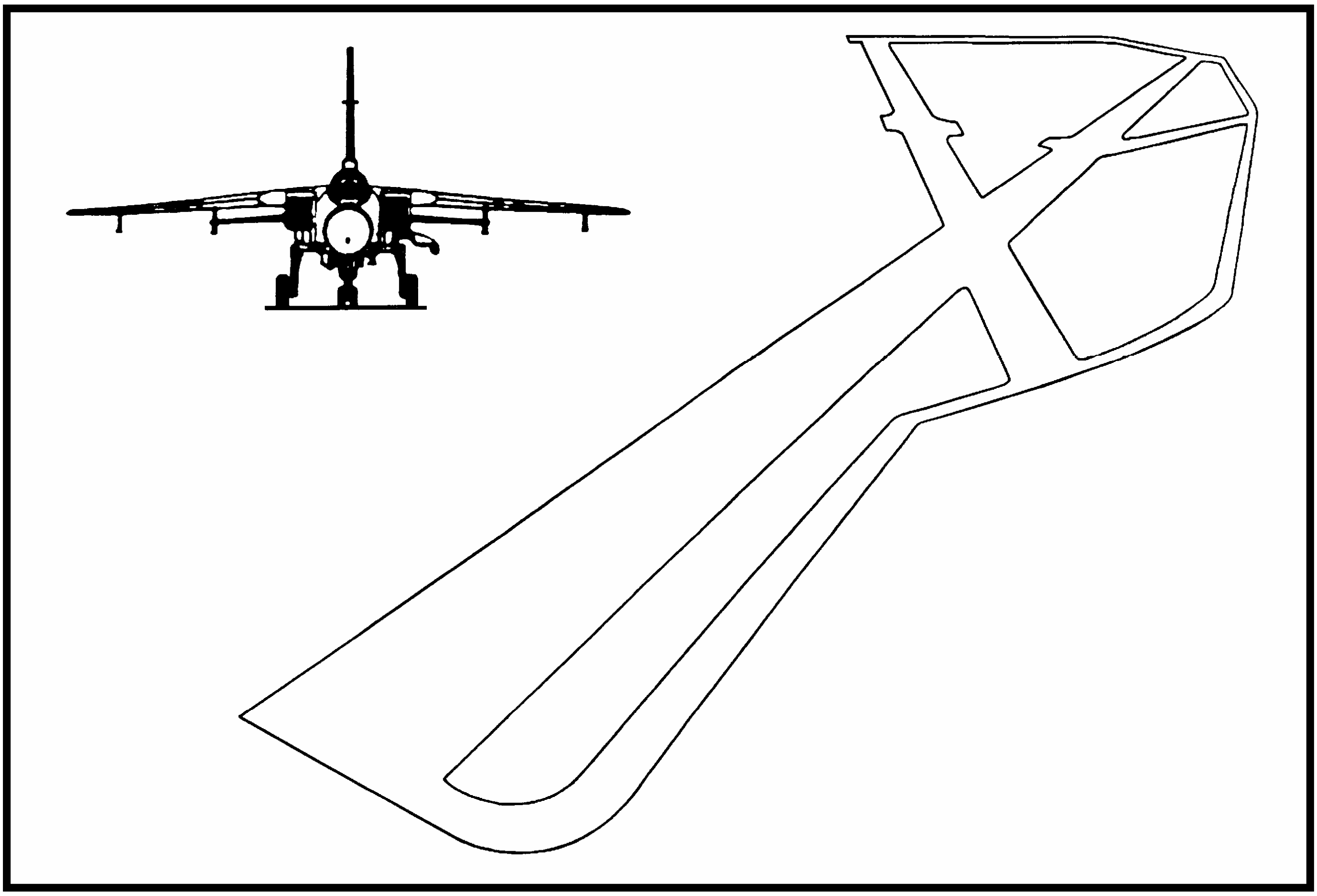
Specification 52



Hydraulically Bound Mixtures for Airfields

DEFENCE INFRASTRUCTURE ORGANISATION
MINISTRY OF DEFENCE

Draft Specification 52

Hydraulically Bound Mixtures for Airfields

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Foreword

This document is for the use of Top Level Budget Holders (TLBHs) for application by the Project Sponsors and their Project/Works Services Managers, Property Managers (PROM), Establishment Works Consultants (EWC), Works Service Managers (WSM) and other parties involved with airfield pavement works.

This draft Defence Infrastructure Specification covers hydraulically bound mixtures (HBMs), apart from those wholly using cement as a binder.. These are a family of materials that may be used for construction of subbase or roadbase layers. The binders used in these mixtures are slag, flyash, and hydraulic road binders referred to in the relevant parts of BS EN14227. Their use is consistent with a desire to use alternative materials from secondary sources. Hence the draft nature of this specification is to support the development of a body of knowledge of their use for airfields.

This specification does not supersede any previous DIO standards. For wholly cement bound HBM reference should be made to DIO Specification 51 Cement Bound Granular Material (Drylean Concrete) for Airfields which supersedes older PSA specifications.

This DIO Specification commenced under the patronage of the then Construction Support Team, Defence Infrastructure Organisation, Ministry of Defence and is for application to airfield pavement works on the MOD estate.

The application and limitations of the specification requirements in this DIO Specification are outlined in Section 1. Further technical assistance regarding the contents of this document can be obtained from DIO. Approaches may be made through local DIO offices or directly to the Airfield Pavement Technical Works Authority (DE TA):Head of Airfield Pavements

Building 49
Airfields Section
P O Box 1734
Sutton Coldfield
West Midlands
B75 7QBL
Tel: 0121 311 2119 or Sutton Coldfield MI 2119

Glossary of Technical Terms

Added Filler	Filler aggregate that is additional to that inherent in the course and fine aggregate
Aggregate / Cement Ratio	The ratio between the total mass of aggregate in a concrete mix and the mass of cement in the mix.
Asphalt	A mixture of coarse and fine aggregate, filler aggregate and bituminous binder used in the construction of flexible pavements for roads and airfields.
Asphalt Concrete	An asphalt mixture consisting of continuous graded aggregate, filler aggregate and bituminous binder proportioned to produce a dense and impermeable surfacing.
Asphalt Surfacing	A porous friction course, surface course, or a combination of these, and a binder course.
Asphaltic Concrete	Alternative name for ‘Asphalt Concrete’.
Base	Structural layer(s) of a pavement immediately below the Binder Course that are bound.
Basecourse	Previous name for ‘Binder Course’.
Bay (of Concrete)	The area of slab bounded by adjacent pairs of longitudinal and transverse joints or grooves.
Bay Layout	The pattern of joints and grooves on a concrete pavement.
Binder	A material used for the purpose of holding solid particles together as a coherent mass.
Binder Course	The layer or layers of the asphalt surfacing immediately below the surface course. (Previously called ‘Basecourse’).
Bitumen	Binder obtained from crude oil by refinery processes.
Bitumen Emulsion	An emulsion in which bitumen is dispersed in water or in aqueous solution with the aid of suitable emulsifying agents.
Bitumen Macadam	See ‘Macadam’.
Bituminous	Containing bitumen. (Previously included road tar, pitch or mixtures thereof).
Bituminous Surfacing	Alternative name for ‘Asphalt Surfacing’.
Bond Coat	Proprietary bitumen spray that provides additional adhesion and imperviousness to that achieved with a Tack Coat and, therefore, improved bond between layers when applied at the rate of application recommended by the proprietor for the particular situation.

Coarse Aggregate	For asphalt, aggregate mainly retained on a 2.0 mm test sieve and containing no more finer material than is permitted for the various sizes in BS EN 13043. For concrete and block making, aggregate mainly retained on a 4.0 mm test sieve and containing no more finer material than is permitted for the various sizes in BS EN 12620.
Cold Recycled Bound Material (CRBM)	A material produced *ex situ* in a fixed or mobile mixing plant from recycling base and binder courses from existing pavements. The recycling process allows for the crushing, screening and grading of excavated material, blended if necessary with other aggregate, and bound with bituminous and hydraulic binder(s) including cement.
Construction Joint	A joint separating area of a concrete pavement slab placed during different pours, usually on different days. May be a longitudinal, or lane, joint or a transverse joint across a lane.
Contraction Groove	A groove formed in the surface of a concrete slab, either during or soon after laying, in order to induce shrinkage cracking to occur in a controlled manner. Usually formed transversely at regular intervals along a lane of concrete by saw cutting so as to subdivide it into approximately square bays.
Crushed Aggregate	Aggregate produced by crushing rock or gravel.
Cutback Bitumen	Bitumen whose viscosity has been reduced by the addition of a suitable volatile diluent.
Dense Bitumen Macadam (DBM)	See ‘Macadam’.
Drylean concrete	A cement bound granular material with low water content suitable for use as a Base or subbase. Unlike conventional concrete, it is usually compacted by rolling.
Edge Restraint	Device that serves to prevent sideways movement of paving units and prevents loss of material from the laying course, base or subbase.
Expansion Joint	Joint provided in a concrete pavement to accommodate the expansion which occurs when the temperature of the pavement rises.
Filler Aggregate	For asphalt, aggregate, most of which passes a 0.063 mm sieve as permitted in BS EN 13043, which can be added to construction materials to provide certain properties. For concrete and block making, aggregate, most of which passes a 0.063 mm sieve as permitted in BS EN 12620, which can be added to construction materials to provide certain properties.

Fine Aggregate	For asphalt, aggregate mainly passing a 2.0 mm test sieve and containing no more coarse material than is permitted for the various gradings in BS EN 13043. For concrete and block making, aggregate mainly passing a 4.0 mm test sieve and containing no more coarser material than is permitted for the various gradings in BS EN 12620.
Fines	Any solid material passing a 0.063 mm test sieve.
Fly ash Bound Material (FABM)	A hydraulically bound mixture in which siliceous or calcareous fly ash is the essential constituent of the binder (note: siliceous fly ash used in this specification)
Foreign Object Damage (FOD)	Damage sustained by aircraft as a result of foreign objects striking the aircraft or being ingested into jet engines. Potential sources of damage are generally referred to as FOD hazards.
Free Water/Cement Ratio	The ratio between the mass of water, less any water absorbed by the aggregates, in a concrete mixture and the mass of cement in the mixture.
Friction Course	See ‘Porous Friction Course’.
Grading	Particle size distribution of an aggregate.
Heavy Duty Macadam (HDM)	See ‘Macadam’.
Hot Rolled Asphalt (HRA)	An asphalt mixture of gap-graded aggregate, filler aggregate and bitumen binder proportioned to a design or recipe to produce a dense and impermeable surfacing material.
Hydraulically Bound Mixture	A mixture which sets and hardens by hydraulic reaction. It is compacted by rolling and is suitable for use as a base or sub-base.
Hydraulic road binders (HRB)	Hydraulic road binders are proprietary binders which are a powder made from a blend of different constituents
Immediate Bearing Index (IBI)	Mechanical stability of a mix in its fresh or early life stage used to assess early trafficking capability
Interlock	Effect of frictional forces between concrete blocks that prevent them moving vertically in relation to each other.
Intermediate Restraint	Device that is used to provide restraint of concrete block paving units at intervals in the paved surface.
Joint Filling Material	Material used to fill the joints between concrete blocks. Often referred to as ‘joint filling sand’.
Joint Width	The distance between adjacent concrete blocks or concrete blocks and restraint.
Laitance	On a concrete pavement, a thin layer with poor durability formed of fine aggregate, cement and water brought to the surface, usually by overworking.

