

Failed Reinstatements Due to Incorrect Compaction !

West Midlands
HAUC
Materials Group



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**I Worked for a Compaction
Manufacturer for 23 years as Product
Manager, and was involved with the First
SORH in 1999**

There are many reasons why a reinstatements could fail, In this presentation I am only looking at Compaction.

I Have Been Visiting Sites Around
The West Midlands, to Check
Reinstatements Carried Out By
Utilities, Utilities Contractors & Sub
Contractors.

Objectives of compaction

Compaction is applied to improve the properties of an existing soil or in the process of placing fill.

The main objectives are to:

- Increase shear strength and therefore bearing capacity
- Increase stiffness and therefore reduce future settlement
- Decrease the voids ratio and aid permeability, thus reducing potential water ingress & frost heave



What Type of Compaction to Use

Compaction Rammer / Vibratory Rammer

This is the best item of equipment we can use, it will compact any type of soil, is easy to use and is well known throughout our industry.

Take the Wacker BS 50-2 (150 mm 200 mm shoe) 52 kgs

Every time the ram shoe hits the ground, and it does it 700 times a minute, it imparts 0.75 kN (approx 0.75 tonne) of energy, effective depth of 100 / 200 mm, no other item of equipment in our industry comes any where near this performance, all rammers in this category have similar performance figures.

To meet Appendix A8 Equipment has to be 50 kg or above



What Type of Compaction to Use

Compaction Plate / Vibratory Plate 62 kg

Take the Wacker VP 1135 best selling vibration plate in the UK (3,000 per year).

This is the worst item of equipment we can use, it will not compact most types of soil used in reinstatements, is very easy to use, cheap and is well known throughout our industry.

This plate or any plate of this size dose not meet the specification, can only be used with local agreement for compacting around difficult areas (street furniture, poles etc.).

You see this type of plate being used in reinstatements all over the UK as the only method of compaction, useless on cohesive soils, imparts 1.1 kN, but only to a depth of 50 / 70 mm, and then only on fine dry soil.



What Type of Compaction to Use

Vibratory Rollers Diesel /Petrol single drum roller c/w Hyd breaker

This is the most common rollers seen in street works, weighs in at 740kgs that includes trailer and breaker, the added advantage is that the breaker can be used as a compaction tool in difficult areas (square elephants foot required).

This roller Meets the specification Appendix A8 vibrating rollers with a mass of 600kg per meter width, with the correct number of pass and Materiel lifts (In confined areas a smaller roller (BW55) can be used with agreement, if marking or damage could result with larger rollers).

Twin drum rollers also meet the specification with a mass of 600kg per meter width, mostly used on large excavations.

What Type of Compaction to Use



What Type of Compaction to Use

A photograph showing a worker in high-visibility orange and yellow clothing operating a yellow Wacker plate compactor on a road surface. The machine is being pushed forward, compacting a layer of material. The background shows other workers and a road with yellow markings.

If This is your only
method of
Compaction your
Reinstatement will
Fail

What Type of Compaction to Use

To meet the specification the vibration plate must meet the 1400 to 1800kg / m² this is a very large plate, weighting in at 274kgs not practicable for day to day use in small excavations.





What Type of Compaction to Use

Belle PCX 350 Compactor

- New PCX Low hand-arm vibration Single Direction Plate Compactors
- Plates with unique safety, performance and stylish looks. High priority has been given to Health and Safety with the lowest hand arm vibration
- Also available with 'Dual Force' for HAUC compliant high force compaction
- Belle PCX Plate compactors set the industry standards for the Lowest Vibration combined with the Highest Compaction Performance
- These machines have been designed from square one to provide low hand-arm vibration levels as standard
- As vibration reduction is integrated the low vibration performance is reliable and high outputs are maintained
- The lowest hand-arm vibration - offers the longest safest operator time
- Faster travel speed - for improved productivity
- Engine protection frame - also provides a lifting point
- Handle folds flat - compact size for transport and storage
- 1800+ kg/m² compaction from 'Dual Force' - complies with NRSWA (HAUC)
- Optimum vibration force - 16.5kN (PCX 400-500) 14.5kN (PCX350) at 101Hz
- All the low vibration advantages from the Standard PCX range with additional extra high compaction force
- 'Dual Force' gives compaction equal to large double drum rollers

