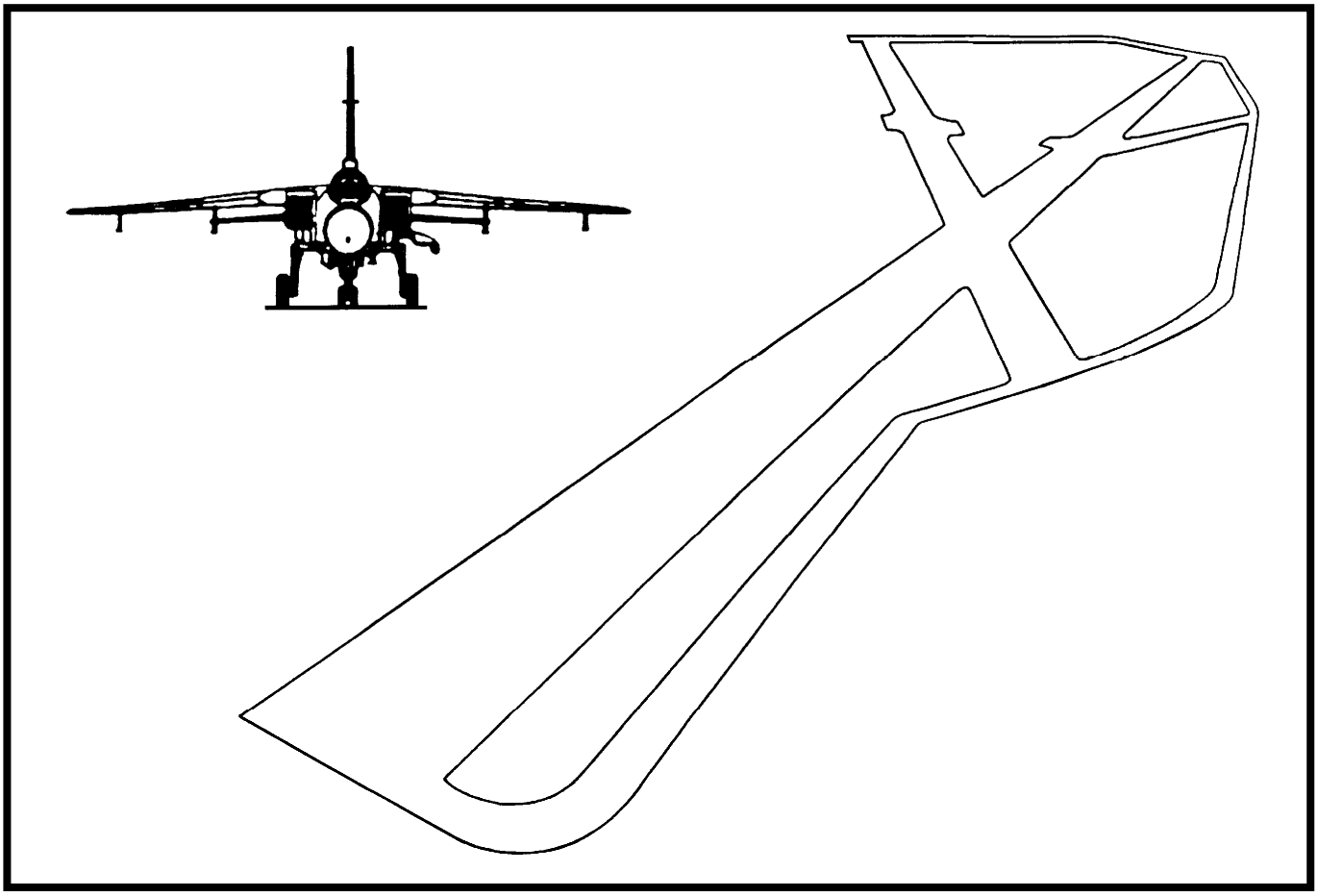
Specification 13



Marshall Asphalt for Airfields

DEFENCE ESTATES
MINISTRY OF DEFENCE

Specification 13

Marshall Asphalt for Airfields

August 2009

CONSTRUCTION SUPPORT TEAM
DEFENCE ESTATES

Ministry of Defence

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The specifications in this document have been prepared by TRL Limited in conjunction with and under commission to the Construction Support Team, Defence Estates, Ministry of Defence. It has, in part, evolved from standard specifications previously produced by former Government Departments: Air Ministry Works Department, Ministry of Public Buildings and Works and the Property Services Agency.

Foreword

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

This Defence Estates Specification supersedes the previous edition published in 1995.

This DE Specification was prepared under the patronage of the Construction Support Team, Defence Estates, Ministry of Defence, for application to airfield pavement works on the MOD estate.

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

Head of Airfield Pavements
Construction Support Team
Defence Estates
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This Specification, "*Marshall Asphalt for Airfields* ", has been devised for use of the Crown and of its Contractors in the execution of contracts for the Crown and, subject to the Unfair Contracts Terms Action 1977, the Crown will not be liable in any way whatever (including but without limitation negligence on the part of the Crown its servants or agents) where the Standard is used for other purposes.

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, including the mass of any absorbed water, 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.
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.
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.
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’.
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 DE Specifications for asphalt and concrete pavement materials and the Project 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.)

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1 Introduction

1.1 BACKGROUND

1.1.1 The unique characteristics of military aircraft, in terms of speed, weight, tyre pressures, etc., create specialist requirements in the surfacing of MOD airfields. As such, specialist materials specifications are required to meet these needs.

1.1.2 This Standard for Marshall Asphalt is one of a series being produced by DE to lay down specification requirements for airfield pavement works. The following clauses are intended to set out the applications of Marshall Asphalt in the construction and refurbishment of MOD airfield pavements.

1.1.3 The use of this Standard does not absolve a Project Manager from any responsibility for his designs, neither does its existence 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:

a. Good rideability.
b. Good friction characteristics.
c. High strengths and stability to withstand the shear stresses induced by heavy wheel loads and high tyre pressures.
d. A durable, hard-wearing weatherproof surface free from loose material and sharp edges which might endanger aircraft.
e. 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 asphalt surfacings in certain areas of the airfield.
f. Facilitate economic maintenance.

1.2.2 Main Length of Runway

On the main length of a runway, it is important to have good rideability and wet weather skid resistance. Asphalt surfacings generally give better rideability than concrete, with the latter being partly dependent on the spacing and detail of the transverse joints. Good skid resistance/friction characteristics are achieved by a combination of good surface slope to effect efficient surface water run-off and also surface texture to increase friction and allow water to disperse from the tyre contact area. The standard technique used in the UK for providing texture on asphalt road surfacings is by the provision of rolled-in chippings. This is not acceptable on airfield pavements because materials which are likely to pluck out or spall on the surface of a pavement are a potential FOD (Foreign Object Damage) hazard to aircraft, particularly with regard to ingestion by jet engines. The methods currently favoured for providing suitable friction characteristics on new asphalt surfacings on MOD runways are as follows:

a. The provision of a 20 mm thick Porous Friction Course (not included in this standard) on asphalt surfacing. This is the most favoured construction option but it would not be specified in certain situations including dusty regions, very cold climates, runways used for STOL (short take-offs and landings) operations and where night-time construction work necessitates numerous transverse construction joints.
b. By grooving an asphalt surface with continuous grooves cut perpendicular to the centre-line of the runway.
c. By the provision of a coarse graded slurry seal over an asphalt surfacing. This is the least favoured option.

1.2.3 Runway Ends and Adjoining Aircraft Holding Areas

Service conditions can be severe in these areas where jet blast and fuel spillage are likely to be most damaging and aircraft carry out sharp turns. To avoid excessive tyre wear being caused to turning aircraft, it is usual to reduce the friction properties at runway ends compared with that provided on the main lengths. The material most frequently used on the runway ends and holding areas is pavement quality concrete. However, with certain aircraft, the effect of jet blast on the

pavement surface is not critical (e.g. piston-engined aircraft, turbo props or turbo jets where the jet exhaust is located at a safe height above the pavement). In these instances, asphalt surfacing provided with a fuel resistant surface treatment is likely to be a viable and economic alternative to pavement quality concrete.

1.2.4 Taxiways

Friction characteristics and rideability on taxiways are not as critical as for the main length of a runway. Fuel and jet blast are not normally a critical consideration in these areas such that asphalt surfacings are generally a viable and economic construction option.

1.2.5 Parking and Servicing Aprons

Friction characteristics and rideability on parking and servicing aprons are not as critical as for the main length of a runway. In general, the need for resistance to fuel and oil spillages and to indentation by high tyre pressure tyres of standing aircraft and to damage from dropped tools, etc., will be such as to require the provision of a concrete surface. In certain circumstances, however, where the frequency of use is very low, asphalt surfacings provided with a fuel resistant surface treatment may be a viable and economic alternative to a concrete surface.

1.2.6 Vertical Take Off and Landing (VTOL) Pads and Engine Running Platforms (ERPs)

VTOL pads for Harrier operations and ERPs for high performance jet aircraft provide the most severe conditions for pavements on the MOD airfields. PQC is normally provided in these areas. Its life-span is dependent on frequency and mode of usage but currently the average life-span is 10 years. This compares with an average life-span in excess of 30 years for PQC in other areas of an airfield.

1.2.7 Short Take Off and Landing (STOL) Runways/Strips

Consideration should be given to the use of PQC for STOL runways/strips that are to be used by aircraft with thrust vectoring capability. Further advice on a project/works specific basis can be obtained from the Construction Support Team, DE.

1.2.8 French Drains Adjacent to Airfield Pavements

Where French drains are provided adjacent or in proximity to airfield pavements their surfaces must be stabilised in order to safeguard against the risk of FOD to aircraft. This can be achieved by the provision of a 100 mm thick pervious macadam topping to french drains. A specification for pervious macadam topping to French drains is provided in a separate DE Specification entitled "Hot Rolled Asphalt and Asphalt Concrete (Macadam) for Airfields".

1.3 PAVEMENT MATERIAL SELECTION PRINCIPLES

1.3.1 Unless the severity of the service use of a pavement area demands the use of concrete, asphalt surfacing material will normally be used.

1.3.2 The principal asphalt surfacing material used on MOD airfields is Marshall Asphalt surface and binder course. Marshall Asphalt is a highly controlled and consistent material, provides a high stability and meets the specialist performance requirements for most airfield pavement applications. In general, therefore, Marshall Asphalt is the preferred choice of material for surfacing either new or existing pavements.

1.3.3 Exceptions to this will primarily be dictated either by requirements for friction characteristics or economy. Friction characteristics on the main length of a runway must meet the criteria in JSB 554. Previous experience of works on MOD runways has shown that plain Marshall Asphalt surface courses rarely meet the friction criteria. Hence, prior to using the specifications in this Standard for runway resurfacing works, the Project Manager should first obtain advice from the Construction Support Team, DE on grooving/texture requirements. Alternatives to texturing a Marshall Asphalt surface course are given in Sub-Clause 1.2.2 (a) and (c).

1.3.4 There will be circumstances in which, for practical or economic reasons, it will be preferable to use an alternative asphalt material specification. Separate DE Specifications "Hot Rolled Asphalt and Asphalt Concrete (Macadam) for Airfield Pavement Works" and "Stone Mastic Asphalt for Airfields" provide alternatives to Marshall Asphalt and give guidance on their application and limitations. In general, the use of Hot Rolled Asphalt and Asphalt Concrete (Macadam) are applicable as cheaper and more easily provided asphalt materials for limited, non-critical portions of aircraft operating surfaces.

1.3.5 To aid proper control and make sure that the performance criteria will be met, Marshall Asphalt should be mixed on site wherever it is physically and economically possible.

1.4 SPECIFICATION CLAUSES FOR MARSHALL ASPHALT

Specification clauses are contained in Sections 2 to 7 and Appendix A and Appendix B of this Standard with Guidance Notes given on suitable temperatures and wind speeds for laying in Appendix D and on recommended roller types and sequence in Appendix E. Guidance Notes for the Project Manager on Quality Systems are given in Appendix Y and for the preparation of job specifications in Appendix Z.

1.5 ADVICE FROM CONSTRUCTION SUPPORT TEAM, DE

Clauses 1.2 and 1.3 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 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 Construction Support Team, DE.

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

Marshall Asphalt shall be specified, mixed, transported 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 & Composition	Section 4
Plant & Workmanship	Section 5
Trials	Section 6
Summary of Tests	Section 7
Marshall Asphalt Mix Design Procedure	Appendix A
Magnesium Sulfate Test	Appendix B
Straightedge Test	Appendix C
Temperatures & Wind Speeds	Appendix D
Roller Types and Sequence	Appendix E
Retained Marshall Stability Test	Appendix F

2.3 USE OF MARSHALL ASPHALT

Marshall Asphalt surface course and binder course shall be used in the locations indicated on the project drawings.

2.4 QUALITY ASSURANCE FOR THE SUPPLY OF ASPHALT MATERIALS

2.4.1 Component materials shall either be CE marked in accordance with a harmonised European Standard or European Technical Approval or shall be procured from a supplier with Quality Assurance accreditation to the BS EN ISO 9000 series. All operations in the batching of asphalt materials shall be carried out by a Contractor (or Supplier on his behalf) that has a Quality Assurance accreditation to the BS EN ISO 9000 series for those operations.

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

2.4.2 Each production unit or depot involved in the work shall be registered under a Quality Management scheme to the BS EN ISO 9000 series and under “Sector Scheme 14”, The Production of Asphalt Mixes. The CE mark documentation or the Quality System documentation for the supply of component materials and batching of asphalt materials, together with other relevant records and certificates, are to be submitted at Tender Stage.

(NOTE. The Project Manager should provide a questionnaire requesting the 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 Each laying unit involved in the work shall be registered under “Sector Scheme 16”, The Laying of Asphalt Mixes.

2.4.4 The Contractor shall be responsible for having all testing for the supply of asphalt materials carried out in accordance with the requirements of Section 7 and provide the Project Manager with a written copy of the results in accordance with Clause 7.1.

2.4.5 All documentation relevant to the work, including records of temperature control during mixing and 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.

