vibrating rollers are vibrating rollers providing vibration on two separate drums
5) HBMs must be compacted in accordance with A10.2
6) Mechanical pole tampers may be considered for compaction around iron work.

If I have a 50kg Vibrotamper and need to compact Class A granular. What should I do?

Simply, refer to Table A8.1 where it will show you how many passes of your equipment is required for each lift thickness.

What do you mean by lift thickness and passes?

A lift thickness is after the layer is compacted. Passes are how many times the equipment should pass over it during compaction.

So if I compact to 150mm layers I apply 8 passes

Exactly!

S10 Compaction

Granular, cohesive & cement bound materials

1. A pass is when the compaction equipment has moved over the total surface of the material once.

2. You can see from the photograph the operative is guiding the device to ensure he will cover the whole area of the granular material.

3. The granular material is GSB Type 1 and it is being compacted to 150mm layer thickness as required under SROH Table A8.1

4. Therefore, for each lift ,the whole area needs to be covered 8 times to ensure compaction (8 passes as per SROH Table A8.1).

S10 Compaction

Granular, cohesive & cement bound materials

What is compaction and why is it important?

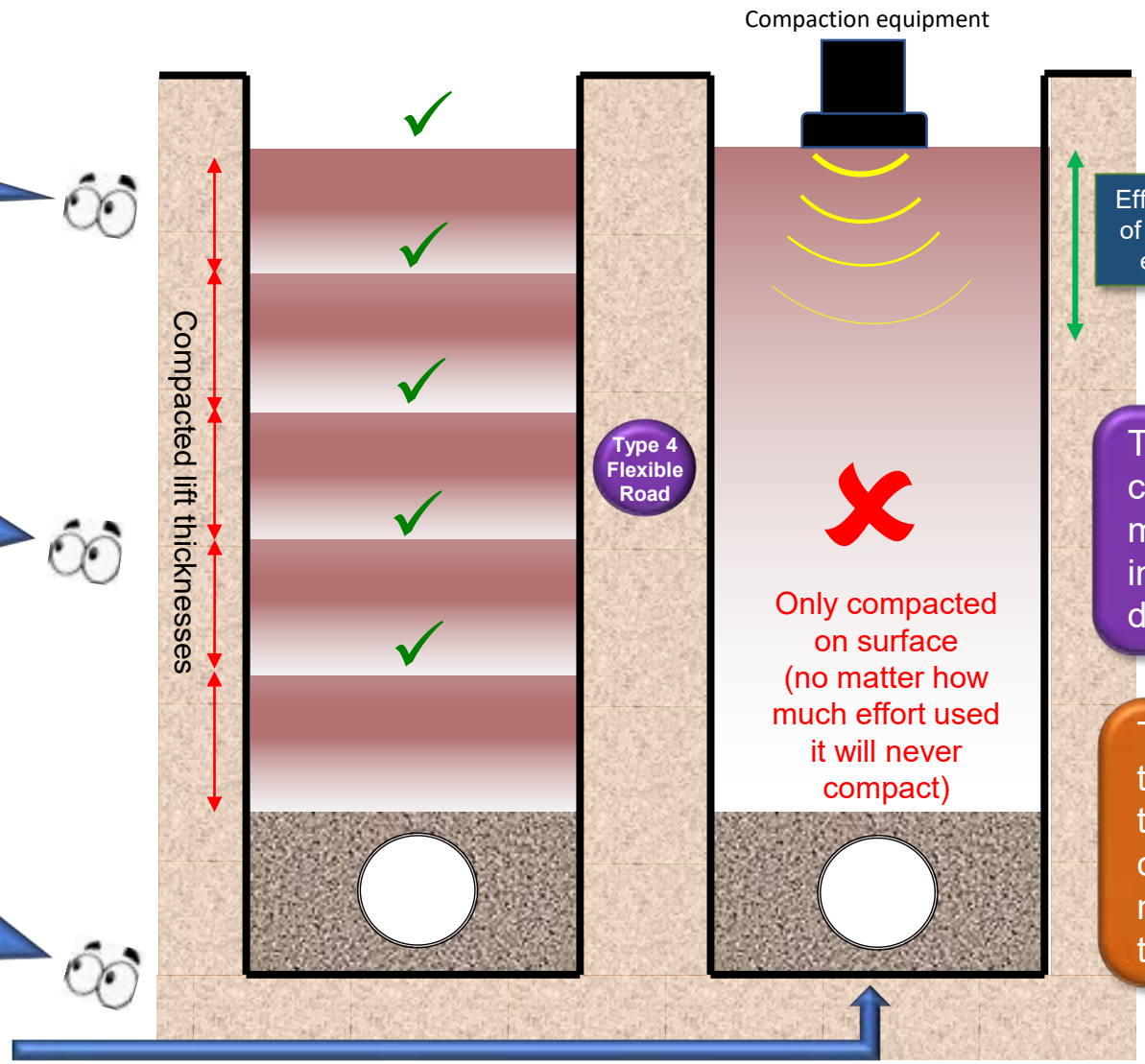
Very simply, it is the expulsion of air voids. If you don't compact properly the works will sink.