THE ONLY PATENTED, 'APPROVED FOR HAUC PLATE' COMPACTOR

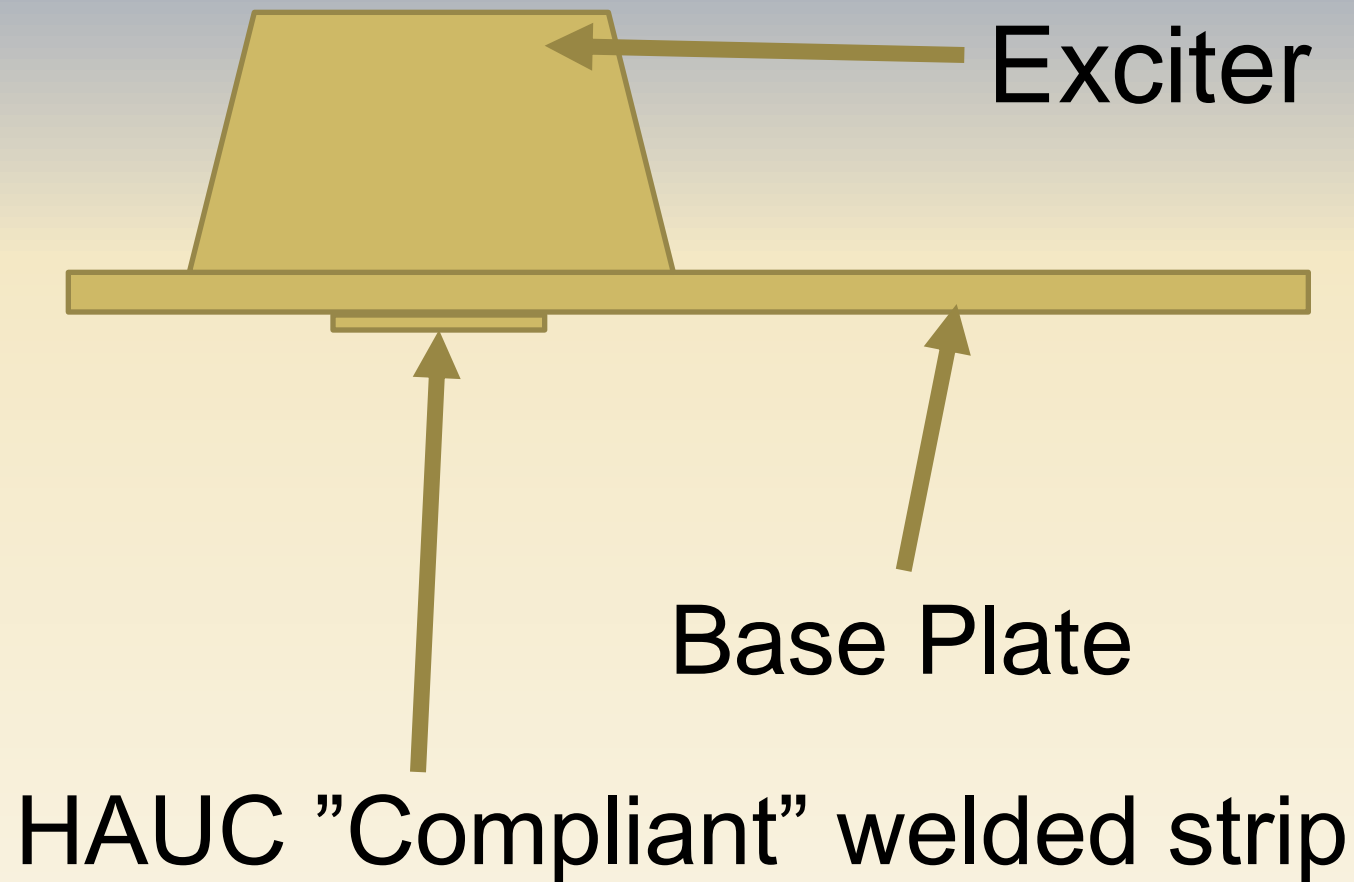
DUAL FORCE

Belle Group studied the act then developed and patented equipment to enable contractors to comply with the act's requirements. The NRSWA legislation requires that compaction equipment meets the minimum specification.

By purchasing an Belle Group 'Dual Force' plate, you are immediately complying with this part of the act. To comply with the specification and maintain surface tolerance, Belle Group 'Dual Force' base plates are divided into two areas providing two stages of compaction.

Stage 1: The full base area compacts the material like a standard machine.

Stage 2: The base rises onto the 'Dual Force' section to give 3 to 4 times the compaction force of standard plates.



- All the low vibration advantages from the Standard PCX range with additional extra high compaction force
- ‘Dual Force’ gives compaction equal to large double drum rollers
- THE ONLY PATENTED, ‘APPROVED FOR HAUC PLATE’ COMPACTOR**

General purpose plate compactor with 450mm wide base plate. **HAUC compliant option available.**

Petrol engine

Base plate size l x w: 500mm x 450mm

Compaction force: 16.5kN

Noise level: 101dBA

Vibration level: 6.05m/s²

Weight: 83kg

Paving pad available

Compliant Equipment



NG 10-1

- 1) Research has shown that failure to operate and maintain compaction equipment in accordance with manufacturer's schedules and recommended practices is likely to result in inadequate compaction with serious implications for the short term performance of individual structural layers and the long term integrity of the entire reinstatement.
- 2) All compaction equipment covered by this specification must be frequently checked , adjusted and maintained, as necessary, in accordance with the manufacturer's recommended practices.
- 3) All compaction equipment covered by the specification must be used in accordance with the manufacturers recommended operation procedures

Material Lifts / Compaction

It will make no difference what compaction equipment you are using on sub base if the material lifts / passes are not adhered too.