3 Constituent Materials

3.1 AGGREGATES, GENERAL

3.1.1 The Contractor shall inform the Project Manager of the source and aggregate properties for each aggregate. The type of coarse aggregate to be used shall be crushed rock for surface course and binder course mixtures; the type of fine aggregate shall be either crushed rock or sand for surface course and binder course mixtures.

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

3.1.3 All aggregates used in the Marshall Asphalt shall be CE marked.

3.1.4 Aggregates shall conform to BS EN 13043 Categories for fines content, physical properties and durability as defined in Clauses 3.2 and 3.3. Aggregates shall not contain deleterious materials in such a form or in sufficient quantity to adversely affect the strength at any age or the durability of the surfacing, including resistance to frost.

(NOTE. Examples of such deleterious materials include significant quantities of:
- clay, loam or chalk, particularly as an adherent coating;
- mica, shale and other laminated materials;
- coal and other organic or vegetable impurities;
- dust or other material preventing thorough coating with binder; and
- sulfates and chlorides or other reactive substances liable to break down during drying or subsequent exposure to weather or moisture.

This list does not include all possible deleterious materials.)

3.1.5 The resistance to freezing and thawing of each source shall be categorised over all fractions using a modification of the Magnesium Sulfate Test in accordance with BS EN 1367-2 as outlined in Appendix B.

OR

The aggregates do not have to be categorised for resistance to freezing and thawing over all fractions using the Magnesium Sulfate Test in accordance with BS EN 1367-2 provided there is local evidence that the aggregate is sound.

(NOTE. Project Manager to select option for specific job specification; advice given in Clause Z.1 of Appendix Z.)

3.2 COARSE AGGREGATES

3.2.1 The coarse aggregate shall be crushed rock.

3.2.2 The properties of the coarse aggregate shall conform to the BS EN 13043 Categories shown in Table 3.1.

3.3 FINE AGGREGATES

3.3.1 Fine aggregates shall be:
- natural bank, river, dune, or pit sand;
- crushed rock; or
- blends of sand and crushed rock.

They shall be free from loosely bonded aggregations and other foreign matter. Sea-dredged sand shall not be permitted.

3.3.2 For surface courses, crushed rock fines shall be washed.

3.3.3 The properties of the fine aggregate shall conform to the BS EN 13043 Categories shown in Table 3.2.

3.3.4 When the asphalt is required to be grooved, the fine aggregate shall be capable of achieving the requirements of 5.33.

(NOTE. A minimum of 25 % of crushed rock fines in the mixture has been found to be beneficial for achieving compliance.)

TABLE 3.1 REQUIRED PROPERTIES FOR COARSE AGGREGATES

Property	Test Method	Situation	Category
Resistance to freezing and thawing	BS EN 1367-2/ Appendix B ‡	Each source Each fraction	MS_{18} MS_{30}
Shape	BS EN 933-3	All	FI_{25}
Resistance to fragmentation	BS EN 1097-2	All	LA_{30}
Water absorption	BS EN 1097-6	All	$WA_{24}2$
Affinity between aggregate and bitumen	BS EN 12697-11 Part B	All	Not greater than 6 particles from a 150 particle test sample
Fines content	BS EN 933-1	All	f_4
Resistance to Polishing	BS EN 1097-8	Runway surface course Taxiway surface course	$PSV_{declared}$* $PSV_{declared}$ *

‡ BS EN 1367-2: 1998 is restricted to the 14/10 mm fraction but, for this purpose, the same techniques shall also be used for other fractions of the coarse aggregate. Advice on the use of the test with non-standard aggregate fractions is given in Appendix B.

* Project Manager to provide value for specific job specification; advice given in Clause Z.2 of Appendix Z.

TABLE 3.2 REQUIRED PROPERTIES FOR FINE AGGREGATES

Property	Test Method	Aggregate type	Limit
Resistance to freezing and thawing	BS EN 1367-2/ Appendix B ‡	Each source Each fraction	MS_{18} MS_{30}
Fines content	BS EN 933-1	All	f_{10}
Fines quality	BS EN 933-9	All	MB_FNR OR MB_F25 *
Water absorption	BS EN 1097-6	All	$WA_{24}2$
Affinity between aggregate and bitumen	BS EN 12697-11 Part B	Parent rock if crushed rock fines	Not greater than 6 particles from a 150 particle test sample

‡ BS EN 1367-2: 1998 is restricted to the 14/10 mm fraction but, for this purpose, the same techniques shall also be used for other fractions of the coarse aggregate. Advice on the use of the test with non-standard aggregate fractions is given in Appendix B.

* Project Manager to select option for specific job specification; advice given in Clause Z.3 of Appendix Z.)

3.4 ADDED FILLER

3.4.1 All filler aggregate used in the Marshall Asphalt shall be CE marked.

3.4.2 The type of filler aggregate to be used for a particular material shall be selected from cement (to BS EN 197-1), crushed limestone or hydrated lime (to BS EN 459-1).

3.4.3 For surface courses, between 1.5 % and 2 % by mass of the combined aggregate grading specified in Clause 4.2 shall be CL 90-S lime to BS EN 459-1. The remainder of added filler shall be limestone or cement. Alternatively, 70 % minimum of the aggregate passing the 0.063 mm sieve shall be cement.

(NOTE: A wetting agent may be used as an alternative to CL 90-S lime if approved by the Project Manager prior to the commencement of work. However, no wetting agent will be considered unless proven by

comparative laboratory testing using, for example, the Saturation Ageing Tensile Stiffness (SATS) test to clause 953 of the *Specification for Highway Works* or comparative testing in accordance with sub-clause 4.2.5.)

3.4.4 Filler shall be stored in dry conditions.

3.4.5 The grading of added filler aggregate shall conform Table 3.3.

TABLE 3.3 GRADING REQUIREMENTS FOR ADDED FILLER

Sieve size (mm)	Proportion passing by mass (%)	
	Overall result for individual results	Producer's max. declared grading range *
2	100	–
0.125	90 to 100	10
0.063	80 to 100	10

* Declared grading range on the basis of the last 20 values, 90 % of the results declared shall be within this range, but all the results shall be within the overall grading range in column 2.

3.4.6 The loose bulk density in kerosene of added filler aggregate, other than hydrated lime, shall be in accordance with Clause 5.5.5 of BS EN 13043 (i.e. between 0.5 Mg/m³ and 0.9 Mg/m³)

3.4.7 A copy of all filler aggregate delivery tickets shall be passed to the Project Manager on a regular basis during production, for his retention.

3.5 BINDER

3.5.1 All binder used in the Marshall Asphalt shall be CE marked.

3.5.2 The binder to be used for Marshall Asphalt shall be 70/100 or 100/150 paving grade bitumen. The selection of a particular grade of bitumen for Marshall Asphalt depends on a number of factors, including the stability requirements in Clause 4.2.

(NOTE. The softest grade consistent with meeting the stability requirements should be used in order to maximise workability, minimise state of hardening and, hence, enhance longevity.)

3.5.3 The binder shall be paving grade petroleum bitumen meeting the requirements of BS EN 12591. The Contractor (or Supplier on his behalf) shall have Quality Assurance registration to the BS EN ISO 9000 series incorporating "Sector Scheme 15", Supply of Paving Grade Bitumen.

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

3.5.4 Each delivery of bitumen to the contract works shall be accompanied by a delivery ticket giving the following details:

- Delivery ticket number;
- Customer name and delivery site number;
- Date loaded;
- Date delivered;
- Vehicle registration number;
- Bitumen grade; and
- Quantity.

3.5.5 Copies of delivery tickets for the binder shall be passed to the Project Manager for his retention.

3.6 TACK AND BOND COATS

3.6.1 Prior to laying surface and regulating courses, a bond coat shall be applied to the existing surface. Prior to laying binder courses and ramps, either a tack coat or a bond coat shall be applied to the existing surface.

OR

Prior to laying any course other than base, either a tack coat or a bond coat shall be applied to the existing surface.

(NOTE. Project Manager to select option for specific job specification)

3.6.2 Tack coat shall be bitumen emulsion complying with either C 40 B 1 or C 70 B 1 of BS EN 13808.

3.6.3 Bond coats shall have a British Board of Agrément HAPAS Roads and Bridges Certificate. In the event that no such certificates have been issued, they shall not be used without the approval of the Project Manager.

3.7 COURSE THICKNESS

The thickness of each course of surfacing shall be as shown on the drawings. It shall be the thickness of the course at any point after compaction. Where the course thickness exceeds the nominal layer thickness allowed in Clause 3.8, the course shall be laid and compacted in two or more layers.

(NOTE. Increasing the thickness of a mat can considerably increase the time that it will take to cool to a temperature below which it cannot be effectively compacted. Therefore, in adverse weather (high winds and/or cold temperatures), the use of a greater course thickness will increase the possibility of having sufficient time to complete compaction.)

3.8 AGGREGATE SIZE

The aggregate size shall be in accordance with Table 3.4 for the relevant combination of course type and nominal layer thickness.

TABLE 3.4 SIZE OF AGGREGATE

Surfacing Layer	Material	Nominal Layer Thickness (mm)	Aggregate Size (d/D) (mm)
Surface Course	Marshall Asphalt	40 – 50	0/14
	Marshall Asphalt	50 – 60	0/20
Binder Course	Marshall Asphalt	50 – 60	0/20
	Marshall Asphalt	70 – 80	0/32
Regulating course/ Ramps	HRA †	0 – 20	0/2
	SMA #	0 – 25	0/4
	Marshall Asphalt	20 – 40	0/10
	Marshall Asphalt	20 – 60	0/14
	Marshall Asphalt	30 – 70	0/20
	Marshall Asphalt	40 – 100	0/32
	DBM ‡	30 – 70	0/20
	DBM ‡	40 – 100	0/32

† Specification for Hot Rolled Asphalt regulating course to be in accordance with *.

‡ Specification for Dense Bitumen Macadam regulating course to be in accordance with *.

Specification for Stone Mastic Asphalt regulating course to be in accordance with *.

* Project Manager to insert requirements. Specifications for these materials/mixtures are contained in separate DE Specifications “Hot Rolled Asphalt and Asphalt Concrete (Macadam) for Airfields” and “Stone Mastic Asphalt for Airfields”.

4 Design and Composition

4.1 GENERAL

4.1.1 All Marshall Asphalt incorporated into the permanent works shall be CE Marked in accordance with BS EN 13108-1.

4.1.2 Marshall Asphalt mixtures shall be designed by the Contractor in his laboratory in accordance with Appendix A. The aggregate size shall be appropriate to the layer thickness in accordance with Clause 3.8.

4.1.3 The production of Marshall Asphalt shall be carried out by a Contractor (or Supplier on his behalf) who works to a Quality Assurance scheme to the BS EN ISO 9000 series incorporating "Sector Scheme 14", Production of Asphalt Mixes, with an appropriate scope of application for those operations.

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

4.2 LABORATORY DESIGN MIXTURE

4.2.1 The target grading of combined fine and coarse aggregates shall fall within the limits of Table 4.1.

4.2.2 At least 60 % of the material passing the 0.063 mm sieve in the overall grading to Table 4.1 shall be added separately as added filler as Clause 3.4.

4.2.3 When plotted, the grading of the aggregates, determined in accordance with BS EN 933-1, shall give a smooth curve within the specified aggregate grading and shall not vary from the low limit on one size of sieve to the high limit on an adjacent sieve, nor vice versa.

4.2.4 'Laboratory Design Mixtures' for surface course and binder course shall comply with the BS EN 13108-1 categories listed in Tables 4.2 and 4.3 at the target binder content when determined for each mixture in accordance with the procedures stipulated in Appendix A. The limits on binder content shall not include any correction for aggregate density.

TABLE 4.1 TARGET GRADING LIMITS

Aggregate Size	0/32	0/20		0/14	0/10
Course	Binder (Regulating)	Binder (Regulating)	Surface	Surface (Regulating)	Regulating
Sieve (mm)	Proportion by Mass Passing (%)				
40	100				
31.5	88 – 100	100	100		
20		76 – 100	89 – 100	100	
14	58 – 80	64 – 89	78 – 90	86 – 100	100
10			69 – 83	78 – 90	95 – 100
6.3	40 – 64	46 – 71	60 – 75	66 – 79	77 – 85
2	24 – 45	27 – 50	42 – 56	43 – 57	48 – 56
1	17 – 35	18 – 39	33 – 46	31 – 46	37 – 46
0.5 *	11 – 27	12 – 30	24 – 36	21 – 36	27 – 35
0.125	5 – 13	6 – 14	8 – 16	7 – 15	9 – 12
0.063	2 – 7	3 – 8	3 – 7	3 – 7	3 – 7

* Informative limits on an additional sieve to those required by BS EN 13108-1.

TABLE 4.2 REQUIRED DESIGN CATEGORIES

Requirement	Binder course	Surface Course	Regulating Course‡
Minimum binder content †	4.0 %	5.0 %	5.0 %
Maximum binder content †	7.0 %	7.0 %	7.0 %
Air voids content	$V_{\min 3,0}$, $V_{\max 5}$	$V_{\min 3,0}$, $V_{\max 4}$	$V_{\min 3,0}$, $V_{\max 5}$
Voids filled with binder	$VFB_{\min 65}$, $VFB_{\max 77}$	$VFB_{\min 75}$, $VFB_{\max 83}$	–
Marshall flow	F_4	F_4	F_4

† The minimum and maximum binder contents are before applying any correction for aggregate density (as for determining the BS EN 13108-1 Categories $B_{\min}$ and $B_{\max}$).

‡ 0/10 regulating course mixtures only (not surface course or binder course mixtures used for regulating).

TABLE 4.3 REQUIRED MARSHALL STABILITY CATEGORIES

Location	Minimum Stability Category	
	Surface Course	Binder Course
*	*	*

* Project Manager to provide categories for specific job specification; advice given in Clause Z.4 of Appendix Z.

(NOTE 1. A well compacted mat having a design air voids content of less than 4 % is expected to provide good durability.)

(NOTE 2. The Project Manager is requested to issue copies of the 'Laboratory Design Mixture' tests and results to the Construction Support Team, DE. These shall include individual binder increment test results and graphs.)

