Technical Note 171

Use of High Standard Granular (HSG) Bases in Heavy Duty Unbound Granular Pavements

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Queensland Government

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1 Introduction

Unbound granular and lightly bound pavements with sprayed bituminous surfacings make up the majority of the road network in Queensland, particularly in rural and regional areas. These pavements provide important access for freight and passenger transport through both dry and wet conditions.

Historically, unbound granular pavements have been constructed in accordance with the pavement material requirements specified in MRTS05 *Unbound Pavements* using either standard pavement materials (Type 1, 2 or 3) or non-standard materials (Type 4).

The purpose of this Technical Note is to provide guidance regarding the specification and use of pavements containing 'High Standard Granular' (HSG) materials in heavy-duty unbound granular pavement applications.

This Technical Note is intended to complement the requirements for heavy-duty unbound granular pavements [SG(HD)] covered in Transport and Main Roads *Pavement Design Supplement*.

The requirements of this Technical Note have been developed from, and benchmarked against:

a) Learnings from the TrackStar Alliance Project (Centenary Motorway Duplication Stage 2 - Darra to Springfield Transport Corridor), where a heavy duty unbound granular pavement was constructed in 2013. The pavement has subsequently been monitored under the TMR/ARRB NACoE research project titled *Queensland Trial of High-Standard Granular Base: TrackStar Alliance Project*.

b) Consistency with national standards as detailed by Austroads and other Australian State Road Authorities for similar pavements. Alignment with other state road authority specifications not only builds on their proven experience and performance history, but is also intended to reduce barriers between jurisdictions and help provide opportunities for economies of scale to be developed.

2 Specification of high standard granular (HSG) material

2.1 General requirements

Austroads (2012) refers to high standard granular (HSG) material as a high standard crushed rock with the following properties:

a) manufactured from sound and durable igneous and metamorphic rock

b) high durability, strength and shear strength, specified in a way that includes plasticity, permeability, modulus and performance under repeated loading at the in-service moisture content

c) manufactured in a highly processed and controlled manner to tight tolerances with respect to durability, hardness, grading, Atterberg limits and so on

d) placed to very high standards with respect to density, degree of saturation, level, thickness, shape, surface evenness and so on (for example, a minimum insitu density of 100% (modified) compaction)

e) constructed with a very high level of quality control using on-site testing facilities and quality assurance based on lot testing of stockpiled materials, and

f) part of an overall design that addresses essential issues including:

   i. protection from the infiltration of water from all sources (side, below and surface)

   ii. the support required/provided by the construction platform

   iii. the suitability of the surfacing course.

2.2 Technical specification MRTS05

The publication of this Technical Note aligns with updates to Transport and Main Roads Technical Specification MRTS05 *Unbound Pavements* that introduce default specification requirements for HSG pavement materials.

The specification of HSG material through these updates is structured as follows:

- deletion of Subtype 1.2 material
- modification of previous Subtype 1.1 to become the specification for HSG, now referred to as 'Type 1 (HSG)'
- Type 1 grading revised and minimum/maximum linear shrinkage limits specified
- modified compaction standard specified
- specific construction requirements specified for HSG materials.

3 Adoption of default specification requirements

Prior to specifying 'Type 1 (HSG)' in accordance with the default requirements of MRTS05 *Unbound Pavements*, the Principal and Designer should consider the following:

- relevant local experience in the construction of high standard granular materials, including the availability of experienced placement Contractors
- the ability to procure the material locally, noting that in some areas of the state local procurement of the material may not be possible or cost effective
- the scale of the project being undertaken, and the quantity of material required, bearing in mind that specific production runs may be required to produce this material, and it is unlikely to be available at short notice, and
- local experience may warrant additional controls over and above the default requirements specified in MRTS05 *Unbound Pavements* (additional requirements should be specified using Annexure MRTS05.1)
- the likely maintenance regime over the life of the pavement.