Lane	A longitudinal strip of a pavement layer produced by one pass of a set of paving equipment.
Lane Joint	A construction joint between adjacent lanes.
Laying Course Material	Layer of material on which concrete blocks are bedded. Often referred to as the 'bedding sand' or 'laying course sand'.
Laying Face	Working edge of the wearing surface when concrete blocks are being laid out.
Laying Pattern	An arrangement of concrete blocks to form specific patterns for structural requirements.
Macadam	An asphalt mixture (nominally an Asphalt Concrete) consisting of graded aggregate coated with bitumen. a. Dense Bitumen Macadam (DBM): A dense, relatively impermeable, Macadam coated with a bitumen binder and with a filler aggregate content of between 2 % and 9 %. b. Heavy Duty Macadam (HDM): A dense bitumen Macadam with 40/60 grade bitumen binder and a high filler aggregate content of 7 % to 11 %. c. Pervious Macadam: A layer of 0/32 mm Porous Asphalt which acts as a topping to protect whilst allowing free penetration of the surface water to French drains.
Marshall Asphalt	An Asphalt Concrete designed to achieve specified stability, flow, voids and density characteristics.
Nuclear Density Gauge (NDG)	A device to assess density in situ and at refusal air void content using backscatter photons from a nuclear source
Optimum Moisture Content	The moisture content at which maximum compaction is achieved
Particle Size Fraction	That portion of aggregate which passes one sieve but is retained on the adjacent smaller sized sieve in the sequence of sieves used to specify that grading.
Pavement	A structure consisting of a layer or superimposed layers of selected materials, whose primary purpose is to distribute the applied load to the Subgrade.
Pavement Quality Concrete (PQC)	A cement concrete of a suitable quality for use as the surfacing on airfield pavements.
Pervious Macadam	See 'Macadam'.
Petroleum Bitumen	See 'Bitumen'.
Porous Asphalt	An asphalt mixture consisting of gap-graded aggregate and binder with a relatively open structure that is pervious to air and water.

Porous Friction Course	A relatively thin layer of 2/10 mm aggregate sized Porous Asphalt that allows free penetration of the surface water to the underlying impervious surface course.
Quick Visco-Elastic (QVE)	Type of CRBM in which the primary binder is bitumen but also includes a proportion of Portland Cement.
Ramp	A section of pavement, usually laid at a gradient near the maximum permissible, which accommodates differences in level between adjacent pavements. (Note that, in US terminology, 'Ramp' may also be used to indicate an aircraft parking area).
Regulating Material	Asphalt of variable thickness applied to an existing pavement to adjust the shape preparatory to resurfacing.
Road Tar	A viscous liquid derived from crude tar obtained by the destructive distillation of coal which was, but is no longer, used as a component in asphalt.
Roadbase	Previous name for 'Base'.
Sand (for making concrete)	Now called 'Fine Aggregate'.
Slag Bound Material(SBM)	A mixture containing one or more slags which hardens by hydraulic reaction and/or carbonation
Sieved Fraction	Previous name for 'Particle Size Fraction'.
Stone Mastic Asphalt (SMA)	A dense gap-graded asphalt with aggregate-to-aggregate interlock that includes fibres as a stabilising additive to carry the binder without drainage.
Subgrade	Upper part of the soil, natural or constructed, that supports the loads transmitted by the overlying pavement.
Surface Course	The layer of the asphalt surfacing immediately below the porous friction course or which directly supports the traffic. (Previously called 'Wearing Course').
Tack Coat	A thin film of bitumen emulsion to improve the adhesion between two courses of asphalt or between an existing surface and a new asphalt layer.
Thin (Asphalt) Surfacing System	A proprietary asphalt product with suitable properties to provide a surface course that is laid at a nominal depth of less than 50 mm (previously limited to 40 mm).
Uncrushed Aggregate	Aggregate resulting from the natural disintegration of rock.
Wearing Course	Previous name for 'Surface Course'.

(NOTE. This glossary is common to all DIO Specifications for asphalt, block paving and concrete pavement materials and the Project/Works Services Manager should delete any terms not applicable to a particular project and should add any terms necessary due to the particular nature of that project.)

Contents

Chapter 1 Introduction

1.1 Background

1.1.1 The unique characteristics of military aircraft, in terms of speed, weight, tyre pressures, etc., demand specialist requirements in the design of MOD airfields. The specifications for materials and workmanship need to be particularly stringent to meet these requirements.

1.1.2 This Draft Specification for Hydraulically Bound Mixtures (HBMs) is one of a series being produced by DIO to lay down requirements for airfield pavement works. The following clauses in this Section are intended to set out the applications of HBM in the construction and refurbishment of MOD airfield pavements.

[Note: DIO Specification 51 for Cement Bound Granular Material (Drylean Concrete) for Airfields is also available and this specifically covers the requirements for cement bound material. DIO Specification 052 is therefore dedicated to HBMs other than cement bound dry lean concrete. In follow up text below cement bound granular material is referred to as DLC].

1.1.3 The use of this Standard does not absolve a Project/Works Services Manager from any responsibility for his designs; neither does it constrain him from using alternatives, provided such alternatives can be demonstrated to provide a result of equal quality.

1.2 Functional Requirements of Airfield Pavements

1.2.1 The pavements must facilitate safe aircraft ground operations. In order to do this they must meet certain specialist performance requirements. The following sets out the main requirements, the relative importance of which will be dependent on the function of the pavements and the nature and type of aircraft operations:

- Good rideability.
- Good friction and drainage characteristics.
- High strengths and stability to withstand the shear stresses induced by heavy wheel loads and high tyre pressures.
- A durable, hard-wearing, weatherproof surface free from loose material and sharp edges which might endanger aircraft.
- Resistance to fuel spillage and jet blast. Depending on the nature and type of aircraft operations, these requirements are likely to be too onerous for bituminous surfacings in certain areas of the airfield.
- Facilitate economic maintenance.

1.3 Use of Hydraulically Bound Mixture

The use of HBM either for new pavements or for refurbishment of existing ones is dependent on the functional requirement of the pavement and cost. The HBM may be used as a base layer, as a subbase layer or as a working platform. In this specification, the use of HBM beneath a PQC pavement is referred to as a base layer.

1.4 Application and Limitations of this Standard

1.4.1 Design of Rigid Pavements

Specification Clauses in this Standard are consistent with the requirements for HBM as an alternative to cement bound drylean concrete (DLC) base, subbase or working platform in the DE reference document for the design and maintenance of airfield pavements (A Guide to Airfield Pavement Design and Evaluation – DMG 27 – Defence Estates, 2011). The relevant factors are as follows:

- For new rigid pavements the standard practice on MOD airfields has been to provide a cement bound granular material DLC base. The purpose of this is to provide a uniform and improved support to the PQC and help preserve aggregate interlock at transverse joints (and thereby load transfer) and also to provide a level and firm working course on which to lay the PQC.

- The purpose of this DIO Specification 52 is to enable and promote use of binders and binder constituents other than just cement. It is also an enabler for the use of both recycled aggregates from within an existing pavement and for the use of secondary aggregates.

- Appendix C of DMG27 is now being updated and provides guidance on the use of cement bound granular material (DLC) and other HBMs. The intent is to provide guidance on design issues arising from use of all HBMs, the possible early trafficking requirements, and the range of gradings on offer through BS EN 14227 Parts 1, 2, 3 and 5
- For new flexible pavements HBMs may be used as the base layer beneath a substantial thickness of bituminous material, however liaison must take place with Airfield Pavements Section on this matter. **Proposed Departures from normal use of Cement Bound Granular Material (DLC) by using other HBMs should be discussed with Airfields Section DIO at an early stage of the pavement design. This is to ensure that a body of knowledge is developed for future application in the safety critical airfields work**.
- On subgrades with CBR <5%, there may be a need to lay a HBM working platform in order to facilitate adequate compaction in the upper layers.
- The spacing and layout of joints in the Specification complies with the requirements in the Design Guide reference document.

1.4.2 Climate

For laying HBM in hot climates some modifications to the Specification may be required,

[Note: The time allowed for laying from the addition of water to the mixture to the finishing of the slab may need to be reduced and the curing provision may need to be enhanced. Conversely a slow set HBM may provide advantages].

1.4.3 For Works of Small Scope

For small scopes of work it may be necessary to modify the Specification in order to achieve a realistic balance between cost and quality requirements. Such considerations may apply to aggregate types and test requirements and the provision of a dedicated on-site mixing plant. Some guidance is given at Appendix Z.

1.4.4 For Works in Remote/Overseas Locations

Similar considerations apply as described for works of small scope in Clause 1.4.3.

1.5 Specification Clauses for HBM

Specification clauses are contained in Sections 2 to 7 and Appendices A and B of this Specification. Guidance Notes for the Project/Works Services Manager on Quality Systems are given in Appendix Y and for the preparation of job specifications in Appendix Z.

1.6 Advice from Airfields Section DIO

Clauses 1.2 to 1.5 provide general advice on the application of this Standard. However, having regard to the various design parameters affecting the choice of construction and specifications, including scope of work, aircraft type and frequency of usage, location of a pavement on an airfield, design life, timescale constraints and existing pavement constructions, the guidance notes cannot be exhaustive. Further advice on a project/works specific basis can be obtained from the Airfields Section DIO.

Chapter 2 General

2.1 References

All references to British Standards and other documents given in this Specification refer to the editions as listed in the References at the end of this document unless otherwise stated.

2.2 Overall Requirements

Hydraulic bound mixtures may be either:
SBM 1 to BS EN 14227-2
FABM1 to BS EN 14227-3
or HRBBM1 to BS EN 14227-5

They shall be specified, mixed and laid to the requirements of the following clauses in this Specification. The requirements of this Specification are arranged in the following parts:

General	Section 2
Constituent Materials	Section 3
Design and Composition	Section 4
Plant, Workmanship and Production Testing	Section 5
Routine Testing	Section 6
Summary of Tests	Section 7
Straightedge Tests	Appendix A
Determination of Density using a Nuclear Density Gauge	Appendix B

2.3 Use of Hydraulically Bound Mixtures

2.3.1 Hydraulically bound mixtures may be used at the discretion of the Project/Works Services Manager, as an alternative to Drylean concrete in locations where DLC is indicated to be used on the Project drawings.

2.3.2 The concept employed with HBM is to provide a mixture that has the same performance at one year as a Drylean concrete. These materials are specified here by their 28 day strength with faster acting cement bound mixtures being cured at 20ºC and the other slower acting binders at 40ºC. For cement bound mixtures the 28 day strength is assumed to be 80% of the one year strength. . .

This relationship comes from TRL611 but accumulated UK data for SBM and FABM illustrates that the 28 day strength at 40ºC of ‘slow’ mixtures is similar to the cement bound material percentage of 80% for the one year strength. In addition, it should be noted that SBM and FABM mixtures continue to develop strength beyond 360 days which is not the case for CBM.

Proprietary road binders may be cured at 20ºC or 40ºC depending whether the major constituent in the binder is slow or fast acting.

2.4 Quality Assurance for the Supply of HBMs

2.4.1 All operations in the procurement of component materials and mixing/batching of HBMs shall be carried out by a Contractor who works to a Quality Assurance scheme to BS/EN/ISO 9001:2008 (formerly BS 5750) for those operations.

(NOTE. Advice for the Project/Works Services Manager on Quality Systems is given in Appendix Y).

2.4.2 Each production unit involved in the work shall operate under a Quality Assurance scheme to BS EN ISO 9001. The Quality Policy Manual/s for the supply of component materials and batching of HBMs, together with other relevant records and certificates, are to be submitted at Tender Stage.

(NOTE. The Project/Works Services Manager should provide a questionnaire requesting details of information that are required; advice is given in sub-Clauses Y.5.2 and Y.6.4 of Appendix Y).

2.4.3 The Contractor shall be responsible for having all testing for the supply of HBMs carried out in accordance with the requirements of Section 7 and shall provide the Project/Works Services Manager with a written copy of the results in accordance with Clause 7.1.

2.4.4 All documentation relevant to the work, including test results, shall also be available at the plant or the depot for inspection. The documentation, including worksheets, shall be stored in an easily retrievable form for a minimum of 3 years.

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3 Constituent Materials

3.1 Aggregates - General

3.1.1 The contractor shall inform the Project/Works Services Manager of the source and aggregate properties for each size of aggregate from each separate source of supply. The aggregate shall comply with BS EN 13242:2013:2013 and shall be either crushed or uncrushed or a combination of both. They shall be naturally occurring, artificial aggregate or recycled construction aggregate or a combination.