Appendix A8 gives the lifts of 100 mm and 200mm if the lifts are deeper then the reinstatement will fail.

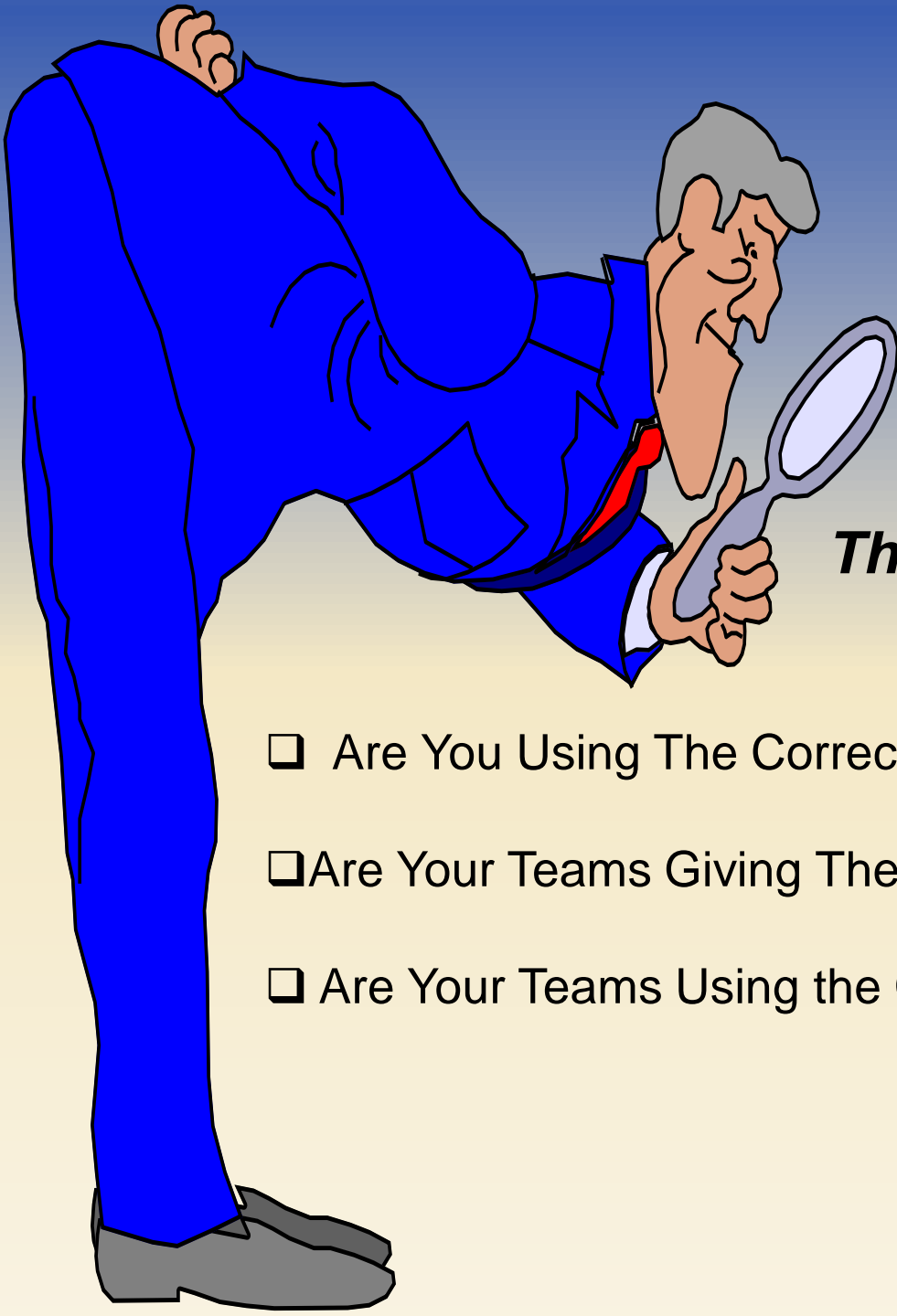
Passes, this means a complete compaction pass of the whole excavation.