Is this why you should always compact in layers?

Exactly, otherwise the likelihood of the work sinking is greatly increased. It is important to use the correct layers and compaction equipment.

If I use thicker layers and apply more passes of the equipment will that work?

Unfortunately not…
Compaction equipment can only work to certain depth (known as effective depth). That's why we have layer thickness values for each lift.



The effective depth of compaction equipment means it can only influence to a certain depth below it.

This is why it is required to have compacted lift thickness and, why some compaction equipment is not permitted for use on thicker layers.

S10 Compaction

How to verify sufficient compaction

If you have concerns about compaction not being sufficient. There are ways to monitor or check this which may provide evidence to show materials, equipment, or method have not been applied correctly

The following slides will better describe some of the methods of testing currently in use and how they are applied.

S10 Compaction

How to verify sufficient compaction – Clegg Hammer

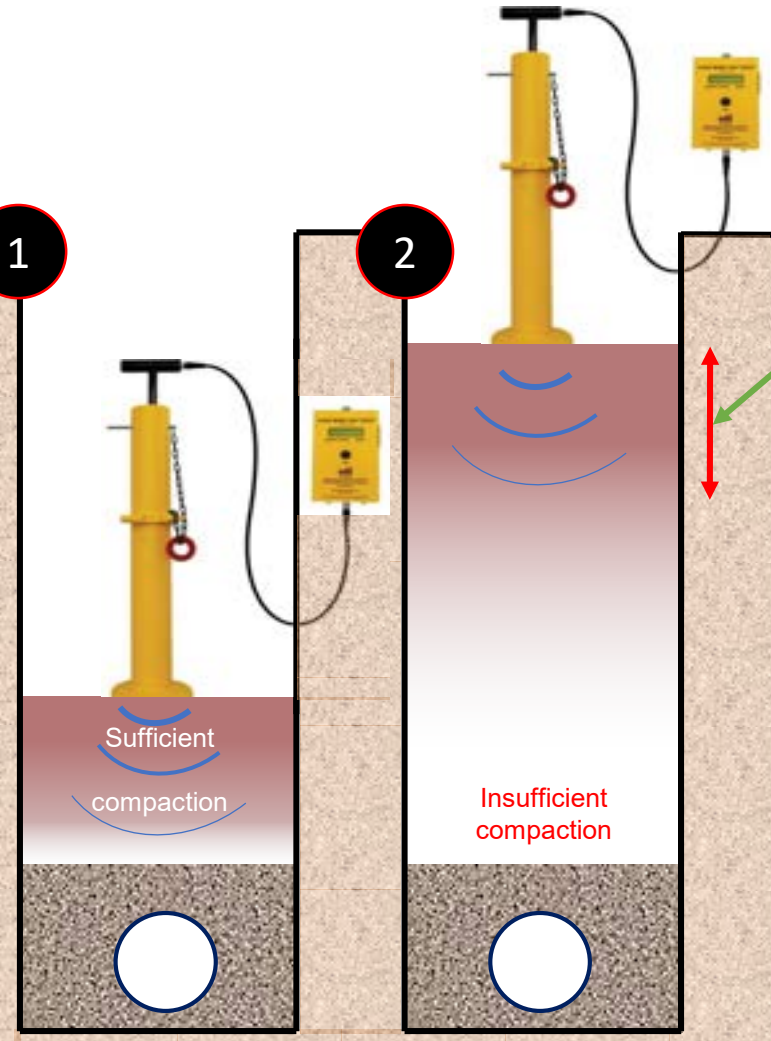
Regarding compaction, the current SROH (Ed 4) is written as a method specification. This means the methods and equipment prescribed within it should achieve correct compaction when followed faithfully.