3.1.2 Initial approval of aggregates shall be obtained from the Project/Works Services Manager before mixing starts; approval shall be based on results supplied to the Project/Works Services Manager of those tests listed in Clause 7.2 and carried out by the Contractor.

3.1.3 The Contractor (or Supplier on his behalf) shall operate under a Quality Assurance scheme to BS EN ISO 9001 with a scope appropriate for the production and supply of aggregates.

3.1.4 Natural Aggregates should be in accordance with BS EN 13242:2013 and as detailed below. Aggregates shall be clean, hard and durable as defined in Clauses 3.2 . Aggregate shall not contain deleterious materials in such form or such quantity to adversely affect the strength at any age or the durability of the surfacing, including resistance to frost. Examples of such deleterious materials include:

- clay, loam or chalk, particularly as an adherent coating;
- mica, shale and other laminated materials;
- coal and other organic or vegetable impurities;
- sulphates and chlorides or other reactive substances liable to break down during drying or subsequent exposure to weather or moisture. Weathered rock shall not be permitted.

3.1.5 The adequacy of natural, recycled and artificial aggregate used in a mix requires an immersion test to assess the strength after immersion and to confirm an absence of cracking or swelling. The approach is to check the soundness of the mix rather than that of all the individual constituents. This is intended to enable the use of aggregates from various sources.

Details of the immersion test are at Section 4.2.4 and the requirements are also detailed at 4.5

3.2 HBM Mixture Gradings

3.2.1 HBM shall be either:

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SBM 1 Line 1 to BS EN 14227-2 (0/31.5)
FABM1 to BS EN 14227-3
HRBBM1 to BS EN 14227-5.

3.2.2 The mixture grading requirements are given in the relevant British Standard in the 14227 series. Part 1 is for cement bound granular mixtures (covered by DIO Spec 51), Part 2 for slag bound mixtures, Part 3 for fly ash bound mixtures and Part 5 for hydraulic road binder bound mixtures.

TABLE 3.2 PERMISSIBLE TEST LIMITS FOR AGGREGATE

Test Property	Test Reference	Permissible Limits
Max. Flakiness Index (%)	BS EN 933-3	40
Maximum Resistance to Fragmentation Value (Los Angeles coefficient)	BS EN 1097-2	50
Magnetic Permeability [1]		<1.005

1 Testing is only required for compass swinging bases or other locations indicated in the Contract documents. The Project/Works Services Manager shall provide the Contractor with details of a laboratory where magnetic permeability may be determined.

3.3 Blank

[Note: Coarse and fine aggregates are now included totally within Clause 3.2. instead of in separate clauses as in previous DIO Specs]

3.4 Cement

3.4.1 The cement shall conform to the requirements within the relevant parts of BS EN 14227

3.5 Slag

3.5.1 Slag may be granulated blast furnace slag, partially ground granulated blast furnace slag or ground granulated blast furnace slag complying with the requirements of BS EN 14227-2.

3.6 Fly Ash

3.6.1 **Fly ash** (pulverised fuel ash) shall be siliceous fly ash complying with BS EN 14227-4.

3.7 Hydraulic road binder

3.7.1 Hydraulic road binders are proprietary binders which are a powder made from a blend of different constituents. A high degree of uniformity is obtained through continuous mass production processes. HRBs shall comply with the requirements of DD ENV 13282.

3.8 Activators

3.8.1 Activators are constituents used with slag and fly ash to enable or enhance the hydraulic reaction. They include lime complying with BS EN 14227-11, gypsum, steel slags and other similar products containing lime and/or sulfate.

3.9 Water

3.9.1 Clean water, satisfying the requirements of BS EN 1008 shall be used.

3.10 Admixtures

These shall conform to the requirements of BS EN14227

3.11 Joint filler board

3.11.1 These are normally used around obstructions. These shall be rot-proof, resilient, non- extruding fibrous or cork based material, which shall be compatible with the material that is to be placed over it. It shall be supplied in widths appropriate to its use, as specified in Clause 4.9, and it shall be 20 or 25 mm thick.

3.12 Curing liquid

3.12.1 The liquid for the initial curing shall be bitumen emulsion K1-40 in BS 434-1.

3.12.2 It shall be delivered to site in weather proof containers each clearly marked by the supplier to show the Class and binder content of the emulsion, or in bulk carriers accompanied by a certificate from the supplier stating the Class and binder content of the consignment; alternatively a bond or tack coat mist spray can be used.

3.13 Minimum Binder or Binder Constituent Additions for HBM

Refer to the minimum requirements in Table 3.13

TABLE 3.13 MINIMUM BINDER OR BINDER CONSTITUENT ADDITIONS FOR HBM

Binder or binder constituent	**Application**	**Minimum addition for mix-in-plant method of construction using batching by mass (by dry mass of mixture)**	**Minimum addition for mix-in-plant method of construction using volume batching and for mix-in-place construction** **(by dry mass of mixture)**
Lime (quicklime or hydrated lime)	when used with another binder constituent when used as the only binder in FABM 5	1.5% 3%	2% 4%
Cement	when used with another binder constituent	2%	3%
Ground granulated blast furnace slag (ggbs)	when used with cement when used with lime	2% 3%	3% 4%
Air-cooled steel slag (ASS)	when used with GBS(see Note)	2.5%	3%
Dry fly ash (FA)	when used with cement when used with lime	4% 5%	5% 6%
Granulated blast furnace slag (GBS)	when used with lime when used with ASS (see Note)	6% 2.5%	8% 3%
Wet conditioned) Fly ash(FA)	All applications	6%	8%
Hydraulic road binder	All applications	3%	4%

NOTE: When GBS and ASS are used in combination, the sum of the two shall be not less than 11%.

4 Design and Composition

4.1 Design - General

4.1.1 The HBM shall be designed by the Contractor in his laboratory within the limits defined in Clauses 4.2 to 4.7 inclusively.

4.1.2 The suitability of the design shall be demonstrated by trial mixes and trial areas in accordance with Clauses 4.7 and 5.6.

4.1.3 After approval by the Project Manager, changes of the constituents or changes in mix proportions, beyond the routine adjustments needed to allow for variations in laying conditions or in gradings of aggregates as delivered, shall be made only with the agreement of the Project/Works Services Manager and after repetition of trial mixes and laying and approval of new trial areas.

4.2 Laboratory Mixture Design Procedure

4.2.1. Prior to the commencement of the work or any change in mixture constituents, the Contractor shall determine the target proportions of the constituents, including water, for the specified HBM, based on the mixture design procedure described in this Clause.

4.2.2. The mixture design procedure shall determine the properties of the HBM at a minimum of 3 values of binder contents, and a minimum of 2 values of water content for each value of binder

Immediate Stability

4.2.3. When required, the mixture design procedure shall include the determination of the immediate bearing index (IBI) at the selected design water and binder content, measured in accordance with BS EN 13286-47. The IBI value shall be taken as the average value for a set of 3 test specimens.

Immersion Test

4.2.4. The strength after immersion in water shall be assessed by comparing the average strength and condition of: (i) 3 specimens initially cured in a sealed condition for 14 days at the test temperature; and then removed from their moulds and immersed in aerated water for 14 days at the same test temperature (ii) 3 specimens cured in sealed condition for 28 days at the same test temperature. The immersed specimens shall be unconfined and have water in contact with all surfaces. On completion of the immersion stage of the test the specimens shall show no signs of cracking or swelling and shall be tested for strength to check for compliance with the immersion requirement in 4.5.

4.2.5. For mixtures containing less than 3% by dry mass of the mixture of cement, the test temperature shall be (40 ± 2) ºC. For mixtures containing 3% or more cement, the test temperature shall be (20 ± 2) ºC.

4.3 Mixture Grading

4.3.1 The grading envelope for the mixture is specified in the relevant part of BS EN 14227 in accordance with Clause 3.2.1.

4.4 Mix Proportions

4.4.1 Trial mixes will be undertaken in order to determine the water content that produces a mixture that meets the compressive strength requirement and can be adequately compacted. This mixture will be known as the job standard mixture.

4.4.2 The required water content of the mixture, suitable for achieving adequate compaction, depends on the aggregate size, the binder content, climatic conditions distance of transportation and equipment for compaction.

4.4.3 To determine the water content a test procedure conforming to BS EN 13286 parts 1, 2, 3, 4 or 5 shall be used.

4.4.4 There are three different types of HBM permitted. Types R, FH and F must be laid on *well-compacted formations of good bearing value (K = 40 MN/m^2/m or in situ CBR = 5% or better) or on existing pavements.* Each of the three types has its own specific application:

4.4.5 Type R (HBM for use directly beneath Pavement Quality concrete).

For this material cubes or HDPE cylinders shall be made from trial mixes as specified in Clause 4.7. The proportions finally selected shall result in a characteristic strength at one year of 18.8 N/mm^2 **(C12/16 at 28 days)**

[Note: Where planings constitute 100% of the aggregate there is evidence to indicate that this 28 designation may be amended to C8/10, however this is subject to review of performance to BSEN14227 System 2 (tensile strength and elastic modulus)]

4.4.6 Type FH (HBM for use as a high strength bound base material in flexible pavements).

For this material cubes or HDPE cylinders shall be made from trial mixes as specified in Clause 4.7. The proportions finally selected shall result in a characteristic strength at one year of 15.6 N/mm^2 **(C9/12 at 28 days)**

[Note: Where planings constitute 100% of the aggregate there is evidence to indicate that this 28 designation may be amended to C5/6, however this is subject to review of performance to BS EN 14227 System 2 (tensile strength and elastic modulus)]

4.4.7 Type F (HBM for use directly beneath a bituminous layer)

For this material cubes or HDPE cylinders shall be made from trial mixes as specified in Clause 4.7. The proportions finally selected shall result in a characteristic strength at one year of 9.6 N/mm^2 **(C6/8 at 28 days).**

[Note: Where planings constitute 100% of the aggregate there is evidence to indicate that this 28 designation may be amended to C3/4, however this is subject to review of performance to BSEN14227 System 2 (tensile strength and elastic modulus)]

4.5 Immersed Strength Requirement

Immersed/Non immersion tests in water are required on 28 day specimens at mix design stage and not routinely.

The strength after immersion is to be > 0.8, at least 80% of the non-immersed specimen.

4.6 Discretionary tests on aggregates

The Project Manager may require additional tests. Where natural aggregates are used the Magnesium Sulphate test may be required.

4.7 Trial Mixes

4.7.1 The Contractor shall undertake a series of tests necessary to design a satisfactory mixture for the following types of HBM. A separate mix design shall be undertaken for each. If the granular mixture source changes and/or grading is changed the mixture shall be redesigned.

(Note: At the discretion of the Project /Works Services Manager, for the following subclauses of Clause 4.7, cylinders of a height/diameter ratio of 1.0 are preferred to cubes)The use of HDPE cylinders has been referred to previously and for cubes read HDPE cylinders.

4.7.2 A set of five 150 mm cubes shall be made and cured from each trial mix in accordance with BS EN 13286. The mean dry density of five cubes shall be determined in accordance with BS EN 13286 The compressive strength at 28 days of each of the remaining three cubes in each set shall be determined in accordance with BS EN 13286-41.

4.7.3 For HBMs designed to BS EN 14227-2 (slag bound) and BS EN 14227-3 (fly ash bound unless containing 3% or more cement) the specimens shall be cured at 40ºC. HBMs designed to BS EN 14227-5 (hydraulic road binder) will be cured at either 20ºC or 40ºC depending whether the major constituent in the binder is fast or slow acting, respectively.

4.7.4 Prior to the commencement of the work or any change of mixture constituents the Contractor shall determine the target proportions of the constituents, including water, for the specified HBM, based on the mixture design procedure described in Clause 4.7.5. The mixture design procedure shall determine the properties of the HBM at a minimum of 3 values of binder contents,and a minimum of 2 values of water content,normally OWC and 1.2XOWC, for each value of binder content. The optimum moisture content (OWC) and the maximum dry density of the mixture shall be determined using the vibrating hammer method detailed in BS EN 13286-4

4.7.5 . The following test procedure shall be followed: .