Material Lifts / Compaction

All back fill material we use is designed to “lock” together when a force is applied (compaction) the reason for material lifts depths is so compaction is kept at a constant, at say 400 mm only the top 150mm to 200mm will be compacted, the lower level will stay un-compacted with air voids, eventually the bottom of the compacted area will migrate into the un-compacted layer this will result in the whole sub base failing.

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Things You Need To Check

- Are You Using The Correct Compaction Equipment ?
- Are Your Teams Giving The Correct Number Of Passes ?
- Are Your Teams Using the Correct Lifts of Materials ?



Conclusions

The point of today's presentation is to show how incorrect / lack of compaction can cause failures in reinstatements, I have not discussed the cost and disruption caused by what could effectively be resolved with a simple, Tool Box Talk.

**I have yet to see the correct Lifts
and compaction passes used**

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TOOLBOX TALK

This Presentation is being added to the West Midlands HAUC Website where can view and use it.

www.wmhauc.org

If You Need and Information Please Contact Me / Materials Group Members

Make A Note In Your Diary !!

This years West Midlands
HAUC Road show will be
held at

Wolverhampton Race
Course (Dunstall Park).

24th September 2015

Information

You can find all the information from
SROH :

S10-1 to S10- 3.6

A 2.5 to A2.6.2

Appendix A 8 - A 8.3 Appendix A 9-1 & ii

NG 1.6 NG 2.5 NG 10 all NGA 8

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S10 Compaction Requirements

S10.1 Introduction

- 1) All compaction equipment covered by this Specification shall be checked, adjusted, maintained and operated in accordance with working practices, maintenance schedules, operating procedures and vibrating frequencies recommended by the equipment manufacturer. Relevant records shall, where available, be provided on request within a reasonable period of time to the Authority.
- 2) If available, records can demonstrate to the Authority that the Undertaker is using calibrated equipment. If data is not available the Authority may monitor more closely to check on compaction.
- 3) All equipment and operating procedures used for the compaction of all reinstatement materials laid above the surround to apparatus shall comply with the following requirements:

S10.2 Compaction of Materials

For all materials, compaction shall be carried out in accordance with the requirements of Appendix A2 and/or Appendix A8, immediately after the material has been placed.

S10.2.1 Unbound Granular and Cohesive Materials

- 1) All Class A Graded Granular Materials, Class B Granular Materials and Class C Cohesive/Granular Materials shall be compacted in accordance with the relevant requirements of Appendix A8, Table A8.1.
- 2) All Class D Cohesive Materials shall be compacted in accordance with the relevant requirements and restrictions of Appendix A8, Table A8.1.
- 3) Where access is restricted, including small excavations and trenches less than 200 mm wide, compaction shall be in accordance with the restricted access provisions of Appendix A8, Table A8.1.

S10.2.2 Alternative Reinstatement Materials

- 1) Certain Structural Materials for Reinstatements (SMRs) and Stabilised Materials for Fill (SMFs) may not require the full compaction specified in Appendix A8, Table A8.1 and may be damaged if compaction is continued. Such materials should be placed and compacted in

accordance with the manufacturer's recommendations and with due regard to the requirements of Appendix A9.

- 2) Foamed concretes (FCRs) shall not be compacted or tamped unless specifically required by the manufacturer. Thereafter, such FCR materials shall be placed and compacted in accordance with the manufacturer's recommendations and with due regard to the requirements of Appendix A9.

S10.2.3

Bituminous Materials

- 1) All bituminous materials permitted by Appendix A2 shall be laid and compacted in accordance with the relevant requirements of Appendix A2, Tables A2.1, 2.3 and A2.4, and Appendix A8, Section A8.3.
- 2) The in-situ air voids content for all bituminous materials as permitted in Appendix A2 shall comply with the requirements shown in Table S10.1. The in-situ air voids content shall be calculated as the average from all results obtained. The maximum density shall be determined in accordance with EN 12697 – 5 Procedure A, in water. For reference purposes and in the event of dispute the bulk density shall be determined in accordance with EN12697 – 6 Procedure C sealed specimen. The maximum density and core bulk density shall be used to determine air void content in accordance with EN12697-8.

Table S10.1 In-Situ Air Voids Content Requirements

Bituminous Materials	Permitted Air Voids			
	Carriageways		Footways	
	Max %	Min %	Max %	Min %
AC 6 dense Surface Course	NP	NP	13	2
AC 10 close Surface Course	11	2	NP	NP
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 NG A8.3			
Note to Table S10.1 – NP = not permitted				

- 3) All surface course materials used at binder course level shall comply with the in-situ air voids content requirement for the relevant surface course material.
- 4) To determine the in-situ air void content core samples shall be taken at a rate of 1 per 6 m² or part thereof. The average void content shall be calculated for each reinstatement covered by a single notice. All core samples shall be 100 mm minimum diameter with no part of any core being within 100 mm of any surface apparatus within the reinstatement. Where there is a potential to encounter the edge of the frame or apparatus then this distance should be increased accordingly.
- 5) Unless agreed otherwise, all air voids testing shall be carried out by a laboratory holding current UKAS accreditation for the specified test methods.
- 6) Where the prevailing weather conditions or other site circumstances are considered likely to militate against the successful laying and compaction of any surfacing materials and the achievement of the required in-situ air voids content, consideration should be given to deferring the permanent surface reinstatement and, if necessary, to an agreed extension of the interim reinstatement period.