4.2.5 For surface course mixtures, at the target binder content, the sensitivity to water of the proposed mixture shall conform to BS EN 13108-1 Category $ITSR_{90}$. For other mixtures, at the target binder content, the sensitivity to water of the proposed mixture shall conform to BS EN 13108-1 Category $ITSR_{70}$.

(NOTE. These categories have been set tentatively and may need to be changed when comparative results with the previous test (retained Marshall stability in accordance with Appendix F) become available. If there is evidence that material would have complied with the retained Marshall stability requirement but fails to comply with the *ITSR* Category, a request for a relaxation can be sent with the supporting evidence to the Construction Support Team, DE.)

4.2.6 Full details of the 'Laboratory Design Mixture' shall be provided to the Project Manager at least 1 week prior to the Trials required at Section 6 of this Specification.

4.3 JOB STANDARD MIXTURES

The 'Job Standard Mixture' shall be the 'Laboratory Standard mixture', modified as necessary in accordance with Section 6 of this Specification. It shall be the standard for the routine production of Marshall Asphalt for the works subject to the plant tolerances permitted in Clause 4.4.

4.4 VARIATIONS IN PLANT MIXTURES

4.4.1 Mixtures which are turned out by the mixing plant during normal routine production shall be designated the 'Plant Mixtures', and the limits of permissible variation between the 'Plant Mixtures' and the 'Job Standard Mixture' shall, at all times, meet the following requirements:

- The aggregate grading limits for each sieve size and the binder content limits shall be as given in Table 4.4 for individual samples;
- The voids in the total mixture shall be ± 1 % of the relevant value for the category given in Table 4.2;
- The voids filled with binder shall be ± 5 % of the relevant value for the category given in Table 4.2;
- The Marshall Flow shall be not more than 4.00 mm;
- The Marshall Stability shall not be less than 0.90 times the relevant value for the category given in Table 4.3; and
- Not less than 90 % of the Marshall Stability values shall be at least the relevant value for the category given in Table 4.3.

TABLE 4.4 TOLERANCES FOR THE ASSESSMENT OF CONFORMITY

Proportion passing	Small aggregate mixtures	Large aggregate mixtures
1.4 *D*	0 / –2	0 / –2
D, *D*/2 or Characteristic coarse sieve	± 4	± 5
2 mm or Characteristic fine sieves	± 3	± 4
0.063 mm	± 1.5	± 1.5
Soluble binder content	± 0.3	± 0.3

4.4.2 Notwithstanding the tolerance on binder contents in Sub-Clause 4.4.1, the minimum binder content without correction for aggregate density shall be 4.0 % for binder course and 5.0 % for surface course mixtures.

5 Plant and Workmanship

5.1 GENERAL

The standard of workmanship and finish of all surfacing included in this Contract shall be equal in all respects to that of the "Approved" areas established in the trials in accordance with Section 6.

5.2 HANDLING AGGREGATES

5.2.1 Test requirements on bulk supplies are specified in Clause 7.4.

5.2.2 Aggregates of different sizes shall be stockpiled separately as supplied and aggregates from different supply sources, though with similar gradings, shall be stockpiled separately for each source of supply. Stockpiles shall be on a concrete or asphalt paved surface, laid to falls to allow unrestricted drainage. The siting and preparation of the sites shall be approved by the Project Manager. Aggregates with different gradings and/or from different sources that are in close proximity shall be separated by sturdy bulkheads.

5.2.3 A description of the methods to be adopted to prevent 'overspill' between adjacent stockpiles, 'coning' or segregation of the aggregate grading in the stockpiles, particularly during tipping, shall be made available to the Project Manager if requested. At all times, the stockpiles shall be kept free from contact with deleterious matter.

5.2.4 Care shall be taken to avoid crushing by stockpiling equipment.

5.2.5 All aggregates produced or handled by hydraulic methods or which have been washed shall be stockpiled for at least 24 h before use in an area such that unrestricted drainage can occur.

5.3 PROPORTIONING COLD AGGREGATES

5.3.1 There shall be at least one cold hopper for each size of stockpiled aggregate from each source. When two or more fine aggregates are being incorporated in the mixture, a separate hopper shall be provided for each. All cold hoppers shall be kept sufficiently charged to ensure a uniform rate of delivery. Hoppers containing fine aggregates shall be fitted with vibrators and/or low friction liners.

5.3.2 The feed gates, vibrators and other devices provided for controlling the output from each hopper shall be capable of accurate adjustment to ensure a uniform rate of aggregate feed.

5.3.3 Overspill between cold hoppers shall be prevented.

5.4 STATIC PLANT

5.4.1 Whenever a regulating course is required, a weighbridge shall be provided on site, irrespective of whether the mixing is to be carried out on- or off-site.

5.4.2 Marshall Asphalt shall normally be mixed on site; proposals to mix off site should be submitted at tender stage.

OR

Marshall Asphalt shall be mixed on site.

(NOTE. Project Manager to select option for specific job specification; advice given in Clause Z.5 of Appendix Z.)

5.4.3 Static plant shall be adequate for the purpose of producing fully-coated asphalt in accordance with this Specification. The Contractor shall submit his proposals in respect of static plant with his Tender. Proposals which include the use of continuous drum mixers shall contain details of the means of controlling the grading of aggregates throughout the mixing process, including that of filler/added filler in association with the control and extraction of dust. Recycling of dust in lieu of added filler will not be permitted (see Clause 5.8.1)

5.4.4 The siting of all static plant shall be agreed with the Project Manager and the layout of the units shall be considered in relation to prevailing winds and the local population to minimise nuisance.

(NOTE. See the Guidance issued by the Department of the Environment for details of Local Authority

requirements and authorisation of plant in respect of Part 1 of Environmental Protection Act as of 1 April 1991.)

5.4.5 The weighing, measuring and recording mechanism and temperature control gauges shall be checked by the manufacturer of the mechanism and gauges, or by an independent testing authority, and the Contractor shall submit proofs certifying that each device is operating accurately or reporting deviation allowances required in respect of each indicator, to the Project Manager, for his retention. These checks shall be carried out before mixing starts, at the end of each month during mixing, and whenever the plant is re-sited or disturbed.

5.4.6 All plant shall be maintained in good working order, controlled by a trained and experienced operator, and shall be subject to inspection by the Project/Works Services Manager. This applies equally to outside mixing plants as well as for on-site mixing.

(NOTE. Approval for mixing outside the airfield should not be given if the distance between mixing plant and site is such that the specified mixing and laying temperatures cannot be routinely achieved.)

5.5 BINDER STORAGE

The binder shall be separately heated to the temperature(s) specified in Clause 5.7 in approved heating tanks. The temperature dials shall be readily accessible, shall be kept clean at all times, and their calibration checked at the start of the contract and thereafter at 6 monthly intervals.

5.6 DRYING AND HEATING AGGREGATES

Aggregates shall be thoroughly dried and heated. The Contractor shall carry out moisture tests as detailed in Clause 7.4 at least once a week to check the effectiveness of the drying processes. If at any time the tests specified in Clauses 7.4 or 7.5 indicate that the drying facilities are inadequate, mixing shall cease until the Contractor has improved his drying capability to the satisfaction of the Project Manager. All drying plant shall be equipped with efficient dust extractors.

5.7 MIXING, DELIVERY AND COMPACTION TEMPERATURES

5.7.1 Marshall Asphalts shall be mixed, delivered, laid and compacted within the material temperature limits given in Table 5.1.

(NOTE. Compliance with the mixing temperature limits given in Clause 5.2.10 of BS EN 13108-1:2006 incorporating 2008 corrigendum will be achieved by these values.)

TABLE 5.1 TEMPERATURE LIMITS

Bitumen Grade	Temperature (°C)					
	Binder (Min)	Binder (Max)	Mixing (Max)	Delivery (Min)	Paver-out (Min) †	Compaction (Min)‡
70/100	150	175	175	130	125	90
100/150	150	175	160	125	115	75

† These values are recommended only but need to be achieved in order to have the maximum available compaction time. They are useful for monitoring purposes to ensure that adequate compaction time is available.

‡ This value is the mid-layer temperature at which completion of compaction shall be achieved.

5.7.2 Overheating of the binder and of binder/ aggregate mixtures is prohibited.

5.7.3 The Contractor shall check the temperature of the delivered load and the load in the hopper according to the method in BS EN 12697-13 at the following intervals:

- within 30 min of arrival on site;
- whilst discharging from the delivery lorry into the paver hopper;
- immediately before restarting the spreader following stoppage;
- immediately prior to the beginning of compaction; and
- at any time the Project Manager or his representative directs.

5.7.4 The prescribed compaction procedure shall have been substantially completed before the surfacing temperature has fallen to the minimum compaction temperature.

5.7.5 Mixtures which do not comply with the above requirements shall not be used. Reheating is prohibited.

5.7.6 The test results shall be recorded in an approved form linking the temperature taken with the location of the material tested and shall be submitted daily to the Project Manager.

5.8 MIXING

5.8.1 The proportion of filler shall be measured by weight. Where the Specification for the material being mixed requires a definite proportion of an added filler, extracted dust shall not be fed back into the mixer.

5.8.2 The proportion of binder may be measured by either weight or volume.

5.8.3 All mixing plant shall incorporate means of access for samples of mixed material, bitumen and filler to be taken.

5.8.4 For batch mixers, the hot aggregates shall be screened and separated into the hot-bins after heating for batching by weight in at least three different sizes into the mixing unit. Means of enabling samples to be obtained from each hot-bin shall be provided. Batch-mixing plant which does not incorporate these requirements is prohibited. The hot aggregates and binder shall be mixed together in the correct proportions until the binder is evenly distributed. Filler may be added before or after the binder but mixing shall continue for at least 1 min after the addition of the filler. The total mixing time may only be reduced if the Project Manager is satisfied that thorough mixing can be achieved in less time. In such cases, the Contractor shall obtain the written authority of the Project Manager to reduce the mixing time to a specific period.

5.8.5 For continuous drum mixers, the hot aggregate and binder shall be mixed together in the correct proportions until the binder is evenly distributed. Filler is to be added simultaneously with the binder to ensure full incorporation and distribution within the mix.

5.9 VARIATIONS IN PLANT MIXTURES

Any variations outside the limits specified in Clause 4.4 shall be investigated. If such variations continue for more than 24 h, all laying shall cease. All plant and processes shall then be checked and immediate arrangements shall be made by the Contractor to make the necessary modifications or corrections, until the Project Manager is satisfied that when laying restarts the mixtures will comply with these requirements. Before laying continues in the construction area, the Project Manager may instruct the Contractor to lay a further trial area of surfacing, as described in Clause 6.3, on disused pavements within the airfield boundary.

5.10 GENERAL WEATHER CONDITIONS FOR LAYING ASPHALT SURFACING

5.10.1 Laying of asphalt surfacing shall not proceed unless:

- the surface to be covered is unfrozen and free from ice, snow and de-icing agents;
- the temperature of the surface to be covered is 0° C or more; and
- the air temperature is either:
  - above 1 °C or
  - between -1 °C and 1 °C and rising.

5.10.2 Laying of asphalt surfacing shall not proceed during precipitation unless:

- both the surface to be covered and the air temperature are above 0 °C;
- there is no free water on the surface; and
- the degree of moisture present on the surface is not detrimental to the finished product.

(NOTE. Guidance is given on suitable temperatures and wind speeds for laying in Appendix D.)

5.11 REDUCTION IN SURFACE LEVEL OF ASPHALT SURFACES

Where the surface level of an existing asphalt surface is being reduced, thicknesses shall be removed with an approved planing machine. The machine shall be provided with control devices which enable the rapid adjustment of blades to fine depth-of-cut settings while the machine is operating.

5.12 REDUCTION IN SURFACE LEVEL OF CONCRETE SURFACES

5.12.1 Where the surface level of an existing concrete surface is being reduced, thicknesses from fine fractions up to the limits as specified hereafter shall be removed by scabbling or planing. Scabbling or planing shall be carried out by machines operated in a manner that results in a minimum of over-cutting and uniform exposure of the aggregate, without shattering or otherwise damaging the concrete slabs.

5.12.2 Unless directed by the Project Manager, such reductions in level shall be bounded by joints

in the concrete pavement. Where they are not and where the scabbling or planing is not tapered to zero depth, the area to be reduced in level shall first be defined by saw cuts, 5 mm deeper than the depth of the scabbling or planing.

5.12.3 The surface treated as above shall be thoroughly cleaned with hand brooms and all loose debris shall be collected and removed.

5.12.4 Before the area is surfaced, a tack or bond coat appropriate to the surfacing material shall be applied as specified in Clause 5.18 and the exposed vertical edges shall be painted with hot bitumen. The new surfacing shall be made to firmly adhere to the vertical edges.

5.12.5 The whole of the concrete layer shall be removed for its full depth where the thickness required to be removed is greater than the lesser of:

- 100 mm; and
- one third the depth of the slab.

Where the concrete is in bays less than 4.5 m square, the boundary of the area to be removed shall be defined by bay joints. Where the bays are larger, part bays may be removed such that the remaining portion shall not be less than 2.25 m by the full length or full width of the bay.

5.12.6 Care shall be taken to ensure that all concrete remaining in the vicinity of cutting-out remains sound and without fracture and that disturbance to sub-bases and underlying layers is minimised.

5.13 PREPARATION OF EXISTING ASPHALT SURFACES

5.13.1 Before the tack or bond coat is applied, all vegetable growth and loose aggregate or other particles shall be removed from all cracks in the existing asphalt surfacing on which new surfacing is to be laid. Loose laitance and other spalling or de-bonded slurry seal shall be removed from the surface. The surfaces shall be swept until standing water, mud, grit and all other extraneous matter has been removed. Immediately ahead of tack or bond coating, all dust shall be removed by vacuum extraction cleaning, with or without high pressure water at the discretion of the Project Manager.

(NOTE 1. Cleaning machines applying high pressure water and vacuum extraction are very effective in removing debris and cleaning the surface. Water pressures about 50 Bar are adequate for general cleaning, but higher pressures may be used subject to the Project Manager's discretion. At very high pressures, damage to the surfacing may result.)

(NOTE 2. Vacuum extraction after high pressure cleaning generally results in a sufficiently dry surface for application of a tack or bond coat.)