(i) Using a mid range quantity of binder, compact the material at a range of moisture contents into 5 moulds

(ii) Following compaction, determine the dry density of the mixture in each mould and plot against moisture content

(iii) Establish the optimum moisture content(OWC) from the 5 point curve

(iv) Using the OWC, make Laboratory Mechanical Performance specimens at 3 binder contents using vibrating hammer compaction in accordance with BS EN 13286-51. After curing to the specified age, test the specimens for compressive strength and plot the results against binder content.

(v) Repeat stage (iv) but at a higher moisture content (typically 1.2xOWC) and plot strength against binder content on the same graph as stage (iv) results.

(vi) Select the binder content which will give the required strength at moisture content above OWC and with an appropriate factor of safety, which may be reviewed when a sufficient number of test results for the mixture have been recorded and analysed.

(vi) Confirmation shall be given that the material meets the specified compressive strength designation in accordance with BSENs14227-,2,3 or 5:2013 and Clause 4.7.6. 4.7.7 and 4.7.8.

4.7.6 **HBM Type R (** HBM for use directly beneath Pavement Quality concrete).

The requirement is for a C12/16 characteristic strength HBM at 28 days to BSEN14227-2, 3 or 5.

4.7.7 **HBM Type FH** (HBM for use as a high strength bound base material in flexible pavements).

The requirement is for a characteristic strength class C9/12 HBM at 28 days in accordance with BSEN14227-2,3 or 5.

4.7.8 **HBM Type F** (HBM for use directly beneath a bituminous layer).

The requirement is for a C6/8 characteristic strength HBM at 28 days in accordance with BSEN14227-2, 3, or 5

[Note : For HBM Types R, FH and F 7 day strength values are to be determined for production control purposes .For the purpose of the trial the mean and minimum compressive strengths are to be established at 7 days or at such later time consistent with the ability to extract specimens/cores]

4.7.9 Water content is defined as the minimum necessary to permit satisfactory laying of the material.

Generally

4.7.10 If the test results fail to satisfy the strength requirements the whole test sequence shall be repeated using a different mix

4.7.11 Trial mixes shall continue until a satisfactory mixture has been designed.

4.7.12 If during the laying of the trial area, the agreed mixture or the mixture modified to the extent permitted by Clause 5.6 is found to be unsatisfactory, further adjustments to the mixture shall be made and a new set of tests shall be undertaken.

4.7.13 The Contractor shall report the proportions of all mixtures used in the mixing trials together with all the dry density results and cube strengths obtained to demonstrate how the optimum moisture content was established.

4.8 Course Thickness

4.8.1 The nominal course thickness of the HBM shall be as shown on the drawings. The preferred minimum thickness of a course or layer shall be 150 mm although there may be circumstances where the Project Manager agrees to a lesser thickness.

4.8.2 The nominal size of aggregate for a particular course or layer shall be in accordance with the following table:

Nominal layer thickness (mm)	Max size of aggregate (mm)
200	31.5
150	31.5
100	31.5 or 20
75	20

4.8.3 In reshaping existing pavements the area of the HBM course shall be contained within that area of pavement where the depth of regulating exceeds 100 mm.

4.8.4 A “course” is defined as the overall thickness of HBM. A course may be made up of one or more layers. If the first layer is required to provide a firm base for subsequent layers it is referred to as a “working layer”. If the working layer is to be specified separately then it is termed a “working course”.

4.9 Layout of Joints

4.9.1 The course shall be divided into lanes by longitudinal construction joints as specified in Clause 5.11.

4.9.2 The widths of the lanes shall not exceed 7.5 m for machine laid, and 4.5 m for hand laid HBM.

4.9.3 Transverse construction joints as specified in Clause 5.11 shall be formed over the full width of the lane at breaks in continuity of laying.

4.9.4 Where the course is spread and compacted in more than one layer the transverse construction joints in vertically adjacent layers shall be staggered by at least 1000 mm and the longitudinal joints by at least 300 mm.The course to be overlain should be kept damp.

4.9.5 Where the HBM is used as the base directly beneath a bituminous surfacing, isolation joints shall be formed over the full depth of the HBM where it abuts a fixed object such as a manhole, catchpit etc. Expansion joints shall also be formed to provide vertical separation between HBM and Pavement Quality concrete where these two abut.

5 Plant, Workmanship and Production Testing

5.1 Storage of Materials

5.1.1 All materials shall be stored in accordance with manufacturers' instructions. They shall be protected against damage by the weather or by exposure to extremes of temperature.

5.1.2 Materials condemned by the Project/Works Services Manager shall be removed immediately from site.

5.1.3 Binder constituents shall be kept protected until use, however not all binder constituents are dry They shall nevertheless be protected from the weather during transit. If delivered in bulk containers they shall be stored on site in silos If delivered in bags or drums they shall be stored in a weatherproof building on a raised floor or platform. Each consignment shall be kept separate from previous consignments. The binder constituents shall be used in the order of delivery. Cement held on site for more than 28 days shall be tested, not more than 7 days before use, for “loss on ignition” as detailed in Clause 7 of BS EN 196-2 and shall satisfy the requirements given in Table 3 of BS EN 197-1.

5.1.4 Bitumen emulsion shall be protected from freezing. Drums in store shall be turned or inverted at least once a month.

5.2 Storing and Handling Aggregates

5.2.1 Aggregate stockpiles shall be on concrete or other approved hard surfaces, laid to falls to allow unrestricted drainage. The siting and preparation of the sites shall be approved by the Project/Works Services Manager. Aggregates shall be stockpiled separately for each size delivered from each source of supply. Each size from each source shall be separated in the stockpiles by sturdy bulkheads.

5.2.2 The methods to be adopted to prevent overspill between adjacent stockpiles, "coning" or segregation of the aggregate in the stockpiles, particularly during tipping, shall be agreed with the Project/Works Services Manager. Care shall be taken to avoid crushing by stockpiling equipment.

5.2.3 The aggregates shall be kept free from contact with deleterious matter.

5.2.4 Aggregates containing more than 5% passing a 4 mm sieve shall not be batched until they have been deposited for at least 8 hours. All aggregates produced or handled by hydraulic methods or which have been washed shall be stockpiled for at least 24 hours before batching.

5.2.5 Aggregates shall be handled from the stockpiles to the batching plant by means which avoid contamination and minimize segregation.

5.3 Tests on Aggregates from Stockpiles

5.3.1 The particle size distribution of a representative sample from each stockpile of each aggregate shall be determined once a day when mixing and laying are in progress. The samples shall be taken in accordance with the requirements of BS EN 932-1, prepared according to BS EN 932-2 and the testing shall be by dry sieving as described in BS EN 933-1. If any of the particle size distributions so determined falls outside the relevant limits given in Clauses 3.2, two further tests shall be carried out. If either of these also fails to satisfy the requirement, mixing shall cease immediately and the non-conforming aggregate shall be removed and replaced with material complying with the specified requirements.

5.3.2 The fines content of each size of aggregate from each source shall be determined at weekly intervals when mixing and laying are in progress. Samples shall be taken in accordance with the requirements of BS EN 932-1, prepared according to BS EN 932-2 and the tests shall be performed by the method described in BS EN 933-1.

5.4 Batching and Mixing

5.4.1 HBMs are normally produced in a continuous mixer.

5.4.2 The proportion of each constituent in the mixture by weight shall be that approved by the Project/Works Services Manager in accordance with Clause 4.1.3.

5.4.3 The allowance made for free water in the aggregates shall be determined on representative samples from each of the aggregate stockpiles in accordance with the methods described in BS EN 1097-5, or, with the agreement of the Project/Works Services Manager, by another method. Regular determinations shall be made before mixing starts each day and, unless moisture meters are fitted at the discharge points from the bins containing 10 mm and smaller aggregate sizes, afterwards at 4-hourly intervals until mixing ceases for the day. Additional determinations shall be made when mixing restarts after rain has stopped production or when moisture meters in the bins indicate a change in moisture content. Following each determination of free water in the aggregates, the precise quantity of added water required to make up the total proportion of mixing water approved shall be recalculated.

5.4.4 Aggregates from each stockpile and binder constituent shall each be proportioned separately by weight to the tolerances given in BS EN 206-1, Table 21

(Substituting ‘binder’ for ‘cement’ in the Table). When the binder constituent is delivered in bags, proportioning by weight of all constituents shall be based on the incorporation of whole bags.

5.4.5 The added water content calculated as described above shall be measured by either weight or volume to the tolerances given in BS EN 206-1, Table 21. All of the mixing water required for each batch shall be added in the approved static mixing plant.

5.4.6 Mixing within the approved mixer shall continue until a well-mixed HBM has been produced. The total mixing time shall be agreed following trials with the mixture and mixing shall be carried out for this period. The consistency of each batch of HBM shall be checked by use of a wattmeter monitoring the power supply to the mixer, or other proven reliable device, and each batch of HBM shall be inspected prior to discharge.

5.4.7 Mixers shall be emptied before being charged with a new batch of HBM. When a delay in excess of 30 minutes occurs during HBM production, mixing shall not restart until the mixer and handling plant have been thoroughly cleaned out.

[Note: Where continuous mixers are used Clauses 5.4.5 and 5.4.6 do not apply]

5.5 Mixers

5.5.1 The Contractor shall submit for approval, with his tender, details of the mixer(s) he proposes to use, including the manufacturer’s name, type of mixer and estimated output. The Contractor’s proposals will be considered and, if requested, he shall also submit at tender stage the following further information:

- A technical description of the plant, including recommended methods of maintenance and operation control.
- Minimum mixing time recommended for HBM.
- Time required for charging and discharging.
- Estimated theoretical output in terms of unit time for HBM.
- Batch size.

or

- Type of water measuring device.
- Any other information concerning the ability of the plant to produce HBM of consistent proportions and properties to the requirements of this Specification and at a rate of output suitable for the laying plant and programme proposed.

5.5.2 Only mixing plants approved as a result of these submissions shall be used.

5.5.3 The mixer(s) shall be set up within the site boundary in a location approved by the Project/Works Services Manager.

5.5.4 The weighing mechanism of each mixer plant shall be checked either by its manufacturer or by an independent testing authority who shall certify compliance within the tolerances given in BS EN 206-1, Clause 9.6.2.2. A copy of the certificate shall be passed to the Project/Works Services Manager before mixing begins. Further checks shall be made and the certificates passed to the Project/Works Services Manager at the end of each month during mixing and whenever a mixer is re-sited or disturbed.

5.5.5 The calibration of the water measuring devices and admixture dispensers shall be checked before mixing begins and at monthly intervals during mixing. Copies of the certificates shall be passed to the Project/Works Services Manager. In addition, the Contractor shall himself check the accuracy of the devices and dispensers to the satisfaction of the Project/Works Services Manager each day before mixing begins.

(Note. General advice for the Project/Works Services Manager is provided in Clause Z.5 of Appendix Z).

5.6 Trial Areas

5.6.1 For each agreed mixture of Type F, FH and R HBM a trial area shall be laid. The length of the trial area shall be not less than 60 m for machine laid HBM or 20 m for hand laid HBM In both cases the maximum length shall be 300m. The area shall be laid to the maximum layer thickness that will be used in the work.

5.6.2 The HBM shall be spread and compacted by the methods specified in Clauses 5.8 and 5.9, or, when hand spreading is appropriate, with the plant that the Contractor proposes to use. If a working layer (as defined in Clause 4.8) is required, this shall be placed and cured for at least three days prior to overlaying with the trial area,

[Note Slow HBM trafficability can be assessed by IBI testing e.g. to assess if the layer is to be loaded before the three day period].

5.6.3 The trial area shall be laid along the outside of the pavement, in a position approved by the Project/Works Services Manager. It shall incorporate at least one longitudinal and one transverse construction joint.