S10.2.4 Cementitious Materials

- 1) Pavement quality concrete, laid as the surface slab of road, footway, footpath or cycle track reinstatements, shall be compacted using a proprietary vibrator, selected and operated in accordance with the manufacturer's recommendations. However, proprietary vibrators may be unsuitable for concrete sections less than 100 mm wide or less than 0.5 square metres in area. In such cases, as a minimum requirement, all concrete shall be thoroughly tamped by hand.
- 2) Cement-bound granular materials, including CBGM B shall be compacted in accordance with the relevant requirements of Appendix A8, Table A8.1.

S10.2.5 Modular Surfacing Materials

Compaction equipment shall be operated in accordance with the manufacturer's instructions.

S10.3 Equipment Operation and Restrictions

- 1) All compaction equipment shall be used in accordance with the requirements of Appendix A8.
- 2) Additional guidance on compaction procedures is included in Section NG10.3.

S10.3.1 Hand Rammers

Except as permitted in Sections S2.2.1 (4), S10.2.2 and S10.2.4 (1), hand rammers shall be permitted to assist the initial placement of material only.

For all materials, full compaction shall be applied, in accordance with the relevant requirements of Appendix A8.

S10.3.2 Percussive Rammers

Percussive rammers shall be permitted for the compaction of reinstatement materials, in accordance with the following requirements:

- a) The nominal mass shall not be less than 10 kg.
- b) The width of the foot shall not exceed 200 mm.
- c) The contact length of the foot shall not exceed 200 mm.

S10.3.3 Vibrotampers

Vibrotampers shall be permitted for the compaction of reinstatement materials, in accordance with the following requirements:

1) 50 kg Minimum Nominal Mass

- a) The width of the foot shall not exceed 5 mm per kg of the nominal mass.
- b) The contact length of the foot shall not exceed 350 mm nor be less than 175 mm.
- c) The foot contact area shall not exceed 1000 sq. mm per kg of the nominal mass.
- d) The mass of any extension leg shall not exceed 10% of the nominal mass.

2) 25 to 50 kg Nominal Mass – permitted in areas of restricted access only

- a) The width of the foot shall not exceed 150 mm.
- b) The contact length of the foot shall not exceed 200 mm.

S10.3.4 Vibrating Rollers

Vibrating rollers shall be permitted for the compaction of reinstatement materials, in accordance with the following requirements:

1) Single-Drum Vibrating Rollers

- a) Single drum vibrating rollers shall include a mechanical means of applying vibration to the roll. Single-drum rollers without a specific vibration unit shall be considered to be single-drum deadweight rollers and shall not be permitted for reinstatement purposes.
- b) The minimum mass of a single-drum vibrating roller shall be 600kg per metre (kg/m) width.

2) Twin-Drum Vibrating Rollers

- a) Twin-drum vibrating rollers shall include two vibrating rolls. Twin-drum rollers in which only one roll vibrates shall be considered to be single-drum vibrating rollers.

- b) The minimum mass of a twin-drum vibrating roller shall be 600 kg/m width.

3) All Vibrating Rollers

- a) The mass per metre width of a vibrating roller shall be calculated by dividing the total mass supported by the roll(s) by the total width of the roll(s).
- b) A minimum mass of 600 kg/m width is required for vibrating rollers for the compaction of bituminous material. Where existing roads, footways, footpaths or cycle tracks may be marked or otherwise damaged by the use of 600 to 1000 kg/m vibrating rollers, the Authority shall notify the Undertaker accordingly, whereupon the use of lower weight vibrating rollers shall be agreed.

S10.3.5 Vibrating Plate Compactors

Vibrating plate compactors of 1400 kg/m² minimum mass shall be permitted for the compaction of reinstatement materials.

S10.3.6 Other Compaction Equipment

Other compaction equipment, including machine-mounted compactors and all other compaction devices not specifically referenced within Appendix A8, may be permitted for the compaction of reinstatement materials, subject to the requirements of Section NG10.

Compaction Requirements

A8.1

Granular, Cohesive and Cement Bound Materials

All graded granular, granular, cohesive/granular, cohesive and cement bound materials laid above the surround to apparatus shall be compacted in accordance with Table A8.1.