5.13.2 Existing overbanding of the surfacing shall be removed when required by the Project Manager.

(NOTE. When resurfacing comprises only a surface course, it will normally be a requirement to at least remove thick depositions of overbanding.)

5.14 PREPARATION OF EXISTING CONCRETE SURFACES

5.14.1 Before the tack or bond coat is applied, all vegetable growth and loose debris including concrete fractions shall be removed from all cracks, joints and joint edges in the existing concrete surfacing on which the new asphalt surfacing is to be laid. The surface shall be thoroughly cleaned and all loose debris shall be collected and removed.

(NOTE 1. Cleaning machines applying high pressure water and vacuum extraction are very effective in removing debris and cleaning the surface. Water pressures about 50 Bar are adequate for general cleaning, but higher pressures may be used subject to the Project Manager's discretion. At very high pressures, damage to the surfacing may result.)

(NOTE 2. Vacuum extraction after high pressure cleaning generally results in a sufficiently dry surface for application of a tack or bond coat.)

5.14.2 All joints in the concrete paving shall be examined and a joint preparation programme shall be agreed between the Contractor and the Project Manager.

5.14.3 When directed, the joint sealing compound shall be removed in joints 20 mm wide or greater where the sealant has lost its original properties and can be removed by hand methods. The sealant shall be replaced with lightly compacted 0/4 mm size asphalt concrete (macadam) in accordance with BS EN 13108-1 and complying with Table 5.5 of DE Specification "Hot Rolled Asphalt and Asphalt Concrete (Macadam) for Airfields". The asphalt shall be laid to a convex finish slightly proud of the general surface level.

5.14.4 In all other cases, the joints shall be prepared by cutting-off any compound which has extruded above the general level of the pavement with heated tools so as to be flush with the concrete surface. Any unfilled joints less than 20 mm wide may be ignored.

5.14.5 Loose laitance and other spalling or debonded slurry seal shall be removed from the surfaces which shall then be swept until standing water, mud, grit and all other extraneous matter has been removed. Immediately ahead of tack or bond coating, all dust shall be removed by vacuum extraction cleaning, with or without high pressure water at the discretion of the Project Manager.

5.15 FILLING RAVELLED LANE JOINTS, RAVELLED CRACKS AND POTHOLES IN EXISTING ASPHALT SURFACING

5.15.1 Ravelled joints, ravelled cracks and potholes shall be made good before the new surfacing is laid.

5.15.2 Trenches shall be formed by carefully cutting out the existing asphalt surfacing on either side of the joints or cracks to the full depth of the surface course and, if directed, to the underside of the binder course or to the top of the underlying concrete or pavement base. The new material shall be bonded into the old surfacing.

5.15.3 The cross section of the trench shall be a minimum of 200 mm wide. The side walls of the trench shall be clean vertical cuts and shall be stepped-back a minimum of 50 mm on each side at a convenient plane of separation between any two courses of the existing surfacing. When the existing pavement level is not to be raised, the edges of the trench or patch shall be defined by means of saw cuts extending to the full depth of the surface course.

5.15.4 All loose and crumbling fractions shall be removed from the bottom and sides of the trench. The bottom and sides shall be completely painted with tack coat.

5.15.5 The defective surfacing shall be replaced with the specified surface course material. It shall be placed in the trenches in lifts of about 50 mm each which shall be compacted separately with approved mechanical or hand tampers as specified in Clauses 5.23 and/or 5.24.

5.15.6 At the time of compaction, the mixture shall be at the specified temperature. The final layer shall be laid so as not to leave a concave finish below the general surface after thorough compaction by rolling.

5.15.7 All loose material shall be removed from any potholes, the bottom and sides of the depressions painted with tack coat and then the potholes backfilled, compacted and finished in accordance with sub-Clauses 5.15.5 and 5.15.6.

(NOTE. Further guidance on making good is given in DE Functional Standard 06, "*Guide to Airfield Pavement Maintenance*".)

5.16 SAMPLING AND TESTING MIXED MATERIALS

5.16.1 Bulk samples of the mixed materials, as required in Sub-Clause 7.5.1, shall be taken by the Contractor and divided. One sample shall be analysed for grading, binder content, bulk density, stability, flow, voids in the total mix and voids filled with bitumen; the other retained for reference in the case of a dispute.

5.16.2 Samples shall be labelled and details shall include material type, date of delivery, vehicle registration number, course location and time of laying and other relevant information deemed necessary by the Project Manager.

5.17 TRANSPORTING PLANT MIXTURES

5.17.1 The plant mixtures shall be transported without delay to the laying sites from the mixing plant or from hot storage bins taking care to prevent segregation. The vehicles shall be double sheeted during transit and while waiting to prevent loss of heat, contamination and wetting. All vehicles shall be mechanically sound and roadworthy and shall be suitable for the spreading equipment in use and shall have insulated bodies.

5.17.2 The use of water or proprietary products on the surfaces of the transporting vehicles to facilitate discharge shall be strictly regulated to the absolute minimum. If the Project Manager considers that contamination of the mixtures is occurring, the vehicle shall be thoroughly cleaned out to his satisfaction before being used again. The use of diesel oil, dust, sand or other fine particles is prohibited.

5.17.3 The temperature of the load in every transporting vehicle shall be checked in accordance with Clause 5.7.

5.17.4 Each delivery of Marshall Asphalt to the contract works, whether batched on-site or off-site, shall be accompanied by a delivery ticket giving the following details:

- Delivery ticket number;
- Vehicle registration number;
- Material type and mix classification;
- Paving grade of bitumen used; and
- Quantity.

For material batched off-site, the delivery ticket shall also give the following details:

- Customer name and Delivery site number;
- Source of supply;
- Date and time loaded; and
- Date and time delivered.

Copies of the delivery tickets shall be passed to the Project Manager for his retention.

5.18 TACK AND BOND COAT APPLICATION

5.18.1 The type of tack or bond coat to be used for the particular material being laid is as specified in Clause 3.6.

5.18.2 Tack and bond coats shall be applied not more than 24 h in advance of surfacing. The target rate of application shall be in accordance with BS 594987. Tack and bond coats may be applied to damp surfaces but ponded or standing water shall be removed as specified in Clauses 5.13 and 5.14.

5.18.3 Tack and bond coats shall be applied uniformly, free of streaks and blobs in accordance with BS 434-2 by mobile mechanical tank-spraying units complying with BS 3136-2. The tack or bond coat shall be allowed to 'break' completely before laying proceeds. Where the size or shape of an area to be sprayed precludes mobile operation, pressure spraying equipment or hand-spraying complying in accordance with BS 434-2 will be permitted with the approval of the Project Manager.

(NOTE. The use of paving machines that incorporate equipment to apply the tack or bond coat immediately before the mix is laid will not allow the opportunity to ensure that the tack or bond coat has 'broken'. If the Contractor wishes to use such equipment, he shall seek prior written approval from the Project/Works Manager. Advice for Project/Works Manager is given in Clause Z.6 of Appendix Z.)

5.18.4 Airfield lighting units, gratings, covers and similar fittings shall be adequately masked with an approved protection during application. Care shall be taken to prevent the spraying of porous surfacing of the french drains and, if the Project Manager considers it to be necessary, these shall also be protected.

5.18.5 After application, no traffic of any kind shall be allowed to run over the tack or bond coat until surfacing starts and arrangements shall be made to cordon off the sprayed areas until it does. When surfacing starts, only the minimum amount of traffic essential to the surfacing operations shall be permitted.

5.19 PERMITTED TOLERANCE OF COURSE THICKNESS

5.19.1 The total compacted thickness of any course of the surfacing material at any point shall not be less than the specified course thickness or exceed this thickness by more than:

- +10 mm / –0 mm for surface courses (except in ramps, see Clause 5.28); and
- +25 mm / –0 mm for binder courses.

5.19.2 A core sample shall be taken to determine course thickness:

- at minimum intervals of every 1000 m² laid or from every 2 h work, whichever is the more frequent; and
- at locations agreed with the Project Manager.

5.20 REGULATION OF EXISTING SURFACES

5.20.1 Where the irregularities in the pavements to be surfaced are such that the permitted thickness tolerances for that course will be exceeded, the existing surfaces shall be regulated as a separate item in advance of general resurfacing. Regulation shall be carried out with a relevant mixture from Clauses 3.8 and 4.2 subject to the additional requirements in this clause.

5.20.2 Regulation for depths below 20 mm shall be carried out with either 0/4 F Hot Rolled Asphalt or 0/4 Stone Mastic Asphalt. The binder shall be 70/100 paving grade bitumen unless the surface course is to be a 10 kN design stability mixture, when the paving grade shall be 40/60. The planning of the layout of the regulating courses shall be such as to minimise the use of 0/4 F Hot Rolled Asphalt or 0/4 Stone Mastic Asphalt.

5.20.3 Regulation for depths between 20 mm and 30 mm that are immediately beneath the surface course shall be carried out with either:

- 0/10 Marshall Asphalt regulating course for which the laboratory design mixture shall provide a stability not less than that of the surface course requirement; or

- 0/14 Marshall Asphalt surface course in which some of the coarser particles may need to be raked out of the mixture by hand to produce dense compacted material.

5.20.4 Regulation for depths between 30 mm and 40 mm that are immediately beneath the surface course shall be carried out, with one of the following:
- 0/10 Marshall Asphalt regulating course;
- 0/14 Marshall Asphalt surface course; or
- 0/20 Marshall Asphalt binder course.

5.20.5 Regulation for depths in excess of 40 mm, where to be immediately beneath the surface course shall be carried out, shall be carried out with either Marshall Asphalt surface course or Marshall Asphalt binder course.

5.20.6 Regulation of the existing surface shall continue, subject to the tolerances specified in Clause 5.19, until the regulated surface, when tested with a straightedge in accordance with BS EN 13036-7, achieves an accuracy of:
- 10 mm in 3 m when a surface course only is to be overlaid on it; or
- 25 mm in 3 m when a binder course and surface course are to be overlaid on it.

Twenty tests shall be made for every 1000 m^3 laid of which at least half shall be across lane joints.

5.21 LAYING REQUIREMENTS

5.21.1 A competent supervisor shall be in charge of all laying and finishing operations.

5.21.2 The mixtures shall be spread to surcharged depths necessary to give the specified course thickness, and to comply with the finished levels and profiles shown on the drawings, after compaction. Where the total specified course thickness exceeds the nominal layer thickness specified in Clause 3.7, the course shall be laid in two or more separate layers, each fully compacted.

5.21.3 The mixture shall be placed in lanes of 3 m minimum width, except where lanes are being reduced in width to infill between full-width lanes, and drainage channels. Lanes shall be laid parallel to the pavement centre line and the first lane shall be placed with its highest edge along the crown of areas with a crowned profile, and on the high side of pavements with a crossfall.

5.21.4 Surface course shall be laid on binder courses as soon as practicable, and shall be made to firmly adhere to binder courses. Binder courses which have been left exposed for more than seven days shall be tack or bond coated in accordance with Clause 5.18 before the laying of surface course.

5.21.5 The use of hand-rakes shall be prohibited when the mixtures are laid by spreading and finishing machines in accordance with Clause 5.22 except at joint edges and around manholes and pits, where their use shall be restricted to an absolute minimum.

5.21.6 After the spreading units have passed, hand-casting of fines behind the spreader as a means of making-up irregularities or disguising blemishes left by the spreader shall not be permitted.

5.21.7 At all times, the courses shall be kept free from all extraneous matter.

5.21.8 The standard of finish, including that at joints, shall comply with the requirements of this Specification and shall be of the standard achieved in the trials (Sub-Clauses 6.2.5 and 6.3.8). The surface finish shall have no laying defects, such as dragging or surface blemishes result.

5.22 SPREADING BY MACHINE

5.22.1 Except where the conditions of Clause 5.24 apply, the mixture shall be spread, levelled and tamped by approved self-propelled spreading and finishing machines which are capable of continuously laying to the required widths, profile, camber or crossfall without causing segregation, dragging, burning or other surface defects or irregularities. They shall also be capable of operating at a speed consistent with the type and thickness of the Marshall Asphalt being laid.

(NOTE. The method of control should be adequate to achieve the tolerances required and should not be limited by the length of the paving equipment if that is not sufficient. It may be necessary to use a wire guidance system or averaging beam to achieve the required accuracy in certain critical situations, such as at or in the vicinity of wandering crowns or for laying of regulating courses.)

5.22.2 Any extension beyond the basic width of the machine shall be strictly in accordance with the manufacturer's recommendations and shall give a level uniform surface over the full width of the lane to the satisfaction of the Project Manager.

5.22.3 Each spreader shall be maintained in good mechanical condition and shall be correctly

adjusted for operation at the speed consistent with the properties and rate of delivery of the mixture and the thickness and agreed rolling procedures for the course. Once adjusted, each spreader shall be capable of producing a surface of uniform density and texture free from segregation, dragging, irregularities, or other unacceptable surface blemishes. If dragging or other faults should occur, laying shall cease until the mechanism and operation of the units have been checked and the defects have been rectified or modifications made.

5.22.4 As soon as possible after arrival at the laying site, the mixtures shall be discharged continuously to the spreader and shall be laid in accordance with the requirements of Clause 5.20.6 without delay. When discharging into the spreader, the lorry shall approach and gentle contact shall be made only between rollers on the spreader and the rear wheels of the lorry to avoid causing the paver screed to indent the mat.

5.22.5 Intermittent stopping of the spreader shall be avoided and the rate of delivery to the spreader shall be so regulated to enable spreading to be continuous.

5.23 COMPACTION

5.23.1 The surfacing shall be uniformly compacted in the manner approved during the laying of the trial area described in Clause 6.3, using the type of equipment and loads applied as agreed with the Project Manager.

5.23.2 Rollers shall be in good condition and fitted with smooth, rapid-acting reverse controls. They shall be equipped with roll scrapers, absorbent mats and tanks connected to spray pipes on both front and rear rolls to ensure a uniform minimal application of water or parting fluid. The rollers shall be operated by skilled and experienced drivers. The weight to which each roller shall be ballasted shall be agreed with the Project Manager during the laying of the trial(s).