5.6.4 An additional area shall be laid for each set of spreading and compacting plant.

5.6.5 If during the initial spreading and compacting of the trial area it appears that greater advantage would be gained from the compactive effort by an increase in the water content, this shall be permitted with the approval of the Project/Works Services Manager, providing

(i) the increase in water content shall not be more than 1 per cent above the content determined in accordance with Clause 4.7

and

(ii) the test results of the specimens at the increased water content, crushed to comply with Clause 4.7, fall within the limits of strength specified in that Clause.

5.6.6 The compressive strength of the HBM used in the trial area shall be established from the cubes in accordance with Clause 4.6. All the results of the five cube tests shall fall within 10% of their calculated mean.

5.6.7 The wet insitu density of the HBM in the trial area shall be established. It shall be determined as the mean result of five wet density tests, carried out in accordance with

Clause 4.6.2 (NDG in direct transmission mode) of BS 1924-2. The five tests shall be taken through the full thickness of the course or layer at locations not less than 5 m apart. All the results of the five tests shall fall within 10% of their calculated mean. This mean wet density of the HBM in the approved trial area shall be at least 95% of the insitu refusal cube densities done on the day at OMC.

5.6.8 If, with or without this modification of the mixture, the resulting trial area indicates that the compaction proposed by the Contractor fails to produce a satisfactory layer or does not meet the surface accuracy specified, the Contractor shall make modifications or additions to his plant, or shall change his working methods and shall lay new trial lanes until the Project/Works Services Manager is satisfied in these matters.

5.6.9 If the laying of the trial area proves that the agreed or modified mixture is suitable for laying, compacting and finishing with the proposed plant, the Contractor shall submit a written statement to the Project/Works Services Manager for his approval, reporting the proportions of each constituent by weight.

5.6.10 Until approval has been given, the general laying of HBM required by the contract will not be permitted to start. The approved trial area shall be left exposed until all the HBM has been laid.

5.6.11 The insitu refusal cube densities done on the day at OMC and standard surface regularity of the approved area shall be the target for all the HBM layers included in the Contract within the limits specified in Clauses 5.9 and 6.3

5.6.12 No changes shall be made afterwards to the mixture, plant or methods of construction without the approval of the Project/Works Services Manager and then only after new trials have been carried out and approved.

5.6.13 At all times during production of HBM at the mixer, the constituent materials shall be thoroughly mixed to ensure even distribution of the binder constituent in the mixture.

5.7 Placing of HBM

5.7.1 The mixtures shall be transported from the mixing site, with care to prevent segregation, loss of constituent materials or dry out, to the laying site. The Contractor shall ensure that the requirements of Clause 5.8 are complied with during the transportation and placing of the HBM.

5.7.2 The HBM shall where possible be laid in lanes parallel to the pavement centre line.

5.7.3 The first lane, apart from the trial lane specified in Clause 5.6.3, shall be laid along the crown of the pavement with a crowned profile, and on the high side of pavements with a crossfall.

5.7.4 Except where shown on the drawings:

A course thickness exceeding 200 mm shall be built up in layers of not greater than 200 mm in depth and not less than 100 mm;

A course thickness not exceeding 200 mm shall be laid as one layer or as separate layers of not less than 100 mm in thickness.

5.8 Spreading of HBM

5.8.1 Spreading of HBM will normally be by machine, especially when the HBM is to be laid on an existing pavement or on a well compacted formation with a good bearing value (say K = 40 $MN/m^2/m$ or in situ CBR = 5% or better) or on a working course (previously laid by hand). The preference is always that HBM be paver laid. However by default, hand lay may be permitted where agreed by the Project Manager and where shown on the drawings.

Spreading by Machine

5.8.2 The HBM shall normally be spread by means of a floating screed paver between forms not more than 7.5 m apart.

5.8.3 The spreading equipment and method will be approved by the Project/Works Services Manager on the basis of the trial area required by Clause 5.6. Equipment not approved shall be removed from the aerodrome, methods not approved will be prohibited.

Hand Spreading

5.8.4 All areas of irregular shape, and situations which will not permit machine laying, shall be laid by hand. Hand lay material are to be placed between fixed forms, unless laying within an infill area. Spreading to be undertaken by the use of a rubber tyred excavator fitted with a grading bucket, manual spreading will also be undertaken where required. Care to be taken to avoid segregation when spreading. Compaction, contraction joint installation and finishing methodology are to be as per machine laid material

5.8.5 HBM spread by hand shall not be dumped in heaps on the underlying surface. It shall be evenly distributed by a method approved by the Project/Works Services Manager, or shall be carefully deposited from barrows in small quantities at regular intervals.

5.8.6 It shall be distributed in lanes of regular width, not exceeding 4.5 m, between timber or metal forms. It shall be distributed along the lanes without break in the continuity of the layer or course. The deposited HBM shall be spread with hand rakes to a regular profile at a depth, which provides a sufficient surcharge proud of the required level, so that after compaction the specified thickness is obtained.

5.9 Compaction and Density Control

HBM Types R, FH and F

5.9.1 Compaction is assessed by NDG [note: Normal practice is for HBM to be compacted by vibrating rollers and pneumatic tyred rollers (PTRs) until visible movement on the surface of the layer beneath the roller ceases and the surface is closed.

(Note: PTR checks mechanical stability of the compacted course ready for immediate trafficking or overlay)

5.9.2 The rollers shall apply a static force of not less than 1.2 kN per 100 mm width of vibrating roller.

5.9.3 The layer shall be compacted to not less than 95 per cent of the Job Standard Density determined as specified in Clause 5.6.6.

5.9.4 At locations approximately equal distances apart agreed with the Project/Works Services Manager, the Contractor shall take density tests from the finished layer in accordance with Clauses 3.3 or 3.7 of BS 1924-2. Each test shall be numbered and arrangements shall be agreed with the Project/Works Services Manager which ensure that the location of each test in the compacted course can be accurately established at any time. The tests shall be carried out not later than 3 days after laying the HBM. They shall be at a frequency of one for every 500 m^2 of concrete laid, or once a day at each point of placing when the day's work is less. The results of the density tests shall be reported daily to the Project/Works Services Manager, together with an evaluation of the test results as a percentage of the daily refusal density, determined as specified in Clause 5.6.7.

[note:The insitu density tests should be all the same age as job standard cube density tests to avoid inconsistencies caused by hydration of the binder constituents]

5.9.5 If any density test result falls below 95 per cent of the daily refusal density the Contractor shall take two additional tests at not more than 7.5 m from the location of the failed test. The two additional tests shall not be less than 7.5 m apart and shall be taken from material laid on the same day as that at the failed test location. If the results from either or both of the tests do not meet the specified requirement then the process shall be repeated on each side of the failed test location until satisfactory density values are obtained. The extent of the defective area shall be identified and all HBM within this area removed and replaced.

5.10 Induced Precracking of HBM

Precracking is to be undertaken where identified by the Project Manager. This is normally for Type FH HBM and only in situations where the overlay asphalt thickness is below guidance values given in Appendix C of DMG27 and DMG33
[Note: slow HBM situations should be referred to DIO Airfields in the first instance]

5.10.1 Where required transverse cracks shall be formed at the specified spacing with a tolerance of ± 150 mm. Where the pavement is made up of two or more layers of HBM with induced cracks, the cracks in the overlying HBM layer shall align with the induced cracks in the layer below with a tolerance of± 100 mm.

5.10.2 Cracks shall be induced in fresh material after initial compaction. The transverse cracks shall be induced by grooving the fresh material to form straight vertical grooves not more than 20 mm wide, to a depth of between one half and two thirds of the layer thickness over the full width of the pavement. Bitumen emulsion shall be poured or sprayed into the grooves prior to final compaction, to form a crack inducing membrane. The bitumen emulsion shall comply with Class C40B4, as specified in the National Foreword to BS EN 13808. During final compaction of the mixture, the surface of the groove shall be fully closed throughout its full length. The bitumen in the groove shall be fully encased and remain continuous, with not less than 70% of the sides of the groove coated with bitumen.

5.10.3 Where required by the Project Manager longitudinal cracks shall be induced using the procedure specified
[Note: This applies if rips of greater width than 4.75m are involved]
.

5.11 Construction (Day) Joints

5.11.1 Longitudinal and transverse construction joints shall be vertical, simple butt joints of regular alignment.

5.11.2 On completion of compaction of each layer, and, where applicable after stripping of the forms, all loosely adhering fractions along the exposed edge of the longitudinal lane joints, together with overspill fragments, shall be removed by raking and brooming.

5.11.3 Non-vertical edges shall be removed by cutting back to fully compacted material and forming a vertical face to the full depth of the layer.

5.11.4 Transverse construction joints shall be made at the end of the day's work and when mixing stops for more than 90 minutes.
[Note: slow HBM situations should be referred to DIO Airfields]
The joint shall be made against a timber or metal form fixed across the lane for its full width. The form shall remain in position as protection until laying of the HBM is resumed. Alternatively, the HBM layer may be feathered out and then cut back before work re-starts to give a straight, vertical face to the full depth of the layer.

5.11.5 The edges of longitudinal and transverse joints shall be painted or sprayed with a uniform film of the bituminous emulsion specified in Clause 3.12.

5.12 Allowance for Edge Support

(1) For HBM directly below machine laid PQC:-

The HBM shall be extended for a minimum of 500 mm beyond the limits of the PQC to provide a support to the formwork and machine guide rails.

(2) For HBM directly below hand laid PQC:-

The HBM shall be extended for a minimum of 250 mm beyond the limits of the PQC to provide a support to the formwork.

(3) For HBM directly below a bituminous surfacing:-

The HBM shall be extended for a minimum of 150 mm beyond the limits of the bituminous surfacing to provide adequate working area for construction of the surfacing.

5.13 Time Allowed

5.13.1 The total time taken from the addition of water to the HBM mixture to the finishing of the slab, including application of the initial curing membrane will be dependent upon the binder used.

Table 5.13 provides requirements based on temperature and time before laying.

With his tender, the contractor shall provide a method statement showing how compliance with this clause can be achieved with the equipment proposed for use. The statement shall include details of the sequence of operations commencing with addition of water at the mixer and finishing with curing of the HBM surface giving estimated times for each operation and an estimated overall time. The estimates given shall be verified during the laying of the trial areas specified in Clause 5.6.

5.13.2 A record shall be kept by the Contractor of areas of HBM that fail to meet this requirement. The record shall be submitted daily to the Project/Works Services Manager. Only a qualified acceptance of the HBM in these areas may be given and, if directed by the Project/Works Services Manager, the Contractor shall cut out the HBM and replace it at his own expense.

5.14 Working in Inclement Weather

5.14.1 Inclement weather may be excessively cold, excessively hot or wet.

Cold Weather

5.14.2 The following requirements shall be met:

- Aggregates which are frozen or contain ice or snow shall not be used.
- Salt shall not be used to prevent freezing.
- Calcium chloride or other accelerators shall not be used.
- HBM shall not be spread when the air/shade temperature is 2°C or lower. Alternatively, with the approval of the Project/Works Services Manager, the Contractor may take measures to maintain or generate sufficient heat in the aggregates and water to ensure that the temperature of the HBM during mixing, spreading, compacting and finishing does not fall below a reasonable temperature making the HBM susceptible to early damage. The Contractor shall undertake a risk assessment approach to include likely strength gain. When temperatures below 0°C are forecast or occur unexpectedly, HBM which has been laid for less than 6 days shall be protected from frost damage by securely-fixed insulation which shall remain in position for at least 6 days after the HBM is laid. Examples of suitable insulating materials are:
    - Expanded polystyrene sheeting.
    - Extruded polyethylene foam sheeting.
    - Straw mats at least 100 mm thick.