Table A8.1 – Compaction Requirements for Granular and Cement Bound Materials						
Compaction Plant and Weight Category	Cohesive Material (less than 20% granular content)			Granular Material (20% or more granular content including cement bound material)		
	Minimum Passes/Lift for compacted lift thickness up to			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
Vibrating Roller Single Drum						
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

Table A8.1 – Compaction Requirements for Granular and Cement Bound Materials

Twin Drum 600-1000 kg/m 1000-2000 kg/m Over 2000 kg/m	NP 4 2	NP 8 3	NP NP 5 #	6 3 2	NP 6 3	NP NP 4
Vibrating Plate 1400-1800 kg/m ² Over 1800 kg/m ²	NP 3	NP 6	NP NP	5 3	NP 5	NP 7
All Above Plant	For Maximum and Minimum compacted lift thickness See Appendix A2.6, Table A2.2					
Alternative Compaction Plant for Areas of Restricted Access (including small excavations and trenches less than 200 mm width)						
Vibrotamper 25 kg minimum	Minimum of 6 compaction passes Maximum of 100 mm compacted lift thickness					
Percussive Rammer 10 kg minimum						
Notes for Table A8.1: 1) NP = Not Permitted 2) # = Not permitted on wholly cohesive material i.e. clay and/or silt with no particles > 75 micron (µm) 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						

A8.2

Chalk Materials

All chalk materials, including medium and high-density chinks shall be compacted in accordance with Table A8.2. However, if the chalk is unstable after compaction, the unstable material shall be removed and replaced with fresh material. The fresh chalk shall be compacted in accordance with Table A8.2, except that the specified number of compaction passes shall be reduced by one pass. If the chalk is still unstable after compaction, it shall be deemed to be unsuitable for use as backfill and replaced with suitable material.

Table A8.2 – Compaction requirements for Chalk Materials

Compaction Plant and Weight Category	Chalk Material		
	Minimum Passes/Lift For compacted lift thickness up to		
	100 mm	150 mm	200 mm
Vibrotamper 50 kg minimum	3	6	NP
Vibrating Roller Single Drum 600-1000 kg/m 1000-2000 kg/m 2000-3500 kg/m Over 3500 kg/m	12 6 NP NP	NP 8 4 NP	NP NP 6 4
Twin Drum 600-1000 kg/m 1000-2000 kg/m Over 2000 kg/m	6 2 NP	8 4 3	NP 6 4
Vibrating Plate 1400-1800 kg/m ² Over 1800 kg/m ²	6 NP	8 6	NP 8
Alternative Compaction Plant for Areas of Restricted Access (including small excavations and trenches less than 200 mm width)			
Vibrotamper 25 kg minimum	Minimum of 6 compaction passes Maximum of 100 mm compacted lift thickness		
Percussive Rammer 10 kg minimum			
Notes for Table A8.2: 1) NP = Not Permitted 2) Single drum vibrating rollers are vibrating rollers providing vibration on only one drum 3) Twin drum vibrating rollers are vibrating rollers providing vibration on two separate drums			

Bituminous Mixtures

All bituminous mixtures for permanent reinstatements permitted in Appendix A2 shall be compacted to the in-situ air void requirements of Section S10.2.3. Guidance on compaction procedures that may be capable of achieving the specified air voids values is given in NG A8

Compaction should be discontinued if the mixture shows any signs of distress, regardless of whether the minimum number of passes suggested in NG A8 have been applied; see Section NG10.2.3.

Compacted materials shall be capable of being wet flush cored as follows:

- i) hot materials – upon reaching ambient temperature;
- ii) PCSMs – at 6 months from the date of the permanent reinstatement.

NG10 Compaction Requirements

NG10.1 Introduction

- 1) Research has shown that failure to operate and maintain compaction equipment in accordance with manufacturer's schedules and recommended practices is likely to result in inadequate compaction with serious implications for the short term performance of individual structural layers and the long term integrity of the entire reinstatement.
- 2) All compaction equipment covered by this Specification must be frequently checked, adjusted and maintained, as necessary, in accordance with the manufacturer's recommended practices, in order to ensure that the manufacturer's recommended operating frequency is maintained throughout each compaction operation.
- 3) All compaction equipment covered by this Specification must be used in accordance with the manufacturer's recommended operating procedures.

NG10.2 Reinstatement Materials

NG10.2.1 Unbound Granular and Cohesive Materials

For granular or cohesive materials, a vibrating roller may be unsuitable in small excavations because of the restricted manoeuvrability of large heavy rollers required to achieve adequate levels of compaction with an acceptable number of passes.

NG10.2.2 *There are no Notes for Guidance*

NG10.2.3 Bituminous Mixtures

- 1) With some combinations of compaction plant and certain types of bituminous mixtures if compaction is continued as the material approaches its maximum density the following may result:
 - a) The migration of fines or binder to the surface.
 - b) The development of shear surfaces and or crushing of aggregates.