However, if you wish to check if a material has received sufficient compaction you can refer to SROH – NG 5.1 which provides guidance on assumed limiting performance for backfill materials.

Table NG5.1 Backfill material performance

Backfill material class	Material performance % CBR
A	Over 15
B	7 to 15
C	4 to 7
D	2 to 4
E	Less than 2

CBR% = California Bearing Ratio, which is a recognised standard of measurement



Trench 1 is 150mm layer of Class A material compacted with 8 passes.
Trench 2 has been backfilled in one layer with 8 passes on the surface only.

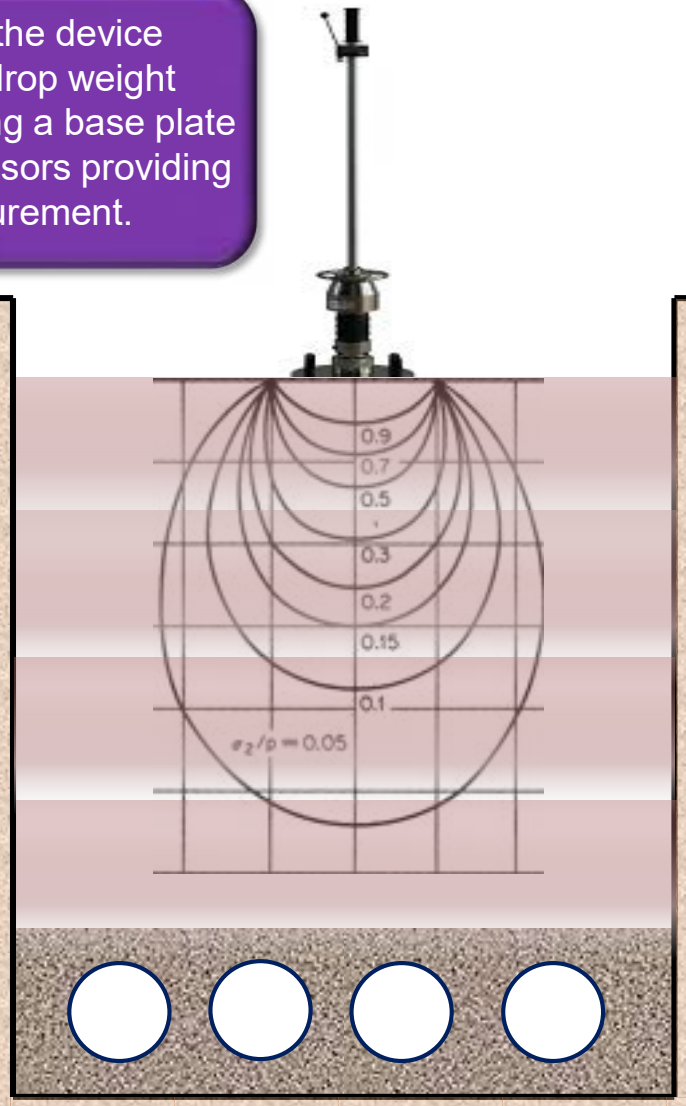
You may recall on the previous slide that compaction equipment has an effective depth. The same applies to using a Clegg Hammer, as it can only effectively measure surface strength (modulus). This is why it is important to measure each compacted layer to get an overall compaction measurement.