The best protection is to lay the next layer shortly afterwards

The construction period shall not be greater than 35, in degree hours calculated as the summation of the products of the average air temperature above 3°C (T°C)and time for each period (t hours):i.e. construction period limit = $\Sigma(T.t)$. The air temperature during the interval, t , shall not fluctuate by more than 4°C

(Note: The strength gain of HBMs with slag and fly ash as binders is very slow at low temperature. Table 5.13 gives information relating to different construction periods for HBM binders)

5.14.3 All insulation material shall be maintained in good condition and shall remain securely fastened for as long as it is being used. After use it shall be removed from the airfield.

5.14.4 Although there is normally insufficient free water in HBM to allow frost damage, it is important that any HBM damaged by frost shall be removed for the full thickness of the slab and replaced.

Wet Weather

5.14.5 The following requirements shall be met:

- HBM shall not be laid during rain. Alternatively, with the approval of the Project/Works Services Manager, the Contractor may provide suitable protection to the mixture during transportation and placing to enable completion of the finishing processes (including the necessary joint forming) to a standard equal to that of the approved trial area.
- All precautions necessary shall be taken to protect freshly placed HBM from rainwater running off adjacent areas.
- Surfaces affected by heavy rain or run-off from other pavement areas shall be broken out and replaced.

Hot Weather

5.14.6 .Laying of HBMs should have regard to both air and shade temperatures.

5.15 Curing

5.15.1 Immediately after each layer of the HBM course has been compacted, curing of its surface shall be carried out by light water spraying unless a subsequent layer can be completed within 4 hours of the start of laying the underneath layer. When the latter is the case only the top layer of the course need be cured with bituminous emulsion to Clause 3.12.

(Note: for slow HBM light water spraying is normally used for the lower layers of multi layer work)

5.15.2 The emulsion should be applied with mechanical or hand operated spraying equipment to provide a uniform coverage, free of streaks and lines and other imperfections.

5.15.3 In the case of a breakdown, sufficient stand-by spraying equipment shall be held on site to complete the spraying of HBM already laid.

5.15.4 The application shall be repeated whenever the skin of the emulsion is broken in the interval between the first spray and the laying of the overlying construction.

5.15.5 Exposed vertical edges in the course shall be painted or sprayed with the bituminous emulsion specified in Clause 3.12.

5.15.6 When a layer has been cured the subsequent layer or construction shall not be laid until a period of at least 3 days has elapsed or the requirements of Clause 5.17 have been complied with, whichever is the longer period.

[Note: To justify departure from the day overlay requirement in the main text of 5.15.6 the Immediate Bearing Index (IBI) values based on field trials may be used to justify departure from the loading requirements within this clause]

5.16 Traffic on Finished Course

5.16.1 The HBM is not to be subjected to the weight of any traffic or equipment not addressed under design considerations.

Then, subject to the Project/Works Services Manager’s approval, it shall only be used by the minimum of equipment essential for continuing the overlying construction, and only by traffic when no other means of access to the work is possible.

5.16.2 The Contractor shall be responsible for the protection of the finished course. He shall maintain the curing film intact by repeated applications of the spray, as specified in Clause 5.15. If loosening of the surface develops, he shall, when so directed by the Project/Works Services Manager, blind the sprayed emulsion with fine grit or sand, lightly rolled. He shall take other precautions he thinks fit, or as directed by the Project/Works Services Manager, to prevent attrition of the surface, or other damage to the HBM.

5.17 Covering of Finished Course

5.17.1 No overlying construction shall be placed on the finished course until density and thickness tests relating to the course have been evaluated, and any instruction from the Project/Works Services Manager consequent upon those results complied with. This avoids abortive work.

TABLE 5.13 Construction Period for HBM Layers (refer to sec 5.14.2)

Binder	Addition event defining the start time for calc. max construction period	Maximum construction period (ºC hours)
Cement, cement with FA or cement with ggbs	Addition of cement	35
Lime with GBS or FA	Addition of lime	1,600
Lime and gypsum for FABM 5	Addition of lime and gypsum	70
GBS + ASS	Addition of ASS and GBS	3,000
Lime with ggbs	Addition of ggbs	200 if ggbs added after lime 1,600 if ggbs added before lime
HRB	Addition of HRB	Workability Period at 20°C determined in accordance with BS EN 13286-45 multiplied by 17

Note:

The construction period, in degree hours, shall be the summation of the products of the average air temperature above 3°C (TC)and time for each period (t hours):i.e. construction period limit = Σ(T.t). The air temperature during the interval, t , shall not fluctuate by more than 4°C

6 Routine Testing

6.1 Tests on HBM Throughout Plant Mixing (Cubes/Cylinders)

6.1.1 For production control purposes 7 day compressive strengths will be used. If suitable 7 day strength values were not established during the mixture design stage then they will have to be established before HBM production commences. See note after Clause 4.7.9.

HBM Types R, FH and F

Laboratory Mechanical Performance

6.1.2 Five 150mm test cubes (cylinders) shall be made from each sample of HBM (per 1000m^2 or part thereof laid each day) with test specimens prepared from a bulk sample taken from each of the locations detailed

Locations

The in-situ wet density of a HBM layer shall be taken as the average value of five determinations equally spaced along a line that bisects each 1000m^2 or part thereof laid each day. The first and fifth positions shall be located 300mm from the edges of the laid area, or other positions agreed by the Project Manager.

6.1.3 The cubes (cylinders) shall be tested at 7 days. The compressive strength of each cube (cylinder) shall be determined according to check BS EN 13286-41 and the results reported daily to the Project/Works Services Manager or his representative on site.

6.1.4 In order to facilitate locating the area of HBM to which a test cube (cylinder) refers the Contractor shall maintain accurate records correlating test cubes(cylinders) taken with the locations of HBM to which they refer. No areas of HBM shall be covered by subsequent construction until the results of the 7 day cube (cylinder) tests have been considered and any remedial action required by the Project/Works Services Manager completed to the satisfaction of the Project/Works Services Manager.

6.1.5 The following action shall be taken on failed cubes (cylinders):

HBM Type R

If any one cube (cylinder) result from the five results representing a day's laying of HBM falls below the value agreed with the Project/Works Services Manager for mixtures made to BS EN 14227-2, -3 or -5, the area of that day's laying shall be defined, removed and replaced.

HBM Type FH

If any one cube (cylinder) result from the five results representing a day's falls below the value agreed with the Project/Works Services Manager for mixtures made to BS EN 14227-2, -3 or -5, the area of that day's laying shall be defined, removed and replaced.

HBM Type F

If any one cube result from the five results representing a day's laying falls below the value agreed with the Project/Works Services Manager for mixtures made to BS EN 14227-2, -3 or -5, the area of that day's laying shall be defined, removed and replaced.

All HBMs

6.1.6 If at the time the defective 7 day cube (cylinder) results become known Type R, FH or F HBM is still being mixed then batching and mixing shall be stopped, the batching and mixing procedures shall be checked, and any modifications required by the Project/Works Services Manager effected immediately.

6.2 Tests on HBM After Laying (Thickness)

6.2.1 The finished level of the course shall be such that the thickness of the overlying construction required to reach the final pavement surface levels shall not be less than the nominal slab thickness nor exceed it by more than 25 mm. If the level of the HBM course does not meet this requirement it shall be cut out for the full thickness of the course, or upper layer, and replaced.

6.2.2 At locations agreed with the Project/Works Services Manager, approximately equal distances apart, the Contractor shall test the thickness of the finished layer. Where appropriate, these tests shall be taken in the same position and time as the density tests. If density tests are not required or the density is determined by the NDG then either holes shall be dug, or one of the methods described in BS EN 13877-2, by cores (Clause 4.3.2) or dips (Clause 4.3.3), shall be used to ascertain the thickness. Each test shall be numbered and arrangements shall be agreed with the Project/Works Services Manager which ensure that the location of each test in the compacted course can be accurately established, at any time. The tests shall be carried out not later than 7 days after laying the HBM. They shall be at a frequency of one for every 500 m^2 of concrete laid, or one a day when the day's work is less. The results of the thickness tests shall be reported daily to the Project/Works Services Manager.

6.2.3 If any thickness test result fails to meet the above requirement, the Contractor shall take two additional tests at not more than 7.5 m from the location of the failed test. The two additional tests shall not be less than 7.5 m apart and shall be taken from material laid on the same day as that at the failed test location. If the results from either, or both, of the tests do not meet the specified requirement then the defective area shall be identified and all the HBM within this area removed and replaced.

6.3 Tests on HBM After Laying (Surface Accuracy)

6.3.1 The surface accuracy of the course including accuracy across joints, shall be such that the gap between the bottom of a 3 m long straightedge and the surface of the pavement does not exceed 10 mm when tested in accordance with Appendix A. A minimum of two tests shall be made for each 50 m^2.

6.3.2 The Contractor shall carry out regular checks with the test straightedge each day on the previous day's work. He shall agree with the Project/Works Services Manager the extent to which he is failing to meet this requirement and shall mark with red paint all areas that fail to satisfy the test, these areas are to be cut out and replaced over the full depth of the HBM.

6.3.3 Providing the requirement of the first paragraph of Clause 6.2 can be met regarding overlying construction, the Contractor shall be permitted to regulate the surface with rolled asphalt, in lieu of cutting out.

6.3.4 If the Contractor fails to meet these requirements in any two consecutive days, all laying shall stop until the spreading and compacting processes have been checked, the cause of the failure has been established, and corrections have been made to the satisfaction of the Project/Works Services Manager, which will eliminate similar failures on the following day's work.

6.3.5 In HBM construction, low areas may be regulated in accordance with Clause 6.3.3.

7 Summary of Tests

7.1 Test Results

7.1.1 The contractor shall be responsible for having all testing carried out in accordance with the requirements of this Section and shall provide the Project/Works Services Manager with a written copy of all results at the first reasonable opportunity but not later than 2 working days after completion of each test. Testing shall be started on specimens within 2 working days of sampling and shall be carried out in an expeditious manner.

7.2 Tests for Initial Approval of Materials

7.2.1 Before mixing starts and as part of the Quality Assurance requirements in Clauses 2.4, 3.1.2 and 3.1.3, the Contractor (or his materials supplier/s on his behalf) shall have carried out those tests required to determine the properties and grading of the aggregates for comparison with the relevant specification clauses as listed below:

- Aggregate Mix:

Test	Reference
Flakiness Index	BS EN 933-3
Resistance to Fragmentation (Los Angeles Coeff.)	BS EN 1097-2
Fines Content	BS EN 933-1
Shrinkage*	BS EN 1367-4
Magnetic Permeability*	—

7.2.2 In addition, the Contractor shall submit the appropriate certificates for:

- cement (see Clauses 3.41)
- slag (as required by BS EN 14227-2)
- flyash (as required by (BS EN 14227-3)
- hydraulic road binder DD ENV 14227-5)
- water (if necessary – see Clause 3.9.1)
- curing compound (see Clause 3.12.2)

7.3 Routine Tests on Bulk Supplies Throughout Plant Mixing

7.3.1 The Quality Assurance procedures for the supply of component materials shall include carrying out tests in order to check on the consistency of bulk supplies, to compare the properties and gradings of bulk supplies with the samples provided and to enable actions to be taken to cope with variations. The tests should include the following:

Test	Clause	Reference
Sieve analysis of aggregates	5.3.1	BS EN 933-1
Fines content of aggregates	5.3.2	BS EN 933-1

7.3.2 If the result of any test indicates that the bulk deliveries are not of a grading or quality consistent with the approved samples, the Contractor shall, at his own expense, carry out further tests to establish the location and extent to which the materials already stockpiled fail to meet the approved standard and, if stored on site, shall remove all material condemned by the Project/Works Services Manager for this reason from the airfield.

7.4 Routine Tests on Plant Throughout Plant Mixing

7.4.1 The Contractor shall arrange for checks on the calibration of weighing, water measuring and admixture dispensing mechanisms to be checked before mixing starts and at specified intervals during production (see Clause 5.5).