5.23.3 Rolling shall proceed in the direction of laying with the rear wheel (3-point roller) or wheels (tandem roller) lapping the edge of any previously laid surfacing and shall progress gradually to the opposite edge of the lane. The lapping of the rolling shall be such that, on completion, all roller marks are obliterated. During rolling, the roller wheels shall be kept moist with sufficient water to avoid picking up material. A water bowser shall be provided alongside each spreading unit to ensure that rolling continues with the minimum interruption.

5.23.4 Rollers shall move at a slow but uniform speed which should not exceed 5 km/h and any pronounced change in direction of the roller shall be made on stable material. The line of rolling shall not be suddenly changed or the direction of rolling suddenly reversed, thereby displacing the mix. Rollers shall not be left standing on the new surfacing within 24 h of laying.

5.23.5 The roller types and sequence shall be such as to provide the required standard of compaction and finish.

(NOTE. Guidance is given at Appendix E.)

5.24 SPREADING AND COMPACTING BY HAND

5.24.1 Spreading by hand will be permitted for:

- filling potholes and cracks;
- repairing joints;
- the regulation of existing surfaces as specified in Clause 5.20;
- feathering;
- shaping drainage channels if impracticable by machine;
- the replacement of old or defective surfacing when the areas are small;
- areas of irregular shape

With the approval of the Project Manager, spreading by hand will also be permitted in areas where manholes or pits are concentrated and in areas which are inaccessible to the spreading and finishing machines specified in Clause 5.22.

5.24.2 The mixture shall be unloaded with care to avoid segregation onto an existing hard, clean surface on, or adjacent to, the area on which it is to be placed or, when this is not available, onto an approved metal sheet alongside the area. The mixture shall be spread portion by portion without break with hot shovels to a uniform thickness which, after compaction, shall not exceed the maximum thickness specified for the mixture. The material shall then be finished with hot hand-rakes by skilled rakers to the level required to give the correct shape and profile after compaction.

5.24.3 The exposed edges of manhole frames, grating frames, lighting units and any fixtures in the pavement or the concrete surrounds against which the new surfacing abuts shall be scraped and thoroughly cleaned to the satisfaction of the Project Manager. An approved sealing system shall be applied around the fixture/surround in accordance with the manufacturer's instructions, or other treatment as recommended in BS 59 4987, within

2 h prior to laying the asphalt surfacing. The surfacing shall then be packed tightly around the fixture and firmly tamped into position.

5.24.4 On completion of compaction, the finished surface of the surface course and other materials as used shall be level with the fixture to the accuracy specified in Clause 5.31. Shaping and dishing to the sides of catchpits shall be carefully carried out to the profiles shown on the drawings. In places that are inaccessible to the rollers that are specified in Clause 5.23, compaction shall be achieved by suitable vibrating rollers or by tamping.

5.25 LONGITUDINAL LANE JOINTS

5.25.1 Longitudinal joints in surfacing materials shall be constructed in such a position that they are at least 600 mm horizontally away from any longitudinal joints in the underlying material. The longitudinal lane joints shall be vertical in straight lines which are continuous for the full length of the pavement, or in smooth curves around bends.

5.25.2 The exposed vertical edges of the longitudinal lane joints in the Marshall Asphalt surfacing materials shall be carefully cut back and trimmed to firm material in the compacted lane, or for a minimum of one and a half times the layer thickness, whichever is the greater, and all loose material arising from this operation shall be removed from the pavement before the cut edge is painted.

5.25.3 Edge rolling shall only be used as an alternative to cutting back if it can be demonstrated during the trials to the Project Manager that satisfactory standards of compaction, surface/joint finish and adhesion can be achieved.

(NOTE. Cores should be taken for test at these joints to demonstrate good adhesion and bulk density within the specified limits.)

5.25.4 Cutting back and trimming will not be required when two or more spreading units operate in echelon in close proximity, permitting adjacent lanes to be continuously compacted before the material around the joint between the lanes falls below the compaction temperature specified in Clause 5.7.

5.25.5 After cutting back and trimming, the exposed vertical edges of the longitudinal lane joints shall be thoroughly cleaned of all adherent material and shall then be painted with a uniform thickness of bitumen just ahead of the spreading unit laying the adjacent lane. Painting shall completely and uniformly cover the exposed edge for its full depth. Excess material to the top and base of the joints, streakiness and blobs shall be avoided.

5.25.6 On completion, the joints shall present the same texture as the remainder of the surface and the accuracy of the surface across the joints shall meet the criteria specified in Clause 5.31.

5.25.7 When laying during cool windy weather, a joint heater may be used subject to the discretion of the Project Manager.

5.26 TRANSVERSE JOINTS

5.26.1 Transverse joints are required at the end of a day's work and following any interruption in laying which prevents continuity of rolling at, or above, the specified minimum temperature. Transverse joints shall be formed at right angles to the longitudinal joints and shall be vertical.

5.26.2 The exposed vertical edges of the transverse joints of all layers shall be cut back for at least 300 mm and trimmed. All loose material arising from this operation shall be removed from the pavement and the underlying surface cleaned. The exposed joint edges shall then be cleaned and painted with bitumen as specified in Clause 5.25 immediately before the laying of the lane continues.

5.26.3 On completion, the joints shall present the same texture as the remainder of the surface and the accuracy of the surface across the joints shall meet the criteria specified in Clause 5.31.

5.27 JOINTS BETWEEN NEW SURFACING AND EXISTING PAVEMENTS

5.27.1 Existing asphalt surfacing against which new surfacing is to be laid shall be cut back as necessary to a line removing all loose or weathered material and shall be finished with a vertical edge. Immediately prior to the laying of new material, either:

- a thin uniform coating of 40/60 or 70/100 paving grade bitumen; or
- an approved joint seal in accordance with the manufacturer's instructions,

shall be applied over the complete face.

5.27.2 Where asphalt resurfacing is ramped into an existing asphalt surface and the ramp ends at a point abutting an existing concrete surface, the

exposed vertical face of the concrete shall be cleaned thoroughly and either:

- a thin uniform coating of 40/60 or 70/100 paving grade bitumen; or
- an approved joint seal in accordance with the manufacturer's instructions,

shall be applied over the complete face within 2 h prior to laying the asphalt surfacing.

5.27.3 The edge of existing concrete surfacing against which a completely new asphalt surfacing is to be laid shall be exposed and thoroughly cleaned to its full depth and for the appropriate length. Unless shown otherwise on the drawings, an expansion joint shall then be formed below the new surfacing by:

- placing a joint filler of non-extruding, heat and rot-proof board against the bottom of the exposed concrete face that is 25 mm thick and of a height equal to the depth of the concrete slab less the greater of:
  - 100 mm and
  - the total thickness of the new surfacing;
- installing an approved joint sealing material in accordance with the manufacturer's instructions to the upper margin of the exposed face; and
- carrying the new surfacing over the top of the joint filler within 2 h of installing the joint sealing material.

The new surfacing at the junction shall be a minimum of 100 mm thick for a distance of at least 3 m back from the junction, laid in a minimum of two layers.

5.28 RAMPS BETWEEN NEW SURFACING AND EXISTING PAVEMENTS

5.28.1 Junctions to be made with ramps between the new surfacing and existing pavements are shown on the drawings, for which typical details are given in Figures 5.1, 5.2 and 5.3.

5.28.2 Where appropriate, the new binder course shall be reduced in thickness at a slope parallel to that of the finished surface to a minimum thickness of 40 mm. It shall be further ramped down at the same slope in hand-laid material to a compacted thickness of 20 mm using the materials specified in Sub-Clauses 5.20.3 and 5.20.4.

5.28.3 For thicknesses less than 20 mm, regulating materials shall be as specified in Sub-Clause 5.20.2.

5.28.4 The width of these reductions in level shall be as shown on the drawings and shall be formed so the surface course remains within the tolerances of thickness specified in Clause 5.19 at all points within it. The surface course shall, however, be permitted to exceed the higher tolerance in the limited area immediately following the end of the binder course ramping.

5.28.5 Where the existing surface is asphalt, the end of the ramp furthest away from the new surfacing shall be defined by a clean saw cut to the depth shown in Figure 5.2 or 5.3 before planing is commenced.

5.28.6 Where the existing surface is concrete, the end of the ramp furthest away from the new surfacing shall be along the line of existing joints or grooves. The surface so prepared shall be thoroughly cleared of all loose materials and either:

- a thin uniform coating of 40/60 or 70/100 paving grade bitumen; or
- an approved joint seal in accordance with the manufacturer's instructions,

shall be applied over the complete face within 2 h prior to laying the asphalt surfacing.

5.28.7 The exposed vertical edges of the existing surfacing shall be painted with bitumen and the new surfacing shall be compacted against it.

5.28.8 In areas where ramping as described above is not considered necessary (i.e. non-trafficked areas), a ramp finished to a step not exceeding 15 mm in the material specified in Sub-Clause 5.20.2 is permissible.

5.29 TEMPORARY RAMPS

(NOTE. This is a specimen clause only; the Project Manager must agree the details with the Aerodrome Authority/Station staff on a job-specific basis. Further advice for the Project manager is given in Clause Z.7 of Appendix Z.)

5.29.1 Temporary ramps (e.g. to enable aircraft operations to continue during daylight hours with construction work being carried out at night) shall be constructed in the same manner as specified in Clause 5.28. However, where the Contractor can demonstrate to the satisfaction of the Project Manager that he can provide an acceptable and sound surfacing without the use of the saw cut, the saw cutting may be omitted.

Prior to the commencement of each * work, the Contractor shall obtain the approval of the Project Manager to the proposed layout of the temporary ramps. At no time shall there be more than one ramp in the length of each Hot Rolled Asphalt, Stone Mastic Asphalt or Asphalt Concrete

(Macadam) course and the ramps shall be transverse to the line of aircraft movement or as directed by the Project Manager. The ramps shall slope in the same direction unless directed otherwise. On runways, the construction work shall proceed from the primary takeoff/landing end such that temporary ramps slope down in the direction of aircraft movement. If the Contractor proposes to lay any areas of the ramps by hand methods or methods not approved in the trial areas, he shall seek prior approval of the Project Manager.

* Project Manager to provide the relevant period for the specific job specification; advice is given in Clause Z.7 of Appendix Z.

5.29.2 Temporary ramps shall be arranged so as to avoid covering manholes and aviation ground lighting fixtures whenever practicable. When this is not practicable, the manholes and aviation ground lighting fixtures shall be covered by the temporary ramps.

OR

Temporary ramps shall be arranged so as to avoid covering manholes and aviation ground lighting fixtures wherever practicable. When this is not practicable, ramping, which must be smoothed over as approved and described in Sub-Clause 5.29.6, shall also be carried out to all edges of manhole surrounds and aviation ground

(NOTE. Project Manager to select option for specific job specification; advice given in Sub-Clause Z.7.2 of Appendix Z.)

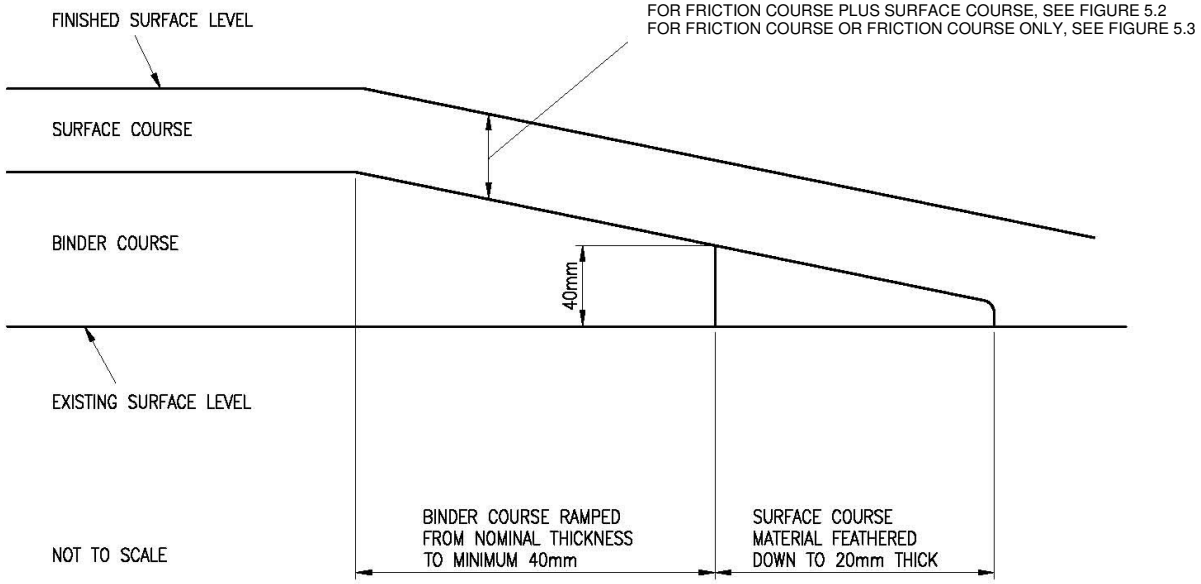


Figure 5.1 – Ramps between New Surfacing and Existing Pavements

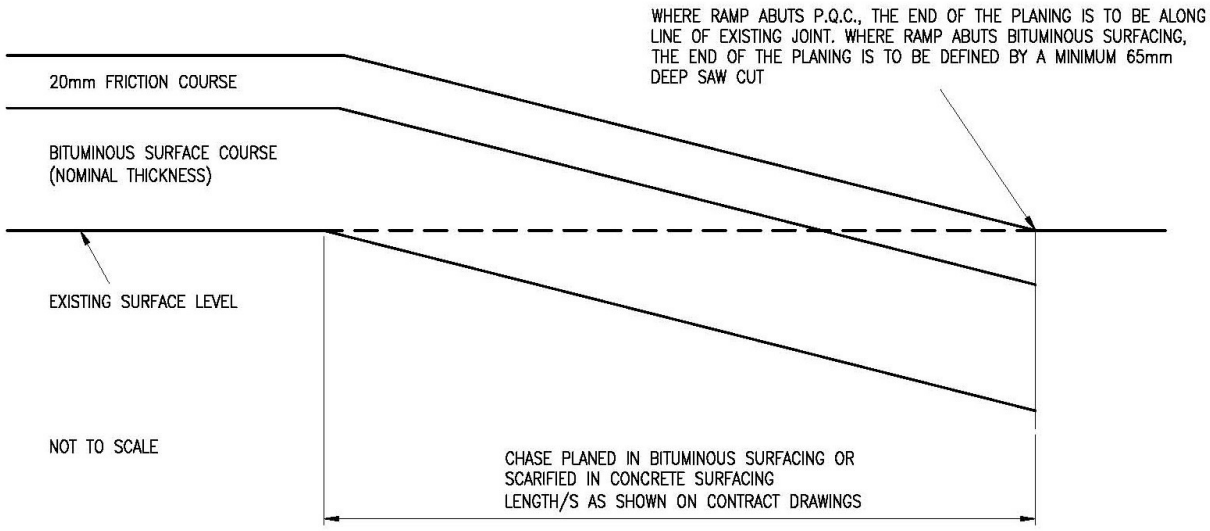


Figure 5.2 – Ramps between New Porous Friction Course on Surface and Existing Pavements