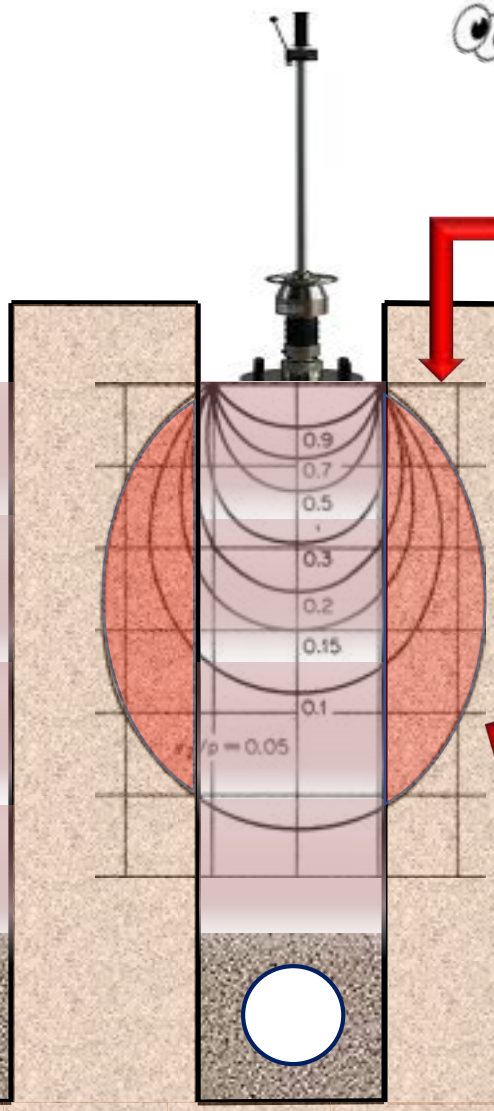
S10 Compaction

How to verify sufficient compaction – FWD

FWD simply means “Falling Weight Deflectometer” which works in a similar way as a Clegg Hammer, but can measure to greater depths.

Simply, the device uses a drop weight impacting a base plate with sensors providing a measurement.





It is not advised to use these devices on reinstatements so narrow or small that the device effectively includes the existing surrounding area. Otherwise, it will be measuring the existing ground as well as the reinstatement. These devices should only be used on areas suitable for this type of equipment.