7.5 Routine Tests on HBM Throughout Plant Mixing

7.5.1 As part of the Quality Assurance requirements specified in Clause 2.4, the Contractor shall carry out the following tests on HBM prepared for the works (including trials). The procedure shall ensure that the positions of HBM batches from which test samples are taken are fully traceable in the finished pavement

Test	Clause	Reference
Cube (cylinder) strength	4.4, 4.7 and 6.1	BS EN 13286-41
Temperature (cold or hot weather only)	5.14.2 and 5.14.6	BS EN 206-1, Clause 5.2.8 and BS 8500-2, Clause 5.4

7.6 Routine Tests on Hardened HBM Layers

7.6.1 The Contractor shall undertake the series of tests on the HBM layers incorporated in the Works necessary to comply with the relevant specification clauses listed below:

Test	Clause	Reference
Cube(cylinder) strength	4.4, 4.7 and 6.1	BS EN 13286-41
HBM density	5.6, 5.9	BS 1924-2 Clause 3.3 or 3.7, Appendix B
Layer thickness	6.2.3	BS 1924-2 Clause 3.3 or BS EN 13877-2
Straightedge Test	6.3	Appendix A

7.7 Certificates Throughout the Work

7.7.1 Throughout the course of the work, the Contractor shall submit certificates for all consignments of the following:

- cement (Clause 3.4.1)
- slag (Clause 3.5)
- flyash (Clause 3.6)
- hydraulic road binder (Clause 3.7)
- curing compounds for exposed HBM (see Clause 3.12.2)

7.8 Additional Tests on Materials

7.8.1 The Contractor shall make the necessary arrangements for check tests to be made on any of the materials specified for compliance with the requirements of the appropriate clause and the British Standard test requirements applicable to the clause if called upon to do so by the Project/Works Services Manager either before mixing starts or at any time during the work.

Appendix A– Test Method for Straightedge

A.1 SCOPE

This Appendix describes the method that shall be followed to determine the surface accuracy of bituminous surfacing layers in this Specification.

A.2 APPARATUS

A.2.1 The straightedge for the tests shall be purpose made and 3 m long. It shall have a flat square edge of metal, at least 75 mm wide, along the full length of its base. The straightedge shall be fitted with lifting hand grips or handles.

A.2.2 A calibrated wedge may be used to determine the straightedge clearance. The wedge should have an angle of 5.75° ± 0.05°, and engraved at 10 mm intervals across the incline, starting at the apex, representing clearances increasing in 1 mm intervals up the incline.

A.3 PROCEDURE

A.3.1 The straightedge shall be placed unsupported on the surface, anywhere in any direction, other than across the crown of a camber or across a drainage channel. The location shall be selected by the Project/Works Services Manager or his representative, and the tests shall be carried out in his presence.

A.3.2 Twenty tests shall be made for every 1000 m² laid and at least half of these tests shall be across lane joints.

A.3.3 The Contractor shall mark with white paint all areas which fail to comply with the specified requirement.

Appendix B – Determination of Density Using a Nuclear Density Gauge (NDG)

B.1 SCOPE

This method, or that in Appendix D, may be followed to determine the dry density of HBM as described in BS 1924-2, Clause 3.7.

B.2 APPARATUS

A proprietary nuclear density gauge capable of determining density and moisture content.

E.1 PROCEDURE

E1.1 The in-situ wet density of a compacted mixture shall be measured using a calibrated nuclear density gauge in accordance with the BS and the following sub-Clauses, except that each test shall consist of at least 3 measurements at 120 degrees to each other using the same source rod hole and the density taken as the average of the higher 2 results.

E1.2 The operation, warming-up period if any, and standardisation of the gauge shall be carried out in compliance with the manufacturer's recommendations. The gauge shall be calibrated in accordance with the BS immediately prior to the construction of the demonstration area and at least once every 28 days thereafter and also when gradings of materials are changed and if readings of more than 100% are recorded.
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E1.3 The gauge shall be used in the direct transmission mode of operation with the source rod lowered to within 25 mm of the bottom surface of the layer. The in-situ wet density shall be determined within two hours of completing compaction.

E1.4 The in-situ wet density of a HBM layer shall be taken as the average value of five determinations equally spaced along a line that bisects each 1000 m^2 or part thereof laid each day. The first and fifth positions shall be located 300 mm from the edges of the laid area, or other positions agreed by the Project/Works Services Manager.

Appendix Y – Guidance Notes on Quality Systems for Project/Works Services Managers

Y.1 INTRODUCTION

These Guidance Notes are intended to assist Project/Works Services Managers in assessing Suppliers' Quality Assurance (QA) systems for the supply of component and mixed materials as required by Clause 2.4. In particular, guidance is given on:

- how to appraise and evaluate different Quality Systems offered by Suppliers when tendering for jobs (Clauses Y.5 and Y.6); and
- how to monitor work undertaken (Clause Y.7).

Separate clauses are devoted to each aspect.

Y.2 GENERAL

Y.2.1 These Guidance Notes are not intended to replace the BS EN ISO 9000 series and associated documentation.

Y.2.2 The generic term "Client" or "Purchaser" in these Guidance Notes is to include the person or organisation that is acting for, or on behalf of, the Property Manager or the Project Sponsor in the role of either a Project Manager or a Works Services Manager.

Y.2.3 The generic term "Supplier" is used to cover any person or organisation that has, or is tendering for, a Contract with the Client to supply a product or service, and includes those traditionally referred to as the (main) Contractor.

Y.2.4 Products which are specified by means of a Harmonised European Standard under the Construction Products Directive are subject to CE marking. It is not permitted to require additional quality assurance or testing requirements over and above those required for Attestation of Conformity within the European Standard. The CE mark certificate should be taken as sufficient evidence of product conformity.

Y.3 QUALITY SYSTEMS

Y.3.1 It is now the accepted practice that all suppliers of goods and services should:

- install and maintain a Quality Management System; and
- become registered to a National Accreditation Council for Certification Bodies (NACCB) accredited third party certification scheme as a Supplier of assessed capability.

Y.3.2 It is general practice that, once a Quality Management Scheme has been set up within an organisation, application for registration to a second or third party certification scheme will be made.

Y.3.3 Second party assessment is carried out by the purchasing organisation; this is very expensive because the resource requirements for systematic and continuous auditing and the management of an assessment scheme are extremely high. Consequently, this form of registration is now in decline and organisations which previously carried out second party assessment, such as British Telecom, British Gas, what used to be the National Coal Board and the MoD, are beginning to insist that their suppliers obtain third party assessment and, hence, pay the costs of quality assurance.

Y.3.4 Certification of a Supplier's Quality Management System by a third party should provide the Purchaser with the confidence that the Supplier is:

- operating and maintaining a fully documented Quality Management System that addresses consistent requirements; and
- operating within the scope of registration.

This avoids the need for the Purchaser to undertake his own structured regime of second party assessments to ascertain the adequacy and focus of the Supplier's Quality Management Systems.

Y.3.5 However, this does not absolve the Project/Works Services Manager of his responsibilities on behalf of the Client to ensure that the Quality System of the Supplier addresses all the requirements and needs. This is because the Quality Standards are interpreted differently by individual organisations.

Y.3.6 In principal, the more independent the assessment and audit regime, the more confident the Purchaser can be as to the value of a Supplier's Quality Management System. Once registered under a certifying body's scheme, there is still a need to audit, by both the Supplier and the third party certification body, that procedures and standards are being maintained.

Y.3.7 Assessments and audits can be carried out by:

- the Supplier's management - Under his own audit and monitoring regime;
- the Client (Project/Works Services Manager) - Second party assessment scheme; or
- an independent body - Third party assessment scheme.

Y.4 PROCESSES COVERED UNDER THE QUALITY SYSTEM

Y.4.1 For a Quality Management System to be effective, it must cover all the operations and processes that are relevant to the business conducted by the Supplier.

Y.4.2 Dependent upon the type of work being tendered for, but as a minimum for the purpose of this Standard, the following areas should normally be addressed:

- procurement, inspection and safe storage of constituent materials;
- training of plant operatives;
- setting up on-site mixing plants and the mixing of bituminous materials;
- off-site supply and mixing of bituminous materials;
- storage and transportation of bituminous materials prior to use/despatch;
- laying and compaction of bituminous materials;
- inspection and test regimes and records at appropriate stages;
- sub-contractor/supplier assessment and control;
- calibration of equipment; and
- statistical techniques to be used for trend analysis, statistical process control and inspection.

Y.4.3 Quality Management Systems should include provisions for planned and systematic audits, inspections and tests by participating organisations. The Project/Works Services Manager has the responsibility to evaluate and audit the system being operated by the Supplier to ensure adequacy. This should include checking records to substantiate that the procedures are being followed and that the Supplier has evidence that the materials and works are conforming to the specified standard.

Y.4.4 A Quality Plan in accordance with Defence Standard 05-67 should be stipulated in the Contract as a deliverable, but may be included in the *Invitation to Tender* if required. The activities described within the Quality Plan shall be stated unambiguously and concisely so that their intent is clear and that, upon implementation, they can be conducted, assessed, audited, demonstrated, measured or verified.

Y.4.5 The Quality Plan must state or contain definitions as to the levels of quality assurance and control to be applied throughout the Contract, which should include:

- traceability of materials;
- frequency and stages of inspections and tests;
- process controls; and
- records (including the retention periods and reviews).

Y.4.6 As quality standards are not extensively defined in relation to the process control, it is the responsibility of the Project/Works Services Manager to ensure that all processes and methods proposed in Quality Plans are clearly defined and understood with regard to how the Supplier will deal with these aspects of the operation, and that all anomalies, shortfalls, errors and omissions are documented and resolved.

Y.5 ASSESSMENT OF QUALITY MANAGEMENT SYSTEMS

Y.5.1 The assessment of Quality Management Systems is a logical and progressive multi-stage process that encompasses good management precepts.

Y.5.2 A list and records should be maintained of acceptable suppliers and only suppliers on this list should be chosen. Therefore, any solicited or unsolicited suppliers should, as the first stage in the selection process, be required to complete a supplier questionnaire and must, as a minimum, include the following elements:

- verification/proof that the Supplier's Quality Management System is registered by a Certification Body accredited by NACCB;
- that the registration certificate is current;
- that the offices/sites from which the works or services are to be provided are covered by the registration certificate;
- that the scope of registration is appropriate for the works/services to be provided;
- experience or references of other users of the Supplier's services;

- the Supplier's past performance, covering experience and results with similar work/projects;
- financial information;
- insurance information; and
- Health and Safety information.

Y.5.3 If the responses to the above are satisfactory, an assessment of the Supplier's Quality System can be undertaken.

Y.5.4 The extent of the assessment can range from a visit to the Supplier's premises to overview the Quality Management System in operation on a similar project, to a full formal audit conducted against the BS EN ISO 9000 series and in accordance with BS EN 30011 by the Project/Works Services Manager's own QA staff.

Y.5.5 It is the responsibility of the Project/Works Services Manager to decide if an assessment is necessary. The decision for, and the scope of, such an assessment should be taken on the basis of the size, complexity, cost and length/duration of the Contract in conjunction with the level of confidence that can be established from other sources.

Y.6 ASPECTS TO ASSESS TENDER ACCEPTABILITY

Y.6.1 The requirements for the purchasing of goods and services should, as a minimum, be those set down in the BS EN ISO 9000 series. In order to ensure successful procurement, it is a prerequisite that the purchaser (the Project/Works Services Manager) provides a clear definition of requirements in the form of contractual conditions and specifications. This aspect applies equally to Quality Management System requirements.

Y.6.2 All *Invitations to Tender* must contain elements outlining the quality requirements. These should be in the form of asking tenderers to provide:

- proof of registration to the pertinent part of the BS EN ISO 9000 series with an appropriate scope of registration for that particular Contract;
- method statements for all processes to be carried out;
- inspection/test schedules; and
- other information relevant to the Contract.

Y.6.3 When the Supplier returns a tender, his submission must be scrutinised to assess whether his Quality Management System covers all the areas that are relevant to the processes necessary for him to carry out in order that the work is to the required standard. Where only part of the required elements are covered in the Quality Management System, it may be acceptable for the tenderer to address these areas in his Quality Plan and to compile site-specific procedures for unique elements of the Contract.