- 2) Provided that the material has been laid and compacted within the appropriate temperature range, fewer passes will be required when any signs of distress become apparent.
- 3) Asphalt maximum density values, used in the calculation of air voids content, are specific to particular asphalt mixtures incorporating constituents from specific sources. Any variation in mix proportions or constituents requires the maximum density to be re-established.
- 4) Although consistent asphalt supply may allow an established maximum density for a particular mixture and source to be used for some time in routine situations, the definitive method to be used in the event of dispute will require the maximum density to be determined for the mixture actually used. The maximum density may be determined from bulk samples, if available, or from material obtained from additional core samples.
- 5) When taking cores near surface apparatus, Section S10.2.3(4) requires a minimum clearance of 100mm to avoid damaging the apparatus or structure it is bedded on. However it is possible that some surface apparatus may have wider than normal flanges and there may be instances where a greater clearance is required to avoid damage. If doubt exists, liaison with the owner of the apparatus should be undertaken in advance.

NG10.2.4 *There are no Notes for Guidance*

NG10.2.5 Modular Surfacing Materials

Depending on the size and type of paving module to be laid, and/or the extent of the area to be surfaced etc., the use of additional mechanical compaction may become necessary.

NG10.3 Equipment Operation and Restrictions

- 1) A single pass of any compaction plant is deemed to be completed when the foot, roll or plate of the compactor has impacted the entire surface area of the layer.
- 2) Where the excavation width is more than 50 mm greater than the foot, roll or plate width (i.e. side clearances between the compacting surface and the wall of the excavation exceed 25 mm per side), two or more traverses of the compaction device will be required to ensure coverage of the entire surface and all will be deemed to constitute a single pass.
- 3) Compaction plant should be steered along a line offset from that steered on the previous pass so that alternate passes are run close in to each side wall of the excavation.
- 4) Small items of compaction plant will frequently be required and additional provisions must be considered for use in trenches of less than 200 mm width, small excavations and other areas of restricted access. In general, lightweight vibrotampers and poletampers are capable of achieving the same degree of compaction as the heavier items of plant specified in Appendix A8. However, small plant is usually not self-advancing and therefore more difficult to operate effectively.

NG10.3.1 Hand Rammers

- 1) Hand rammers may be used for initial tamping of fine fill material or immediately adjacent to street furniture, reinstatement edges etc.
- 2) In all cases, full machine compaction complying with Appendix A8 will normally be applied immediately after the required thickness of material has been built-up. However, hand ramming alone may be necessary around standpipes and other isolated fixed features.

NG10.3.2 Percussive Rammer

- 1) A percussive rammer is deemed to be a hand-held and/or pedestrian guided machine in which an electric, pneumatic or hydraulically operated reciprocating mechanism acts on a plate or 'foot'.
- 2) Percussive rammers may only be used to provide full machine compaction in areas where restricted access prevents the effective use of conventional compaction equipment.

NG10.3.3 Vibrotamper

- 1) A vibrotamper is deemed to be a free-standing, pedestrian guided machine in which a reciprocating mechanism, driven by an integral engine or motor, acts on a spring system through which oscillations are set up in a base plate or 'foot'.
- 2) Vibrotampers may be operated at reduced speed, for the first pass only, with cohesive materials.
- 3) Vibrotampers are not preferred for any permanent surface course application or any other application involving a layer thickness of less than 50 mm.

NG10.3.4 Vibrating Roller

- 1) A vibrating roller is deemed to be a self-propelled, pedestrian steered machine with a means of applying mechanical vibration to one or more rolls.
- 2) Vibrating rollers should be operated in the lowest available gear, except for the first pass, which should be at maximum forward speed.
- 3) All compaction passes should be carried out with full vibration, except for the first pass, which should be carried out without vibration in order to nip in the material adjacent to the reinstatement edges and to prevent uneven displacement of material within the remainder of the reinstatement area.
- 4) Vibrating rollers are the preferred method of compaction for all permanent surface courses.
- 5) The use of twin drum rollers is preferred to single drum for the compaction of bituminous mixtures and will improve the quality of the permanent surface course. However, single drum vibrating rollers are permitted, as detailed in Appendix A8.

NG10.3.5 Vibrating Plate Compactor

- 1) A vibrating plate compactor is deemed to be a pedestrian guided plate equipped with a source of vibration consisting of one or more rotating, eccentrically weighted shafts.
- 2) Vibrating plate compactors should be operated in the lowest available gear, except for the first pass, which should be at maximum forward speed.

NG10.3.6 Other Compaction Equipment

Compaction plant not referenced in Appendix A8, including machine-mounted, modified and other alternative compaction equipment, may be permitted for the compaction of reinstatement materials, in accordance with the following relevant requirements:

1) **Machine-Mounted Compactors**

A machine-mounted compactor is deemed to be any compaction equipment that is mounted, as an attachment or accessory, to the chassis or front or rear booms of an excavator, tractor, skid-steer vehicle or other proprietary vehicle, for the purposes of compaction.