It is envisaged that the default specification requirements given in MRTS05 *Unbound Pavements* would not be relaxed without the specific consent of Transport and Main Roads.

While the default specification requirements are intended to provide a premium unbound granular pavement product, consideration should be given as to the overall suitability of Type 1 (HSG) pavement materials on a project by project basis. The specification of heavy duty unbound granular pavements should be managed through the use of these pavements on projects with increasing risk profiles.

For example where there is limited local experience constructing heavy duty unbound granular pavements, the initial use of the material is recommended on moderately trafficked roads ahead of its full scale use on major highway type projects.

4 Technical requirements for HSG base layers

4.1 Specification requirements

Construction of the base course in heavy duty unbound granular pavements requires the use of hard, durable and uniformly constituent materials, along with the implementation of construction practices that deliver high density and homogeneity within the pavement.

To achieve this intent, the following requirements for Type 1 (HSG) materials are provided by the MRTS05 Technical Specification:

a) The HSG material shall:

   i. have a relatively fine particle size distribution (specified by the allowable grading envelope)

   ii. conform to both a minimum and maximum linear shrinkage requirement

   iii. incorporate the appropriate quality and quantity of fines

   iv. be well-mixed using a pugmill or equivalent mechanical process to assure the homogenous incorporation of water and fines into the pavement material, and a homogeneous end product.

b) Each layer shall conform to a higher compaction standard than standard unbound granular materials (specified using modified compaction).

c) Layers are to be constructed using a self-propelled spreading machine (that is, a paver), to reduce segregation, increase the consistency of the insitu material properties, provide reliable thickness control and improve ride.

d) The upper and lower base layers are to be constructed within three days of one another.

e) A default Degree of Saturation (DoS) limit consistent with the recommendations of APRG (2003) is specified. For large scale projects, a process is specified for selecting a material specific maximum DoS limit through the use of Repeat Load Triaxial (RLT) testing.

f) Prior to undertaking any sprayed bituminous surfacing works, a surface hardness measurement is required using the ball penetration test method.

4.2 Design requirements

The following design requirements would typically be adopted for Type 1 (HSG) materials used in heavy duty unbound granular pavements:

a) adoption of a typical pavement structure in accordance with Transport and Main Roads *Pavement Design Supplement*

b) use of a maximum design modulus of 500 MPa for Type 1 (HSG) materials

c) specification of a minimum base course thickness of 200 mm, constructed in two layers, which promotes:

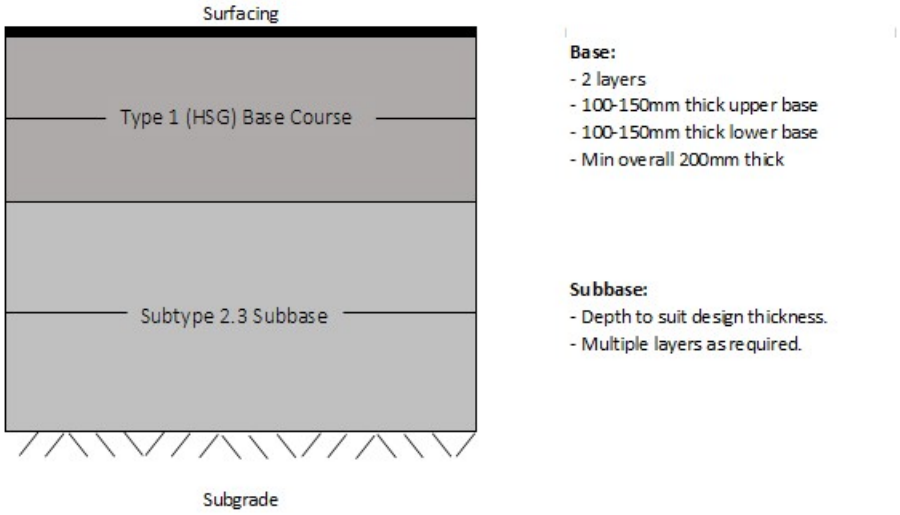
   i. higher insitu densities being achieved with less effort

   ii. improved moisture control, and

   iii. improved layer consistency including final surface evenness.