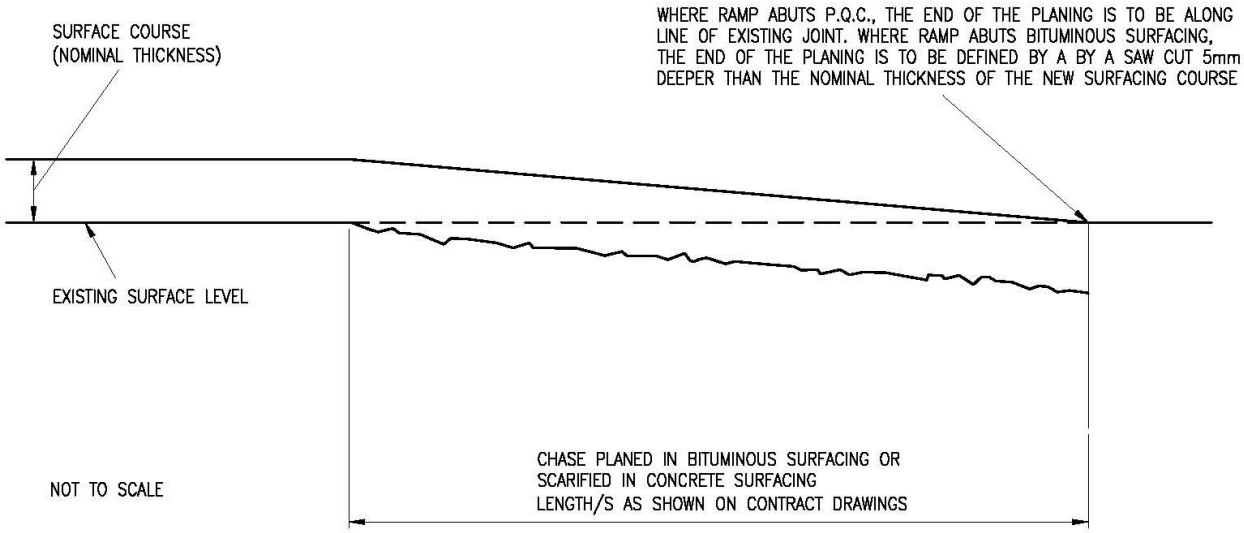


Figure 5.3 – Ramps between Surface Course and Existing Pavements

5.29.3 Ramps on the runway surface within * m of the centre line shall conform with the following requirements:

- The gradient of any ramp shall not exceed ± * in the longitudinal direction;
- The gradient of any ramp shall not exceed ± * in the transverse direction, and there shall be no transverse ramps within * m of the runway centre line;
- The depth of any ramp shall not exceed * mm;
- The spacing of successive ramps shall not be less than * m in the longitudinal direction;
- The profile of the ramps shall be such that it does not create ponding on the surface; and
- All ramps shall be planed into the existing surface to ensure a minimum thickness of * mm of ramping material.

* Project Manager to provide values (if clause is required) for specific job specification after agreement with the Aerodrome Authority/Station staff; advice is given in Clause Z.7 of Appendix Z.

5.29.4 Ramps on the taxiway and the extended taxiway to a point * m from the runway centre line shall conform with the following requirements:

- The gradient of any ramp shall not exceed ± * in the longitudinal direction;
- The gradient of any ramp shall not exceed ± * in the transverse direction;
- The profile of the ramps shall be such that it does not create ponding on the surface; and
- All ramps shall be planed into the existing surface to ensure a minimum thickness of * mm of ramping material.

* Project Manager to provide values (if clause is required) for specific job specification after agreement with the Aerodrome Authority/Station staff; advice is given in Clause Z.7 of Appendix Z.

5.29.5 Ramps on the runway paved shoulders shall conform with the following requirements:

- The gradient of any ramp shall not exceed ± * in the longitudinal direction; and
- The gradient of any ramp shall not exceed ± * in the transverse direction.

* Project Manager to provide values (if clause is required) for specific job specification after agreement with the Aerodrome Authority/Station staff; advice is given in Clause Z.7 of Appendix Z.

5.29.6 All ramps shall be inspected prior to the completion of each * work and are to be modified or made good to the satisfaction of the Project Manager where he deems them to be unsatisfactory. There shall be no uncovered tack or bond coat material, oil, petrol, grease or similar contaminants and no steps, ruts, pits or bumps of greater than 3 mm in height/depth. The surface shall be cleaned and swept of all plant, equipment, unsound or ragged materials, debris, dirt and similar, all to the satisfaction of the Project Manager.

* Project Manager to provide the relevant period for the specific job specification; advice is given in Clause Z.7 of Appendix Z.

5.29.7 All or part of the temporary ramps are to be planed out at the commencement of the next period of work to ensure that a minimum of * mm of material can be laid. The planning out of the ramps and laying of the new material is to be carried out in accordance with Clause 5.28.

* Project Manager to provide value (if clause is required) for specific job specification after agreement with the Aerodrome Authority/Station staff; advice is given in Clause Z.7 of Appendix Z.

5.30 FINISHED LEVELS

5.30.1 The finished surface levels shall conform with the levels, profiles and contours shown on the drawings and the finished levels of the underlying courses are to be such that at no point will the thickness of any overlying courses be less than the thickness specified.

5.30.2 Where the Project Manager so directs, deviations from the required levels exceeding 6 mm shall be corrected by replacement with new surfacing at not less than the specified course thickness after removal of the appropriate thickness of the offending area by heating and planing, carried out as specified in Clause 5.11, or by total removal, as detailed in Clause 5.37, when the depth to be removed exceeds 60 mm.

5.31 SURFACE ACCURACY

5.31.1 The surface accuracy of the surfacing material shall be measured as the gap between the bottom of a 3 m long test straightedge and the surface of the pavement when the straightedge is placed unsupported on the surface in accordance with Appendix C. The surface accuracy shall not exceed 3 mm for surface course nor 10 mm for binder course anywhere in any direction, other than across the crown of a camber or across a drainage channel.

5.31.2 Twenty surface accuracy tests shall be made for every 1000 m^3 laid, of which at least half shall be across lane joints. The location of all tests shall be selected by the Project Manager or his representative and shall be carried out in his presence. The Contractor shall mark with white paint all areas which fail to comply with the specified requirement.

5.31.3 Any non-complying area shall be removed for the full width of the lane and replaced by the Contractor, at his own expense, with material that shall satisfy the acceptance criteria, as specified in Clauses 5.37 and 5.38.

5.32 BULK DENSITY OF COMPACTED MARSHALL ASPHALT

5.32.1 After the surfacing has cooled sufficiently to allow sampling, two core samples of 150 mm diameter shall be extracted from every * m^2 of surfacing laid and, in addition, twin samples shall be taken adjacent to longitudinal lane joints at not more than * m intervals in positions selected by

the Project Manager and, when directed, across transverse joints.

* The Project Manager to provide value for specific job specification; advice is given in Clause Z.9 of Appendix Z.

(NOTE. Reheating a surfacing using an infra-red heater and re-compacting shall not be permitted.)

5.32.2 The cores adjacent to lane joints shall be situated at a distance not exceeding 50 mm or nearer than 25 mm from the joint. The samples shall be used for the determination of bulk density according to BS EN 12697-6, Procedure A. Not more than three bulk density values out of any twenty consecutive results shall be below 98 % of the 'Job Standard Mixture Bulk Density' or 94 % of the 'Maximum Density', whichever is appropriate as specified in Clause 6.4.

5.32.3 Any non-complying area shall be removed for the full width of the lane and replaced with material that shall satisfy the acceptance criteria.

5.33 SURFACE REQUIREMENTS PRIOR TO GROOVING ASPHALT RUNWAYS

5.33.1 For runways to be provided with a grooved asphalt surface course, the skid resistance of the surface course prior to grooving shall be measured using the pendulum test in accordance with BS EN 13036-4. The rate of testing shall be 10 tests per 1000 m³ of laid asphalt or 10 tests per day, whichever gives the greater number of tests. The test positions shall be evenly distributed over the surface area as agreed with the Project Manager.

5.33.2 Each individual result shall be rounded to the nearest whole number. The running mean of 20 results shall be greater than 72 with no individual result less than 65.

5.33.3 Any non-complying area shall be removed for the full width of the lane and replaced with material that can satisfy Clause 5.33.2.

5.34 AIR VOIDS OF COMPACTED MARSHALL ASPHALT

Using the same core samples as obtained for the bulk density test at Clause 5.31.3, the maximum density of the Marshall Asphalt shall be determined for each sample according to BS EN 12697-5, Procedure B with de-aired water and, hence, the air voids content calculated in accordance with BS EN 12697-8. Test results of air voids content shall be submitted to the Project Manager for research purposes.

(NOTE. The Project Manager is requested to issue copies of the air voids content to the Construction Support Team, DE.)

5.35 RECOVERED PENETRATION OF BINDER FROM COMPACTED MAT

The binder shall be recovered from cores according to BS EN 12697-3 or BS EN 12697-4 at intervals as required by Clause 7.6 and tested for penetration in accordance with BS 2000-49. Test results of recovered binder penetration shall be submitted to the Project Manager for research purposes.

(NOTE. The Project Manager is requested to issue copies of recovered binder penetration to the Construction Support Team, DE.)

5.36 TRAFFIC ON FINISHED SURFACING

5.36.1 No trafficking of freshly laid surfacing is permitted until the surfacing has cooled to ambient temperature and no parking of vehicles is permitted within:

- 24 h of laying a surfacing in summer conditions; and
- 12 h of laying a surfacing in winter conditions.

Traffic allowed on finished cold surfacing shall be restricted to the minimum required for the conveyance of mixed materials for the laying of the surfacing immediately adjacent to the area being laid.

5.36.2 If early trafficking of freshly laid material is required, the Contractor shall propose a method of measuring the temperature of the surfacing and validate it during the trials (Section 6).

(NOTE. Advice for the Project Manager on the assessment of the temperature of freshly laid surfacing is given in Clause Z.8 of Appendix Z.)

5.36.3 The Contractor shall be responsible for maintaining the finished surfacing in good and clean condition. He shall make good any defects, damage or defacement which occurs during the Contract by the means, and to the standards, described in this Specification.

5.37 CUTTING OUT DEFECTIVE OR OLD SURFACING OTHER THAN POROUS FRICTION COURSE

5.37.1 When defective surfacing is cut out, the full depth of the layer shall be removed. The area to be cut out shall extend across the full width of the lane between the longitudinal joints, and shall extend at least 300 mm beyond the defective area into sound material. The area of the lane to be cut out shall be defined by straight saw cuts, at least 40 mm deep or the full thickness of the layer, whichever is the thinner.

5.37.2 The area shall be cut away carefully by approved mechanical scabbling or planing machines. Pneumatic spade cutters may also be used if the risk of damage to operatives from hand arm vibration syndrome (vibration white finger) has been minimised and the remaining risk has been assessed as acceptable. Where spade cutters are used, the cutting tool blades shall overlap the previous cut on each move and each cut shall penetrate the course for its full thickness.

5.37.3 The surface of the exposed material below shall be thoroughly cleared of all loose fragments and cleaned, using high-pressure water and vacuum extraction, or as directed by the Project Manager.

5.37.4 Replacement shall not begin until the Project Manager has approved the conditions of cleanliness of the base.

5.37.5 When the level of the pavement is to be raised by 20 mm or more, saw cutting shall be omitted.

(NOTE. Guidance may be found in DE Functional Standard 06, "*Guide to Maintenance of Airfield Pavements*".)

5.38 REPLACEMENT OF DEFECTIVE OR OLD SURFACING

5.38.1 A tack or bond coat in accordance with Clause 5.18 shall be applied over the exposed base, care being taken to include all corners, angles and irregularities. The exposed vertical faces of the surfacing shall be painted with bitumen.

5.38.2 The replacement surfacing shall comply with the specified course thicknesses shown on the drawings and tolerances specified in Clause 5.19, and with the standards detailed in this Specification.

5.39 FILLING CORE HOLES

The walls and base of all holes from which core samples have been cut are to be painted with bitumen and filled with the specified surfacing material, well rammed in lifts not exceeding 50 mm.

5.40 GROOVING OF SURFACE COURSES

5.40.1 Where the drawings indicate that new or existing surfaces are to be grooved, the grooves shall be formed 4 mm wide and 4 mm deep at 25 mm centres. Grooving operations shall not commence within 24 h of laying the surfacing and only proceed provided the surface temperature is less than 40 °C.

5.40.2 The surface of the surface course shall be grooved across the pavement at right angles to the pavement edges with grooves which follow across the pavement in a continuous line without break.

5.40.3 The machine for grooving shall be a sawing machine incorporating a minimum of 12 N^{o} blades and an automatic guidance system to ensure that the spacings between peripheral grooves on successive passes remain constant. The Contractor shall state the type and technical details of the machine he proposes to use for grooving at the time of tender.

5.40.4 Prior to commencing work, the Contractor shall carry out a trial on an area of disused pavement selected by the Project Manager to prove the suitability of the sawing and cleaning equipment. Until approval of the trial is given, grooving work as required by the Contract will not be permitted to start.