All machine-mounted compactors, whether integral to the vehicle design or special attachments for front or rear mounting to the chassis or booms of any excavator, tractor or skid-steer vehicle etc. should be operated in accordance with the recommendations of the compactor or attachment manufacturer, to the relevant compaction procedure required by Appendix A 8. However, other operational variables should also be considered prior to the operation of such plant as follows:

a) **Compactor Downforce**

The total downforce will vary depending upon the weight of the vehicle chassis or compactor frame, and any additional downforce applied by hydraulic rams etc. However, changes in the configuration of any vehicle, by the addition or removal of other accessories etc, changes in the width of the vibrating foot, roll or plate etc, movement of any boom resulting in a significant change of loading geometry or outreach etc, attaching of the compactor to other vehicles of differing types or weights etc, can all result in a significant reduction of compactive performance that is seldom apparent. All operators should be aware of the potential reduction in compactive performance resulting from such changes in configuration.

b) **Applied Downforce**

The mounting of compaction equipment to the front loader arms of an excavator, where the downforce is sensibly limited by the lifting of the front wheels, is preferred. All compactors mounted to the backhoe of an excavator should be fitted with a downforce-limiting device, correctly set, or with a simple indicating device allowing the amplitude to be estimated.

c) **Compactor Set-up**

Where vibration frequency or amplitude, or any other parameter affecting the dynamic output of a compactor, is expected to be adjusted on a routine basis, all parameters should be set in accordance with the manufacturer's recommendations unless specific testing, meeting the requirements of Section NG1.6.3, has shown other settings to be at least as effective.

2) **Modified Compaction Equipment**

Modified compaction equipment shall include any proprietary vibrotamper, vibrating roller, vibrating plate compactor, percussive rammer or other compaction plant which has been adapted, converted, revised or otherwise changed from the original manufacturer's Specification, resulting in a significant change to the original configuration, dimensions, operational weight or power output.

Modified compaction equipment shall be permitted, provided it is operated in accordance with compaction procedures meeting the following requirements:

- a) The original manufacturer shall provide written confirmation that the modified compaction equipment, operated in accordance with the original compaction procedure, is capable of achieving the same degree of compaction as any other option permitted in Appendix A8, or
- b) A revised compaction procedure is developed in accordance with the requirements of Section NG1.6.

3) **Alternative Compaction Equipment**

Alternative compaction equipment shall include all other compaction devices not specifically permitted within Section NG10.3. Alternative compaction equipment may be permitted, provided it is operated in accordance with compaction procedures developed in accordance with the requirements of Section NG1.6 (3).

NGA8 Compaction Requirements

NGA8.1-NGA8.2 *There are no Notes for Guidance*

NGA8.3 Bituminous Mixtures

Table NGA8.3 provides guidance for compaction procedures that may be capable of achieving the specified air voids values.

Table NG A8.3 Compaction requirements for Bituminous Mixtures				
Compaction Plant and Weight Category	Bituminous Mixtures			
	Minimum Passes/Lift for compacted lift thickness up to			
	40 mm	60 mm	80 mm	100 mm
Vibrotamper 50 kg minimum	5 #	7 #	NR	NR
Vibrating Roller				
Single Drum				
600-1000 kg/m	10	12	NR	NR
1000-2000 kg/m	6	10	NR	NR
2000-3500 kg/m	5	7	8	NR
Over 3500 kg/m	4	6	7	NR
Twin Drum				
600-1000 kg/m	5	7	NR	NR
1000-2000 kg/m	4	5	6	8
Over 2000 kg/m	3	4	4	6
Vibrating Plate				
1400-1800 kg/m ²	6	NR	NR	NR
Over 1800 kg/m ²	3	5	6	8

Table NG A8.3 Compaction requirements for Bituminous Mixtures

All Above Plant	For Maximum and Minimum compacted lift thickness See Appendix A2.6, Table A2.1
Alternative Compaction Plant for Areas of Restricted Access (including small excavations and trenches less than 200 mm width)	
Vibrotamper 25 kg minimum	Minimum of 6 compaction passes Maximum of 75 mm compacted lift thickness
Percussive Rammer 10 kg minimum	
Notes for Table NG A8.3: 1) NR = Not Recommended 2) # = Vibrotamper not recommended on permanent surface course of trenches > 500 mm width 3) Twin drum vibrating rollers are preferred for compaction of bituminous mixtures 4) Single drum vibrating rollers are vibrating rollers providing vibration on only one drum 5) Twin drum vibrating rollers are vibrating rollers providing vibration on two separate drums	