The typical configuration of a heavy duty unbound pavement incorporating Type 1 (HSG) material is shown in Figure 4.2.

Figure 4.2 – Typical configuration for a heavy duty unbound granular pavement incorporating high standard granular (HSG) material



5 Protection from moisture

High standard granular pavement materials can potentially be highly permeable, especially during construction. To help overcome this, minimum plasticity requirements and a higher compaction standard are specified.

When in service, HSG materials are likely to fail rapidly if the wearing course fails and water is allowed to enter the pavement. Maintenance is important.

The overall performance of heavy duty unbound pavements depends largely on the degree of saturation limits not being exceeded in any pavement layer (particularly in base layers) during the life of the pavements. This requires protection from moisture ingress from the subgrade, surface and sides of the pavement such that the required moisture content is not exceeded. To achieve this, the following is recommended:

a) protection of HSG material stockpiles by covering them with a tarpaulin or a similar waterproofing material

b) avoiding placement and compaction of pavement materials when heavy rain is expected during or immediately after placement

c) adequately designing, constructing and maintaining surface and subsurface drainage including pavement drains

d) controlling moisture across the pavement cross section, for example:

   i. in rural environments – placing unbound granular pavement material across the full width of the formation and 'daylighting' the shoulders so that moisture can drain out of each layer at the shoulder

   ii. in urban environments – designing and constructing well-drained subsoil drains below kerbs and channels

   iii. in cuttings – providing adequate subsoil drainage by designing a high-permeability drainage blanket and/or pavement drains as required, providing open table drains where practical

e) ensuring adequate pavement crossfall is provided

f) ensuring there is no standing and/or ponded water in table drains, the subsoil drainage system and within 10 m of the edge of the pavement

g) where necessary, providing protection from moisture absorbed through soil suction, for example, by installing a full width drainage layer over the subgrade

h) ensuring the surfacing is adequately designed, constructed and maintained throughout the life of the pavement

i) managing the risk of excess moisture during construction, for example by:

   i. planning the construction works to avoid the periods of the year when higher rainfall is likely

   ii. monitoring rainfall forecast as well as actual rainfall on site

   iii. constructing the pavement to its full depth (including the surfacing) in shorter sections to reduce the risk of exposure to inclement weather

   iv. ensuring there are provisions to rectify (for example, dry back, repair and/or reconstruct) the unbound granular pavements when rain falls on an unprotected section prior to covering

j) not opening the pavement to traffic prior to construction of the surfacing.

6 Construction

6.1 Construction practices

When properly constructed, a HSG base provides a dense, low-permeability, structural layer with increased durability, strength and stiffness. Greater insitu density is a key characteristic of the HSG material, which is mainly achieved through the use of appropriate materials and careful attention to construction practices. These characteristics have a significant effect on the long-term performance of the pavement (Austroads 2008a) and can be achieved through:

a) Proper construction of the HSG base following a rigorous process requiring strict adherence to specifications (Austroads 2012). The major construction activities of laying, compacting, finishing, and quality control testing should be undertaken in accordance with best practice for unbound granular pavements.

b) Recognising that achieving a higher density in unbound granular pavements typically costs more due to:

   i. the need for more, higher energy and/or heavier compaction equipment

   ii. the need for more consistent pavement material

   iii. the dry back period may be longer due to a lower rate of evaporation from denser pavement layers and because more water overall may have to be removed to achieve the required dry back condition.

c) Restricting access to construction traffic while the pavement is being dried back to the required DoS limit and prior to the surfacing being applied.

d) During construction, undertaking appropriate supervision, surveillance and auditing.

6.2 Construction procedure and trail pavement construction

To ensure the intended specification outcomes are consistently achieved for Type 1 (HSG) materials, MRTS05 *Unbound Pavements* requires an unbound pavement construction procedure to be developed and submitted to the Administrator for acceptance prior to the commencement of works.