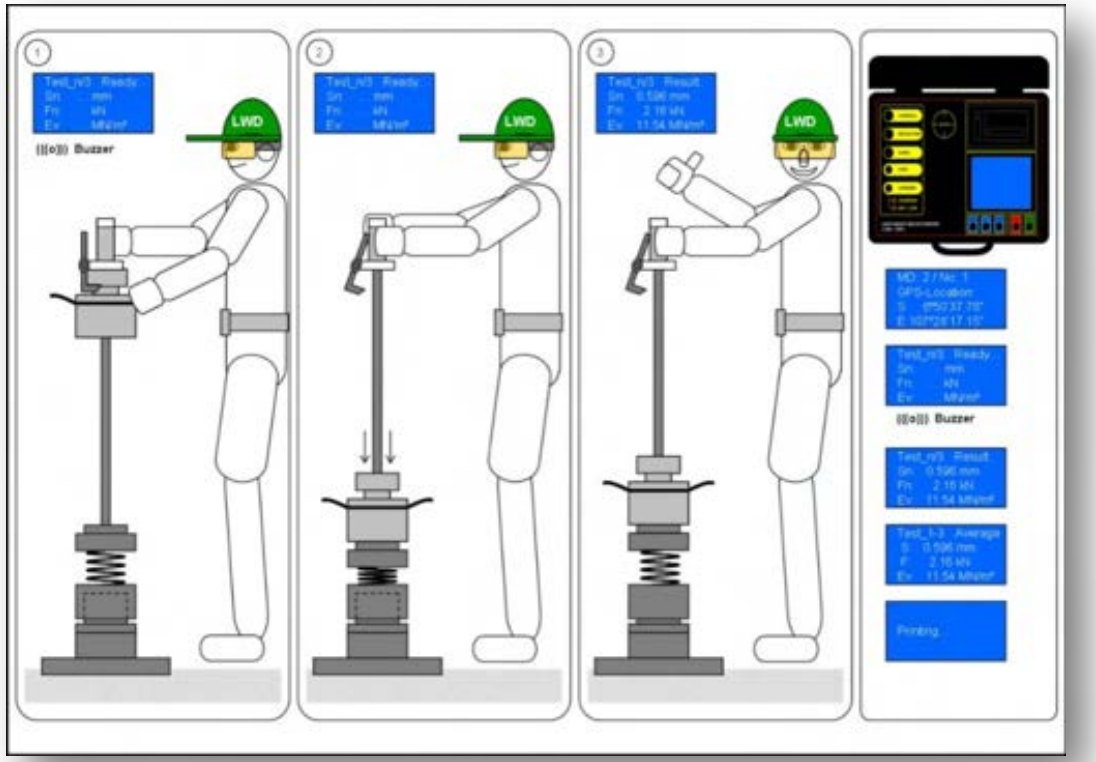
NOTE

There are different plate diameters. Ensure the correct one is used for the size of the opening to prevent the scenario shown here.

S10 Compaction

How to verify sufficient compaction – FWD

What it looks like, and how it is used



Remember, do not use in small areas or narrow trenches

PLEASE NOTE

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How to verify sufficient compaction – Penetrometer

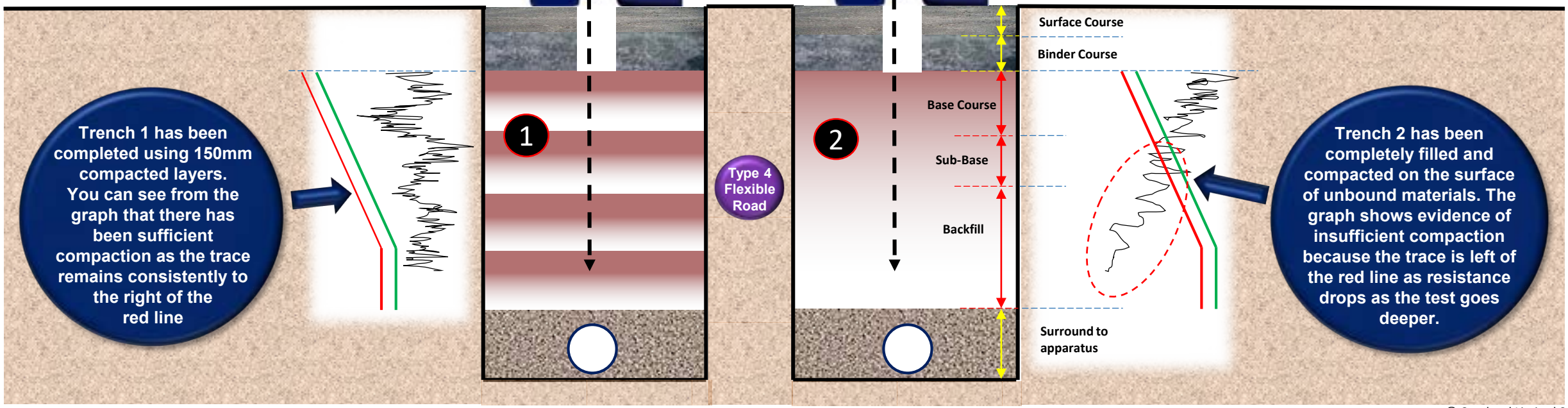
A penetrometer works by driving a (2cm²) cone into the material using a standard weight (10kg) and a standard height (1m). The measurement is how far each drop pushes the cone through the material (this will show resistance of the material).

There are also advanced penetrometers that can be tapped through the materials with a special hammer (as pictured)

The advantage of Penetrometer testing is that it can be applied after full reinstatement is completed. This is done through a core test hole.