5.40.5 At all times during cutting, a high pressure water and vacuum extraction cleaning machine shall be in attendance to pick up the detritus arising, whether wet or dry, as soon as possible after the grooving machine has passed so that the work area is left in a clean condition free of all loose material and of wet or dry slurry at the end of each shift. Care shall be taken not to wash slurry down the drainage catchpits.

6 Trials

6.1 GENERAL

Trials shall be carried out on all Marshall Asphalt mixtures proposed for use in the Works. For small works, the procedures and requirements for the preliminary and final trials may be combined and/or modified at the discretion of the Project Manager.

6.2 PRELIMINARY TRIALS

6.2.1 For each Marshall Asphalt, after the 'Laboratory Design Mixture' has been approved by the Project Manager (see Clause 4.2), the Contractor shall mix at least one 20 tonne batch of the material for laying in Preliminary Trials. At the discretion of the Project Manager, this requirement may be modified for regulating or ramping material.

6.2.2 Preliminary trial mixtures shall be made up in the mixers that the Contractor proposes to use at the appropriate mixing temperatures and with the aggregates proportioned from either:

- the various hot bins for a Batch Mixer; or
- the cold feed hoppers for a Continuous Drum Mixer

to produce the required aggregate grading with the binder content at the appropriate target binder content.

6.2.3 The preliminary trial mixtures shall be laid on disused pavements within the airfield boundary, in locations selected by the Project Manager, with the spreading and compacting equipment that the Contractor proposes to use. The materials shall be laid and compacted according to the requirements of this Specification, according to material type and specified thickness.

6.2.4 The mixture shall be transported to the airfield and laid and compacted on a clean firm and level test area, not being part of the works, using delivery, paving and compaction machinery that the Contractor proposes to use during the works. The area shall be tack or bond coated prior to laying. The Contractor shall select paving and compaction operations such that no laying defects such as dragging or surface blemishes result, to the satisfaction of the Project Manager. The Project Manager may order further 20 tonne loads to be laid until a satisfactory result is achieved.

(NOTE 1. Attention needs to be given to the material feed rate via the paver screws to the screed to avoid dragging and segregation.)

(NOTE 2. For planning purposes, the following equations will assist the Contractor to select paving and rolling rates to achieve the minimum specified number of roller passes before the surfacing has cooled to the minimum temperature for compaction:

Rolling length (m) = average paving speed (m/min) x 8 (min)

Roller passes = (Rolling rate/Paving Rate) x No of Rollers

where:

Rolling rate (m^2/min) = Roller width (m) x Roller speed (m/min)

Paver rate (m^2/min) = Paver width (m) x Paver speed (m/min))

6.2.5 The paving and rolling rates, demonstrated to be satisfactory during the laying of the trial mixture, shall be agreed with the Project Manager and shall be adhered to during the main works.

6.2.6 If the preliminary trials indicate that the trial mixtures or the 'Laboratory Design Mixtures' are unsatisfactory for mechanical spreading and compacting, or fail to produce the specified surface accuracy or result in surface blemishes which are unacceptable, the proportion of binder and the grading of the combined aggregates and filler may be slightly modified within the limits of the Specification.

(NOTE. The Project Manager, at his discretion, may order a new design to be carried out.)

6.2.7 Further preliminary trials shall be laid to demonstrate that a satisfactory mixture has been achieved. The Contractor shall submit the results of an analysis and tests, carried out in accordance with BS EN 12697-1, BS EN 12697-2 and BS EN 12697-34, to the Project Manager for each load of the trial mixture laid to demonstrate compliance with the requirements of Clause 4.2. The Project Manager will then agree the mix design as the provisional 'Job Standard Mixture' and authorise the laying of final trial area as described in Clause 6.3.

6.2.8 After completion of all preliminary trials, the edges of the lanes shall be feathered off in asphalt

surfacing as necessary for the requirements of vehicular traffic to the approval of the Project Manager.

6.3 FINAL TRIAL AREAS

6.3.1 Following completion of the preliminary trials described in Clause 6.2, a trial area of surfacing, not less than 60 m or more than 300 m long by two lanes wide, shall be laid for each layer thickness for each provisional 'Job Standard Mixture'. Duplicate areas shall be laid for each additional spreader and for each thickness on which each particular spreading unit will be working. The trial areas shall be laid along the outside edges of the pavements in positions approved by the Project Manager.

6.3.2 Each trial area shall contain at least one 60 m continuous length of longitudinal joint and at least 4.5 m of transverse joint.

6.3.3 For each trial area, the Contractor shall take, as described in BS EN 12697-27, at least three samples of the provisional 'Job Standard Mixture' after discharge from the mixer and before loading into the paver. He shall submit to the Project Manager the results from those three samples of:

- an analysis of the binder content in accordance with BS EN 12697-1;
- an analysis of aggregate/filler grading in accordance with BS EN 12697-2; and
- stability, flow, air voids content and voids filled with bitumen from Marshall specimens manufactured from the sample in accordance with Appendix A.

Specimens for the determination of the 'Job Standard Mixture Bulk Density', as described in Clause 6.4, shall also be prepared from these specimens.

6.3.4 When the trial surfacing has cooled to ambient temperature, four pairs of 150 mm diameter cores shall be cut through the finished course with an approved coring machine for the determination of the field bulk density of the course in accordance with BS EN 12697-6, Procedure A. At least two pairs of the cores shall be taken adjacent to the longitudinal lane joint in accordance with Clause 5.31.3. The mean field bulk density of the four pairs of cores shall not be less than 98 % of the 'Job Standard Mixture Bulk Density' or less than 94 % of its maximum density, whichever is appropriate as defined in Clause 6.4.

6.3.5 The mean field air voids content of each pair of cores cut from the trial area shall be determined in accordance with BS EN 12697-8 using the maximum density determined in accordance with BS EN 12697-5, Procedure B with de-aired water. Test results of air voids content shall be submitted to the Project Manager for research purposes.

(NOTE. The Project Manager is requested to issue copies of the air voids content to the Construction Support Team, DE.)

6.3.6 If the required field bulk density criterion is not obtained, further trials shall be conducted and new cores shall be taken and tested. This procedure shall be repeated until satisfactory bulk density results have been obtained and the finished courses are equally satisfactory in all other respects and the final trial areas have been approved by the Project Manager.

6.3.7 If the surface is to be grooved, the surface of the trial area shall be checked for surface requirement prior to grooving in accordance with Clause 5.33.

6.3.8 The Contractor shall demonstrate the effectiveness of his compaction method as defined by the requirements of Sub-Clause 6.3.4. The standard of finish, including that at joints, shall comply with the requirements of this Specification and be acceptable to the Project Manager as the standard to be achieved in future laying. The surface finish shall have no laying defects, such as dragging or surface blemishes.

6.3.9 As a result of the approved trials, the 'Job Standard Mixture' shall be confirmed and the Contractor shall report to the Project Manager in writing the following details for his approval and as a target for all future plant mixing:

- The precise grading for the combined aggregate/filler;
- The quantities for each aggregate size by dry weight; and
- The precise binder content and unit values (on the basis of the mean value of not less than four, or more than six specimens) for Marshall stability, Marshall flow, voids in the total mixture and voids filled with binder.

6.3.10 The approved 'Job Standard Mixture' shall comply with the 'Laboratory Design Mixture' modified when necessary as described in Clause 6.2 and shall be within the limits for grading, binder content, Marshall stability, Marshall flow,

voids in the total mixture and voids filled with binder given in Clause 4.2.

6.3.11 Until approval has been given, the general laying of asphalt surfacing required by the Contract shall not begin.

6.3.12 The standard of workmanship and finish of all surfacing included in the Contract shall be equal in all respects to that of the 'Approved' areas and shall not be changed afterwards without the specific approval of the Project Manager.

6.3.13 If for any reason the quality, grading or source of supply of aggregates is changed or if at any time the cause of variations outside the permissible limits specified in Clause 4.2 cannot be corrected for reasons beyond the control of the Contractor, the Project Manager may request a new 'Laboratory Design Mixture' or 'Job Standard Mixture', depending on the extent of change or variation.

6.3.14 Based on the trials, the rollers and rolling method to be adopted for each course shall be agreed with and approved by the Project Manager.

6.3.15 No change shall be made in the mixing and spreading plant or rolling methods without the approval of the Project Manager, and then only after new trials have been carried out and approved.

6.4 JOB STANDARD MIXTURE BULK DENSITY

6.4.1 The bulk density of the compacted courses throughout the work shall be related to the 'Job Standard Mixture Bulk Density' when not more than 10 % by mass of the total aggregate is retained on a 32 mm sieve, or to the 'Maximum Density' when more than 10 % is retained.

6.4.2 The 'Job Standard Mixture Bulk Density' shall be obtained by making six standard Marshall specimens from samples of the approved 'Job Standard Mixture', determining the bulk density according to BS EN 12697-6, Procedure A of each specimen and comparing them with the mean value of the six. Any individual result which differs from the mean by more than 15 kg/m^3 shall be rejected and, provided not more than two results are so rejected, the mean of the remaining results shall be designated the 'Job Standard Mixture Bulk Density'.

6.4.3 The 'Maximum Density' for mixtures having more than 10 % by mass of total aggregate retained on 32 mm sieve shall be calculated in accordance with Clause A.4 of Appendix A.

6.4.4 The 'Job Standard Mixture Bulk Density' for a particular mixture shall be determined at the start of the works with that mixture. The 'Job Standard Mixture' shall be recalculated with fresh specimens whenever the source or proportion of aggregates changed or when there is a dispute as to its validity.

7 Summary of Tests

7.1 TEST RESULTS

The Contractor shall be responsible for having all testing carried out in accordance with the requirements of this Section and provide the Project 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 the Contractor (or his materials supplier(s) on his behalf) shall provide current CE mark certificates for all aggregates showing conformity with all requirements of Section 3.

7.2.2 In addition to 7.2.1, the Contractor (or his materials supplier(s) on his behalf) shall have carried out the aggregate tests in Table 7.1 for comparison with the relevant specification clauses

TABLE 7.1 ADDITIONAL AGGREGATE TESTS FOR INITIAL APPROVAL

Component material	Clause No.	Test	
		Title	Reference
Coarse Aggregate	3.2	Magnesium Sulfate Val. Affinity between ag. & bitumen	Appendix B BS EN 12697-11 Part B
Fine Aggregate	3.3	Magnesium Sulfate Val. Affinity between ag. & bitumen *	Appendix B BS EN 12697-11 Part B

* Test on particles of rock from the same source when crushed rock fines are used

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

- the binder;
- other constituents, including tack or bond coat; and
- tack and bond coat spray-bar equipment.

7.3 TEST FOR THE PROPORTIONING AND DESIGN OF MIXTURES

7.3.1 Before mixing starts the Contractor (or his materials supplier(s) on his behalf) shall provide current CE mark certificates for all Marshall asphalt mixtures showing conformity with all requirements of Section 4 and the relevant specification clauses in Table 7.2.

7.4 ROUTINE TESTS ON BULK SUPPLIES THROUGHOUT PLANT MIXING

7.4.1 The Quality Assurance procedures for the supply of component materials and asphalt mixtures shall include carrying out tests in order to:

- check on the consistency of bulk supplies;
- compare with the properties and gradings of the samples approved; and
- check on the capability of the dryers to function efficiently with aggregates of variable moisture content.

The tests should include the tests in Table 7.3.

7.4.2 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 specified requirements and, if stored on site, shall remove all material condemned by the Project Manager for this reason from the airfield.

7.4.3 Where the material is mixed off site, any condemned material shall be carefully removed from the stockpiles to be used for the work.

TABLE 7.2 TESTS FOR DESIGN MIXTURES

Component or material to be tested	Clause Number	Test	
		Title	Reference
Marshall Asphalt	4.2	Grading Design Water sensitivity	BS EN 933-1 Appendix A BS EN 12697-12
Trials	6.3	Sampling Analysis Cores Thickness Bulk density Aggregate/Filler Grading Binder Content Stability and Flow Voids in the Total Mix Voids Filled with Bitumen	BS EN 12697-27 & -28 BS EN 12697-1 & -2 BS EN 12697-27 BS EN 12697-36 BS EN 12697-5 BS EN 933-1 BS EN 12697-1 Appendix A

TABLE 7.3 TESTS ON BULK SUPPLIES

Test	Test Method	Representative Sample From	Minimum Frequency	Use For Results
Sieve analysis of aggregates	BS EN 933-1	Each stockpile	Daily on receipt	Comparison with the grading of the initial samples
Moisture content of aggregates at/after mixing	Samples shall be weighed, dried in a ventilated oven at a controlled temperature of (175 ± 2) °C for 24 h, and then weighed again	After completion of mixing process but without the addition of binder	Weekly	Measures are to be taken to improve the drying processes if the difference in the weight of the sample before and after oven drying exceeds 0.5 % (Clause 5.6)
Sieve analysis of filler aggregate	BS EN 933-10		Daily on receipt	Comparison with the results from the initial samples
Loose bulk density in kerosene of filler	BS EN 196-6		Weekly	

7.5 ROUTINE TESTS ON MIXTURES THROUGHOUT PLANT MIXING

7.5.1 As part of the Quality Assurance requirements in Clause 2.4, the Contractor (or his materials supplier on his behalf) shall carry out the tests in Table 7.4 on mixtures prepared for the works. The procedure shall ensure that the position of plant mixtures from which test samples are taken or specimens made are fully traceable in the finished pavement layer.

7.5.2 If either the grading or the binder content of any individual test, out of the total number of tests for the day's production of that mixture, fails to comply with the specified requirements, the additional tests specified in Clause 7.7 shall be carried out.

7.6 ROUTINE TESTS DURING LAYING AND ON COMPACTED COURSES

The Contractor shall undertake the series of tests on asphalt materials incorporated into the works necessary to comply with the relevant specification clauses listed in Table 7.5.