This construction procedure is intended to be demonstrated through the construction of a trial pavement.

6.3 Construction supervision, auditing and surveillance

When constructing heavy duty unbound granular pavements incorporating Type 1 (HSG) materials, it is recommended that a risk based auditing and surveillance approach is adopted. For Transport and Main Roads projects, this would typically involve auditing a minimum of 10% of all construction lots. On higher risk projects or where there is only limited local experience using these materials, consideration should be given to increasing this frequency.

In addition, audit samples should be taken and stored at least for the duration of the projects defect liability/correction period or until such time as the Principal has confidence in the performance of the pavement.

For heavy duty unbound granular pavements, auditing and surveillance should cover the full construction process, including:

- subgrade preparation and testing (if applicable)
- unbound pavement material production and placement
- surface preparation and finish
- conformance testing
- sprayed seal and/or asphalt surfacing works.

7 Surfacing selection and design

7.1 Surfacing type

Typically for heavy duty unbound granular pavements, a sprayed bituminous surfacing (sprayed seal) would be adopted.

In circumstances where a sprayed seal surfacing is not suitable, a thin asphalt surfacing may be adopted. This would typically be the case when horizontal loading is likely to result in poor performance of a sprayed seal surface. For example, in areas of heavy braking or turning through or near intersections.

In all circumstances where a thin asphalt surfacing is provided, a sprayed bituminous waterproofing seal should be applied over the HSG base prior to placing the asphalt. This would typically involve a prime and single coat (single/single with 10 or 14 mm cover aggregate) spray seal using Class 170 bitumen.

Regardless of the surfacing type that is selected, for heavy duty unbound granular pavements it is important that the surfacing is maintained in a manner that prevents water from entering the pavement.

The surfacing should cover the full width of the formation (including shoulders) to the top of the batters. Where a thin asphalt surfacing is constructed across the traffic lanes, it may be suitable to treat the shoulders with a sprayed bituminous surfacing only.

7.2 Requirements for sprayed bituminous surfacing

Type 1 (HSG) materials typically have a very low unconfined strength. Consequently, a single coat (single/single) seal may not provide adequate confinement, particularly under heavy traffic.

For this reason, the preferred treatment is a prime and double coat (double/double with 14/7 mm cover aggregate) sprayed seal.

The binder to be used in the sprayed bituminous surfacing needs to be selected to provide:

a) an extended service life

b) improved shear resistance for surfacings in high traffic situations

c) a better balance between high and low temperature performance properties

d) the ability to undertake earlier brooming and removal of surplus cover aggregate

e) improved aggregate retention

f) reduced risk of bleeding

g) improved waterproofing.

To achieve these requirements a crumbed rubber or polymer modified bitumen is recommended (for example, PMB Class S35E).

For all sprayed bituminous surfacings, surface preparation is essential. In addition to the specification requirements provided in MRTS05 *Unbound Pavements*, additional guidance can be found in Austroads/AAPA Pavement Work Tips No. 49: *Preparation of Pavements for Priming and Primersealing*.

8 References

APRG, 2003, Technical Note 13 *Control of Moisture in Pavements During Construction*, November.

Austroads, 2008a, Guide to Pavement Technology: Part 4A: G*ranular Base and Subbase Materials*, AGPT04A-08, Austroads, Sydney, NSW.

Austroads 2012, *Guide to Pavement Technology: Part 2: Pavement Structural Design*, AGPT02-12, Austroads, Sydney, NSW.

Austroads/AAPA, 2010, *Pavement Work Tips No 49: Preparation of Pavements for Priming and Primersealing*.

Transport and Main Roads 2017, *Pavement Design Supplement – Supplement to 'Part 2: Pavement Structural Design' of the Austroads Guide to Pavement Technology*, Department of Transport and Main Roads, Brisbane.