1 150mm compacted layers with 8 passes of 50kg Vibrotamper

2 Full depth unbound with 8 passes of 50kg Vibrotamper on surface



Trench 1 has been completed using 150mm compacted layers. You can see from the graph that there has been sufficient compaction as the trace remains consistently to the right of the red line

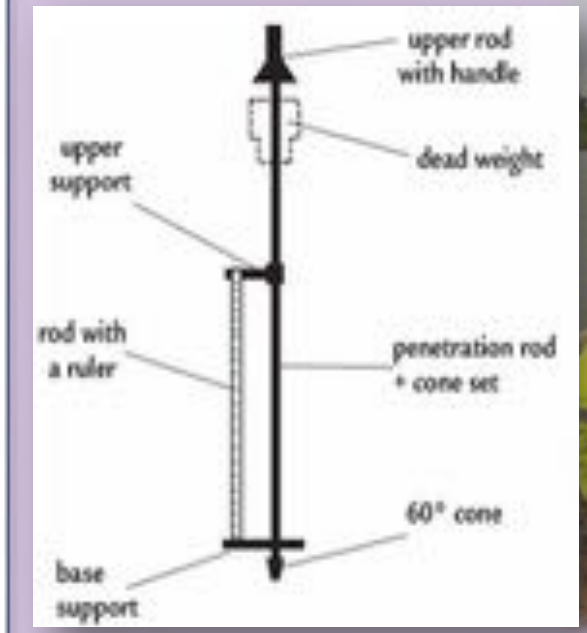
Trench 2 has been completely filled and compacted on the surface of unbound materials. The graph shows evidence of insufficient compaction because the trace is left of the red line as resistance drops as the test goes deeper.

S10 Compaction

How to verify sufficient compaction – Penetrometer methods

How it works

2cm² Cone



Standard Penetrometer (known weight & known drop height) measure distance travelled for each hammer drop and record measurement to plot on graph.

Variable Energy Input Penetrometer which does not use sliding weight and can measure input and distance travelled for each strike using a dead weight hammer to record measurement automatically.

S10 Compaction
Bituminous materials

What it says in the SROH

S10.2.7 All bituminous materials permitted by A2, except those covered in A2.5, must be laid and compacted in accordance with the relevant requirements of A2 and Tables A2.5, A2.7 and A2.8, and A8.3

What it means

As you can see there are several requirements relating to bituminous materials. The references in green above, will provide information on **compacted lift thickness** (Table A2.5), **laying temperatures** (Table A2.7), **HRA final rolling temperatures** (Table A2.8) and A8.3 which provides information in relation to **air voids content** (There is a maximum and minimum amount of air voids % allowable within each bituminous material – Table 10.1)

REMEMBER

A "compacted lift" is the required thickness of a bituminous material for compaction. It is not to be confused with a "structural layer" (i.e. Base layer). Several compacted lifts may exist within a structural layer.

Table A2.5 Compacted lift thickness (mm) – Bituminous mixtures

Material type	PD 6691 reference	Compacted lift thickness (mm)		
		Minimum at any point	Nominal lift thickness	Maximum at any point
6 mm DSC	AC6 dense surf	15	20 – 30	40
10 mm CGSC	AC10 close surf	25	30 – 40	50
15/10 HRA	HRA 15/10 F surf	25	30	50
30/10 HRA	HRA 30/10 F surf	30	35	45
30/14 HRA	HRA 30/14 F surf HRA 30/14 C surf	35	40	50
35/14 HRA	HRA 35/14 F surf HRA 35/14 C surf	40	45 - 50	60
55/14 HRA	HRA 55/14 F surf	40	45	55
55/10 HRA	HRA 55/10 F surf	35	40	50
6 mm SMA	SMA 6 surf	15	20 - 40	45
10 mm SMA	SMA 10 surf	20	25 - 50	55
14 mm SMA	SMA 14 surf	30	35 - 50	55
10 mm PA	PA 10*	25*	30 – 35*	40*
20 mm PA	PA 20*	40*	45 – 60*	65*
50/14 HRA	HRA 50/14 F bin	30	35 - 65	85
50/20 HRA BC	HRA 50/20 bin	40	45 - 80	100
60/20 HRA BC	HRA 60/20 bin	40	45 - 80	100
14 mm SMA BC	SMA 14 bin	25	30 - 60	65
20 mm SMA BC	SMA 20 bin	40	50 - 100	110
14 mm DBC	-	35	40 - 70	80
20 mm DBC	AC20 dense bin	40	50 - 100	110