Y.6.4 The returned tenders must provide precise details against the information requested in the *Invitation to Tender*, which is to include the following:

- the Quality System that will be enforced throughout the duration of the Contract;
- the method and procedures to be used to ensure the positive identification and issue status of specifications, drawings, inspection instructions and other data including the requirements for the approval of operational procedures, equipment, staff, operative training and outputs;
- the method and procedures to be used to ensure the conformance to the Specification by processes, inspection and test criteria; and
- methods for the procurement of raw materials, services, etc.

Y.6.5 It is the responsibility of the Project/Works Services Manager to select those suppliers that they consider will provide the level of confidence that they require to meet the Specification and fulfil their obligations under the Contract.

Y.6.6 Information, in the form of Inspection Records, Test Certificates and Certificates of Conformity, from the Supplier will not normally be supplied automatically unless particularly requested or a contractual requirement. To make sure that the Supplier understands these requirements, a Quality Plan can be required as part of the tender response. The Quality Plan must be evaluated as part of the tender selection process.

Y.6.7 Where the Supplier proposes that some of the work is carried out by sub-contractors, it does not absolve the Supplier of any of his responsibilities to ensure that the work is carried out to the contracted specification and quality.

Y.6.8 The Supplier is to ensure that, where sub-contractors have their own Quality Management System, it is found by scrutiny to be acceptable and they work to it. Where a sub-contractor does not have his own Quality Management System, the Supplier is to impose his own on the sub-contractor. The Project/Works Services Manager has a responsibility to audit both the Supplier and any sub-contractors to ensure compliance to the tender proposal.

Y.7 MONITORING THE QUALITY MANAGEMENT SYSTEM AND PROCESSES

Y.7.1 Whilst the Supplier may have registration to the BS EN ISO 9000 series, it does not necessarily mean that his system is fully focused on the specific requirements of the Contract, nor does any second party scheme run by another purchaser. Monitoring of the system should take place irrespective of whether the Supplier has, or has not, achieved registration.

Y.7.2 The Supplier should have procedures in place for the auditing, monitoring, recording and rectifying of all his activities. The Project/Works Services Manager should ensure, by conducting surveillance audits of the Supplier's system, that:

- these are being carried out;
- the system is effective; and
- the system is focused on the Contract requirements and deliverables.

Y.7.3 Within the Contract, there are requirements for the Supplier to carry out tests on the materials, etc. The Supplier may not have his own test laboratory, in which case he will send samples out to a test house. Any test laboratory, whether part of the Supplier's organisation or an independent test house, conducting the tests for initial approval of materials and design of mixtures should be a National Measurement Accreditation System (NAMAS) accredited test house with an appropriate test schedule. Site laboratories used to carry out routine tests on bulk supplies and mixtures throughout plant mixing shall be either NAMAS accredited or, subject to the Project/Works Services Manager's approval, work to a Quality Assurance scheme.

Y.7.4 Where non-compliances are found, whether within the system being operated or the goods or services provided, they can be either random instances when the value is outside the specified range or an indication of a trend. If the running mean of the last, say, twenty results has remained reasonably consistent with a standard deviation that also has not fluctuated, then it is likely to be a random instance. Preferably, the running means and standard deviations should be monitored to allow corrective action before non-compliances occur. All actions taken to deal with non-compliances are to be documented.

Y.7.5 Rates of sampling and testing must be appropriate to the Contract and stated clearly in the Quality Plan. Where rates are stipulated in the Contract (see Section 7), these will take preference.

Y.7.6 The procedures for sampling and testing Bituminous Materials are to be in accordance with the appropriate parts of the latest editions of relevant British Standards, and also with the latest edition of the appropriate Appendices to this Standard. All samples and testing should be carried out by suitably trained personnel. The results are to be supported by valid Test or Sample Certificates.

Y.7.7 The use of a Quality System should minimise the need for the Project/Works Services Manager to carry out his own tests. Therefore, they can:

- do nothing because the Supplier is carrying out sufficient inspections and tests, and assessing the results and implications;
- assess the Inspection and Test Results for the material provided for the Contract to ensure that checks are being made and that the results indicate compliance to the Contract and Quality Plan is being achieved; or
- conduct a separate inspection and test regime of his own to check for compliance.

Y.8 RECORDS

Y.8.1 The training records of all operatives, sampling and testing personnel are to be maintained by the Supplier and are to be made available for inspection.

Y.8.2 The results of all inspections, tests, etc. for the Contract should be obtained and retained for record purposes. All documentation (including work-sheets, Inspection and Test Certificates and Certificates of Conformity) that are relevant to the Contract should be:

- available at the place of work (usually the plant or depot) for inspection by the Project/Works Services Manager for the duration of the Contract; and
- handed over to the Project/Works Services Manager on completion of the Contract.

Appendix Z – Guidance Notes on the Preparation of Job Specifications

Z.1 COARSE AGGREGATE

Z.1.1 The Specification requires that the aggregate for use in HBM be in accordance with Clause 3.1.

Z.1.2 Use of coarse aggregates from secondary sources are therefore permitted within BSEN13242:2002+A1:2007 subject to satisfactory quality and the approval of the project manager.

Z.2 BINDERS AND ACTIVATORS

There are a number of binder/binder constituents that may be used in HBM. These include cement, slag, flyash and hydraulic road binders. Activators are materials that assist the binder such that the mixture achieves the desired end performance requirements. They include lime complying with BS EN 14227-11, gypsum, steel slags and other similar products containing lime and/or sulfate..

Z.3 ADMIXTURES

Z.3.1 In the past, the use of all admixtures other than air entraining admixture has been prohibited in standard specifications for airfield pavement works on UK military airfields. The reasons for this included:

- Uncertainty as to the effect products might have on the "finishability" of the concrete and hence on the surface durability.
- Some products influence the effectiveness of air entraining admixtures.
- Small changes in dosage of plasticisers produce large effects on workability; since consistent workability is essential if surface regularity requirements are to be maintained despite cross bay slumping, plasticisers were not considered desirable.
- Above all, since satisfactory pavements could be produced without using admixtures, there seemed little point in inviting potential difficulties by introducing them.

Z.3.2 However this Specification permits the use of slip-form pavers and, to allow Contractors the maximum flexibility in designing hydraulic bound mixes to suit this equipment, admixtures may be used for this purpose

Z.4 HBM STRENGTH

Z.4.1 The strength requirements for the three HBMs specified by strength are:

Z.4.2 Type R HBM

The specified HBM has a characteristic compressive strength at 28 days of class C12/16

Type FH HBM

The specified HBM has a characteristic compressive strength at 28 days of class C9/12

Type F HBM

The specified HBM has a characteristic compressive strength at 28 days of class C6/8

Z.5 HBM MIXERS

Z.5.1 The Specification requires the HBM batching plant(s) and mixer(s) to be set up within the site boundary (see Clause 5.5.3). Although this may be more expensive than using an off-site readymix plant and in some cases may require contract periods to be longer to allow for the erection of the plant, the following advantages make on-site batching and mixing the preferred technical and value for money arrangement:

- The type and size of mixer and batching system can be selected and the set up of the bins, silos, etc., can be tailored to suit the requirements of the project.
- The Project/Works Services Manager and the Contractor can check materials, batching and mixing easily, quickly, frequently and economically.
- Only those binder constituents aggregates and additives approved for the project are on site so other materials cannot be used erroneously.

- The quality control regime can be organised with emphasis on the particular requirements of this HBM Specification.
- Transport delays for mixed material are avoided, allowing a smooth continuity of laying.
- Transport time for mixed material is minimised, making it more likely that the minimum time allowed between adding water to the mix and applying the curing membrane to the finished HBM (see Clause 5.13) will be met.
- Quick reaction to events is possible (e.g. heavy rain starting; air content drifting out of specified range and needing correction; breakdown of items of spreading, compacting or finishing equipment), reducing wastage and avoiding pressure to lay loads already in transit under unsuitable conditions.
- There is no competition with other customers for mixer time or delivery vehicles.
- Drivers of delivery vehicles are on the contract works full time and so can be properly briefed for driving on active pavements and, if necessary, vetted for security purposes.
- A single organisation is responsible for both the production and laying of HBM and therefore better cooperation is likely when adjustments to the mix are necessary to facilitate laying or finishing.
- The choice of appropriate readymix plants within a suitable road distance of the site may be limited or even non-existent, particularly for more remote airfields.

Z.5.2 Interruptions to the continuity of laying are detrimental to the quality of the layer no matter which method of laying is being used and are particularly so for a slip-form paver. When tenderers submit their proposals for concrete mixers, particular attention should therefore be paid to ensuring that the rate of output will be sufficient. Knowing the layer thickness and lane width, it is a simple matter to calculate the hourly output of HBM needed.

Z.5.3 In assessing the adequacy of the size of mixer proposed, it should be appreciated that the routine output of HBM, which contains 31.5 mm size aggregate and which requires particular care to obtain consistent workability from batch to batch, is unlikely to approach the manufacturer's output rating based on the production of a normal structural concrete.

Z.5.4 A prerequisite for good HBM is consistency of production at the mixing plant. This is particularly so when the material is to be laid by means of a slip-form paver. Mixers incorporating devices which constantly monitor and adjust for variability in the fine aggregate content and which allow precise control of workability by permitting a final dribble-feed of water into the mix under consistometer gauge check will, when used by experienced operators, greatly aid the production of consistent HBM.

Z.6 SPREADING OF THE HBM

Z.6.1 Clause 5.8 relates to spreading of the HBM. The machine spreading of HBM may be undertaken by a conventional paving train, by semi-mechanised methods or by slip forming. The Project/Works Services Manager may omit one or two of these methods if it is felt that the methods described therein would be inappropriate for a particular job.

Z.6.2 Advantages of specifying semi-mechanized construction include:

- The method is likely to be the most economical one where the size and shape of the area dictate that construction will be mainly in runs of less than, say, 200 m.
- The items of plant involved and crews skilled in their use are likely to be readily available.
- Production rates are relatively low and consequently construction periods are likely to be longer than for the alternative methods.
- Surface regularity standards, particularly in the longitudinal direction are likely to be inferior to those obtainable using a skillfully operated paving train.
- The number of "day joints" (i.e. transverse construction joints), which have no load transfer arrangement will usually be greater than in pavements laid by the alternative methods.

Z.6.3 Slip-form pavers have often been used in other countries for constructing airfield pavements and frequently in UK for highway work, but they have not been used a great deal in this country on airfields. Rates of output and economy of production on suitably large areas are potentially considerably better than for either of the alternative methods, although teething problems on recent airfield work in UK have prevented this potential from being completely realised. Many slip-form paving operations have involved a continual struggle to counter the tendency of the edges of the unsupported slab behind the paver to slump. Acceptable standards in respect of surface regularity can be achieved and maintained throughout, but mix design, control of production of concrete and control in the laying process are likely to be more critical than when laying between forms.

Z.6.4 For slip-forming to be successful, an essential provision is a dedicated batching and mixing plant with an output large enough to ensure a constant supply of HBM to the paver and which allows tight control so as to ensure that the HBM has consistent properties from batch to batch. Tenderers' proposals in this respect, submitted in accordance with Clause 5.8, should be checked carefully.

Advantages of specifying slip-form pavers include:

- Rates of output are potentially superior to those obtainable by other methods, so construction periods should be shorter.
- Potentially the most economical method for a large area.
- Quality of mixture is consistently good (otherwise the method will not work at all).
- Number of "day joints" is low.

Disadvantages include:

- Potential for high rates of output, short construction periods and economy may not be realised because of a shortage of expertise amongst UK contractors (at the time of writing).
- Surface regularity standard can be expected to be inferior to that obtainable by other construction methods, particularly across lane joints.
- The presence of AGL fittings, pits, manholes, etc., in the pavement may interfere with the slip-forming operation, requiring some of these to be repositioned.

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