Notes:
The binder course thickness must be adjusted accordingly to the thickness of the surface course to comply with the requirements in appendices A3 to A7.
* The use of Porous Asphalt (PA) is limited in the UK except for specialist uses such as sustainable drainage systems. Where porous asphalt surfaces are encountered refer to S6.4.13 (BS EN 13108-7 contains specifications for this group of asphalts and guidance on the appropriate material should be obtained from the authority).
** 14 mm DBC is not currently included in PD 6691. It should be referenced as AC14 dense bin.

Table A2.5 shows the maximum and minimum compacted lift thickness for bituminous materials named within it.

It must be pointed out that a structural layer (like Base layer in a Type 1 road) may contain several compacted lifts.

For example, if you wanted to lay a 250mm layer of base course material (20mm DBC) you should aim for a compacted layer between 50-100mm on each lift. The absolute minimum compacted layer is 40mm.
The absolute maximum is 110mm, so therefore you will require three compacted layers (lifts) to achieve 250mm overall.

S10 Compaction
Bituminous materials

Plate tamper

Hand punner or tamper

Vibrating plate

Vibrotamper

Identification of common types of bituminous compaction equipment

Single drum vibrating roller

Twin drum vibrating roller

Vibrating plate

Please refer to SROH – Table NGA.8 for recommended layer values and equipment selection.

S10 Compaction

Bituminous materials – Air voids

What it says in the SROH

A8.3.1 Bituminous mixtures for permanent reinstatements permitted in A2 must be compacted to the in-situ air void requirements of S10.2.8. Guidance on compaction procedures that may be capable of achieving the specified air voids values is given in NG A8.

What it means

Essentially, the verification of bituminous materials compaction differs from unbound materials. You will recall that granular, cohesive and cement bound materials are verified through a method specification (layer thicknesses, type of equipment and number of passes). Whereas generally, bituminous materials are based on performance measurement of how much air is trapped within the material. This is why it is so important to ensure they are managed and compacted in the correct manner.

Table S10.1 In-situ air voids content requirements

Bituminous materials	Permitted air voids			
	Carriageways		Footways, Footpaths and Cycle tracks	
	Max %	Min %	Max %	Min %
AC6 dense surface course	NP	NP	13	2
AC10 close surface course	11	2*	11	2*
HRA surface course	7	2	10	2
SMA surface course	8	2	10	2
AC binder course	10	2*	12	2*
HRA binder course	9	2	12	2
SMA binder course	6	2	NP	NP
Permanent cold-lay surfacing materials (PCSM)	10	2	13	2
Any other bituminous materials within the specification	No air-voids limits apply. Guidance on compaction contained in NGA8.3			

NP = not permitted

* If the binder content is increased as per A2.3.5 and A2.3.6 the minimum air voids is 0.5%.

If the air voids content of the bituminous material falls outside of the requirements of SROH Table S10.1 the material has failed to achieve compliance.

Air voids measurement must be undertaken by a laboratory having UKAS accreditation for the test methods unless otherwise agreed.

UKAS = United Kingdom Accreditation Service

S10 - Summary

Why is compaction so important?

If compaction is not properly applied, it is likely the reinstatement will sink.

What happens if there is poor compaction?

As mentioned above, you may see evidence of poor compaction through some of the performance requirements under SROH Section 2 such as edge depression and surface depression or edge (interface) cracking.

Why is compaction required for HBM's and not for FCR's

HBM's are usually semi-dry materials that will require compaction to expel air voids to allow bonding. FCR's are flowable materials that fill the excavation and purposefully contain foaming agent to make them light, and they cure by chemical action and bonding.

Do you use the same equipment for unbound and bituminous materials?

Generally you can, but this will depend on suitability, effective depth and work area. Certain equipment types are not suitable, or not permitted as they may not be effective (e.g. a 50kg Vibrotamper on a 200mm compacted layer as per SROH Table A8.1). Also a large area of bituminous surface course would benefit from a vibrating roller rather than small plate compactor.