7.7 ADDITIONAL TESTS WHEN ROUTINE TESTS ON THE MIXTURES AND ON THE COMPACTED COURSES FAIL

7.7.1 The Contractor (or his materials supplier on his behalf) shall carry out the following additional tests when routine tests fail to establish the extent to which material already laid fails to meet the requirements specified for:

- aggregate/filler aggregate grading and binder content;
- course thickness;
- surface accuracy; or
- bulk density.

7.7.2 The additional tests for aggregate/filler aggregate grading, binder content and course thickness shall be made on:

- four 300 mm square samples for checking grading and binder content; or
- four 150 mm diameter cores for checking course thickness.

The samples or cores shall be cut from the compacted course, at positions selected by the Project Manager, within the lane width at a distance of not more than 5 m from the location in the pavement at which the mixture was laid which failed to satisfy the routine test requirements specified.

7.7.3 If any one of the additional test results specified in Sub-Clause 7.7.2 also indicate failure to meet the specified requirement, further tests shall be made on 3 more samples or cores. These samples or cores shall be cut at further positions selected by the Project Manager, also within the lane width and at a distance of not more than 10 m further along the lane from the location of the previous failure point. Should one of these additional samples or cores also fail to meet the specified requirement, the above process shall be repeated until all samples or cores are satisfactory. The area covered by the failed samples or cores shall be cut out and replaced as detailed in Clauses 5.37 and 5.38.

7.7.4 When a routine test fails to meet the requirements of Clause 5.31, an additional 20 straightedge tests in accordance with BS EN 13036-7 shall be made over the area between the adjacent points where the routine test was undertaken for which the results complied with the requirements of Clause 5.31. If three or more of these additional tests also fail to meet the specified requirement, this area of the surfacing shall be condemned. The condemned areas shall be removed and replaced by the Contractor, at his own expense, as specified in Clauses 5.37 and 5.38.

7.7.5 Attempts to correct the surface accuracy with fine asphalt dressings, synthetic resin formulations, surface dressing applications, or emulsion slurry films shall not be allowed.

TABLE 7.4 TESTS ON MIXTURES

Test	Test Method	Sample From	Minimum Frequency	Use For Results
Analysis of the plant mixtures	BS EN 12697-1 BS EN 12697-2	After the completion of the mixing process	Every 4 h but not less than twice a day for each mixer in use	Determination of binder contents and aggregate/filler proportioning and grading – results plotted on graphs in order to show comparison with the grading curve of the mixture approved in accordance with Clause 6.3 and the relevant binder content
Stability Flow Bulk density Voids	Appendix A	Duplicate Marshall specimens made from each sample taken above		Comparison of mean result from twin specimens with 'Job Standard Mixture' values and permitted variation (Clause 4.4)
Temperature	BS EN 12697-13	Lorry	Each load	Check for compliance with Clauses 5.7 and 5.17

TABLE 7.5 TESTS ON COMPACTED MATERIAL

Test	Ref. Clause	Test Method	Sample From	Minimum Frequency	Use For Results
Wind speed and air temperature	5.10	n/a	n/a	Whenever laying planned	Assess suitability of weather conditions for laying.
Material temperature	5.7 and 5.17	BS EN 12697-13	Paving train	Each load	Check on delivery temperature
Surface accuracy	5.31	BS EN 13036-7	Previous day's work	Daily	Ensure compliance; if more than 2 tests in each group of 20 fail to comply, the additional tests specified in Clause 7.7 shall be carried out
Finished levels	5.30	BS EN 12697-36			Ensure compliance
Core samples	5.31.3	BS EN 12697-27	Previous day's work	Duplicate samples from: • every † laid (or from every 2 h work, whichever is the more frequent); • adjacent to longitudinal lane joints at not more than † m intervals; and • at locations agreed with the Project Manager (Clause 5.31.3)	–
Course thickness	5.19	BS EN 12697-36			Ensure compliance; if any test fails to comply, the additional tests specified in Clause 7.7 shall be carried out*
Bulk density	5.31.3	BS EN 12697-6, Procedure A			Ensure compliance; material that fails to be cut out and replaced
Maximum density	5.34	BS EN 12697-5, Procedure B			For research purposes only, see Clause 5.34
Air voids content	5.34	BS EN 12697-8			
Surface requirement prior to grooving	5.33	BS EN 13036-4	Previous week's work	Greater of 10 results per 1000 m^3 or per day	Ensure compliance; non-complying areas to be removed
Recovered binder penetration	5.35	BS 2000-49	Previous week's work	Weekly; duplicate samples at locations agreed with the Project Manager	For research purposes only, see Clause 5.35

† Project Manager to provide value for specific job specification; advice given in Clause Z.9 of Appendix Z.
* The requirements of Clauses 5.13, 5.14 and 5.18 shall be checked when the courses of the cores fail in adhere on extraction, and the necessary corrections and adjustments shall be made to eliminate the cause of the failure.

7.7.6 If the bulk density results do not comply with Clause 5.31.3, additional duplicate core specimens from positions selected by the Project Manager along the lane are to be taken at distances of not more than 5 m on each side of each failed twin core position and their bulk densities determined. If any of these additional test results also indicate densities lower than specified, further pairs of cores are to be taken at distances along the lane at not more than 5 m from each failed position until material at the specified density is located. The area of low density material so determined between the pair of cores indicating the specified density shall be removed and replaced as described in Clauses 5.37 and 5.38.

7.7.7 When a routine test fails to meet the requirements of Clause 5.33, an additional 20 pendulum tests in accordance with BS EN 13036-4 shall be made over the area between the adjacent points where the routine test was undertaken for which the results complied with the requirements of Clause 5.33. If three or more of these additional tests also fail to meet the specified requirement, this area of the surfacing shall be condemned. The condemned areas shall be removed and replaced by the Contractor, at his own expense, as specified in Clauses 5.37 and 5.38.

Appendix A – Marshall Asphalt Mixture Design Procedure

A.1 SCOPE

This Method details the procedure to be followed in order to:

- Determine the optimum binder content of the 'Laboratory Design Mixture' of Marshall Asphalt mixtures controlled within defined values for stability, flow and voids;
- Make and test standard specimens of the 'Job Standard Mixture' for the determination of requirements for density after compaction; and
- Make and test standard specimens of the 'Plant Mixture' for the purposes of controlling the work on site within defined variations.

A.2 APPARATUS

Apparatus as detailed in Clauses 4.2 to 4.6 of BS EN 12697-30, Section 5 of BS EN 12697-34 and Section 5 of BS EN 12697-35, together with the following:

- *Balance*, of not less than 5 kg capacity, accurate to 1 g, for aggregates, filler and binder; and
- 100 mm diameter filter papers.

A.3 AGGREGATE SAMPLES

A.3.1 Take representative samples of the coarse aggregate, fine aggregate and filler, sufficient to carry out the required tests and to make the requisite specimens for test in accordance with the methods described in BS EN 932-1. Take sufficient of the binder to carry out the required tests and to make the requisite specimens in accordance with the method of sampling described in BS EN 58.

A.3.2 Calculate the quantity of each sample, proportioned by mass, required to give a combined grading which satisfies the requirements of Clauses 3.8 and 4.2 and which will be capable of achieving the practical requirements with the mixing plant proposed for use.

A.3.3 Particles in the aggregate samples retained on the 32 mm sieve shall be replaced with an equal mass of particles passing the 32 mm sieve and retained on the 20 mm sieve.

A.4 DETERMINATION OF MAXIMUM DENSITY

A.4.1 Separate each aggregate sample into three divisions:

- particles retained on the 10 mm sieve;
- particles passing the 10 mm sieve and retained on the 4 mm sieve; and
- particles passing the 4 mm sieve.

Determine the apparent relative density and water absorption (per cent of dry mass) of each division in accordance with BS EN 1097-6. When the absorption is 1.0 % or greater, also determine the relative density on an oven-dry basis.

A.4.2 Determine the apparent relative density of the filler in accordance with BS EN 1097-7.

A.4.3 Determine the apparent relative density of the binder in accordance with BS EN ISO 3838.

A.4.4 Use the values obtained in A.4.1, A.4.2 and A.4.3 to calculate the maximum density of the mixture in accordance with Procedure C of BS EN 12697-5. When the absorption of an aggregate division is less than 1.0 %, the apparent relative density shall be used; when it is 1.0 % or greater, the mean of the relative density on an oven-dry basis and the apparent relative density shall be used.

A.4.5 The ratios obtained of the mass to relative density for the aggregate divisions and the filler in the calculation of maximum density of the 'Job Standard Mixture' shall be used as constant in the determination of the maximum density of the 'Plant Mixtures'. Hence, the only significant variable is the binder content, and the maximum density of the mixtures shall be calculated according to the binder content of the individual samples on analysis.

A.5 SPECIMENS FOR DETERMINING THE OPTIMUM BINDER CONTENT OF 'LABORATORY DESIGN MIXTURES'

A.5.1 Select sufficient mixtures to cover the desired range of binder contents necessary to determine the optimum, including at least five binder contents at intervals of 0.5 % of total mixture with at least two binder contents on each side of the optimum value.

(NOTE. Equation A.1 gives the mass of binder to be added to each 100 g of aggregate to produce these required intervals of binder content.

$$N = 0.9955\,M + 0.0116\,M^2 \quad \text{... (A.1)}$$

where: N = Binder content as a proportion by mass of the total mixture in per cent (%)
M = Mass of bitumen to be added to 100 g of aggregate in grams (g))

A.5.2 Prepare the constituent materials in accordance with clauses 6.2 to 6.4 of BS EN 12697-35.

A.5.3 Mix and compact the specimens in progressively increasing or decreasing order of binder content.

A.5.4 Make a group of four specimens consecutively, with each containing the same content of binder, so that the interval of binder content between each group of four specimens shall be 0.5 % of the total mixture.

A.5.5 Complete the total time of manufacture, from the start of mixing of the first specimen to the last specimen, in less than eight consecutive hours.

A.5.6 Carry out the mixing in accordance with clause 6 of BS EN 12697-35 using mechanical mixing.

A.5.7 On each specimen, carry out the compaction procedure in accordance with BS EN 12697-30 except apply 75 blows of the compaction hammer to each side of a specimen in clauses 7.5 and 7.6.

A.5.8 Reject any individual specimen if its bulk density differs from the mean bulk density of the four specimens in the group by more than 0.5 %. Replace all rejected specimens.

A.5.9 If the plotted stability values from Clause A.10 of the specimens at 0.5 % increments of binder do not result in a definite peak, make and test further groups of four specimens at 0.25 % increments on either side of the probable peak.

A.5.10 If required in order to ensure that the curves for stability (Clause A.10) and bulk density (Clause A.8) show optimum values, extend the upper limit of the binder range. However, in no case will an optimum binder content outside the limits of the range specified in Sub-Clause 4.2.4 be approved.

A.6 SPECIMENS FOR DETERMINATION OF DENSITY FOR 'JOB STANDARD MIXTURE'

Make the six specimens required to comply with Clause 6.4 in accordance with Clause A.5 using the aggregate grading and binder content approved in accordance with Clause 6.3.

A.7 SPECIMENS FOR CONTROL OF PLANT MIXTURES

Prepare twin specimens in accordance with Sub-Clause A.5.7 from each sample taken from the plant and determine the grading and binder content, as required by Clause 7.5.

A.8 BULK DENSITY DETERMINATIONS

A.8.1 Determine the bulk density of all specimens in accordance with BS EN 12697-6, procedure A, when they are thoroughly dry and have cooled to air temperature.

A.8.2 Reject any specimen if its volume is less than 502 ml or more than 528 ml, and replace it with a new specimen.

A.9 DETERMINATION/CALCULATION OF AIR VOIDS CONTENT

A.9.1 The voids in the total mixture (V_M), voids in the mineral aggregate (V_A) and voids filled with binder (V_F) for each specimen shall be determined in accordance with Sub-Clauses A.9.2 to A.9.5.

A.9.2 Following the tests in Clause A.11, the voids in the total mixture is to be determined for each specimen in accordance with BS EN 12697-8.

A.9.3 In addition to Sub-Clause A.9.2, the voids in the total mixture shall be calculated in accordance with Equation A.2.

$$V_M = \frac{(S_{TH} - S_M)}{S_{TH}} \times 100 \quad \% \qquad \text{..... (A.2)}$$

where S_M = Bulk density of the specimen (kg/m³), in accordance with Clause A.8
S_{TH} = Maximum density of the specimen (kg/m³), in accordance with Clause A.4

A.9.4 The mix design value for V_M for each binder increment is the mean of the values determined in accordance with Sub-Clauses A.9.2 and A.9.3 except for mixtures having more than 10 % by mass of the total aggregate retained on the 28 mm sieve, when V_M shall be the value obtained in accordance with Sub-Clause A.9.3.

A.9.5 The mix design value for V_F for each binder increment shall be calculated in accordance with Equations A.2 and A.3.

$$V_A = V_M + \frac{W_B \times S_M}{S_B} \quad \% \qquad \text{..... (A.2)}$$

$$V_F = \frac{W_B \times S_M}{V_A \times S_B} \times 100 \quad \% \qquad \text{..... (A.3)}$$

where W_B = Binder content (% by mass)
S_B = Bulk density of the binder (kg/m³), in accordance with Clause A.4

A.9.6 For routine tests on mixtures throughout mixing, the determination of the voids in the total mixture (V_M) and voids filled with binder (V_F) for check and compliance purposes shall follow the above procedure.

A.10 MEASUREMENT OF STABILITY AND FLOW

Determine the stability and flow for each specimen in accordance with Annex H of BS 5984987.

A.11 DETERMINATION OF OPTIMUM BINDER CONTENT OF 'LABORATORY DESIGN MIXTURE'

A.11.1 The optimum binder content shall be determined from the results of the tests on the specimens prepared as detailed in Clause A.5. Average the individual values of each specimen of the group of four consistent specimens for each binder increment, and plot the mean value against binder content on graph paper with a smooth curve drawn through the plotted values.

A.11.2 Determine the following binder contents from positions on the curves and not necessarily from the actual results:

- At the peak of the curve from the stability graph;
- At the peak of the curve from the bulk density graph;
- At 3.5 % voids in the total mixture for surface course mixtures, or at 4.0 % for binder course mixtures; and
- At 79 % voids filled with binder for surface course mixtures, or at 72 % for binder course mixtures.

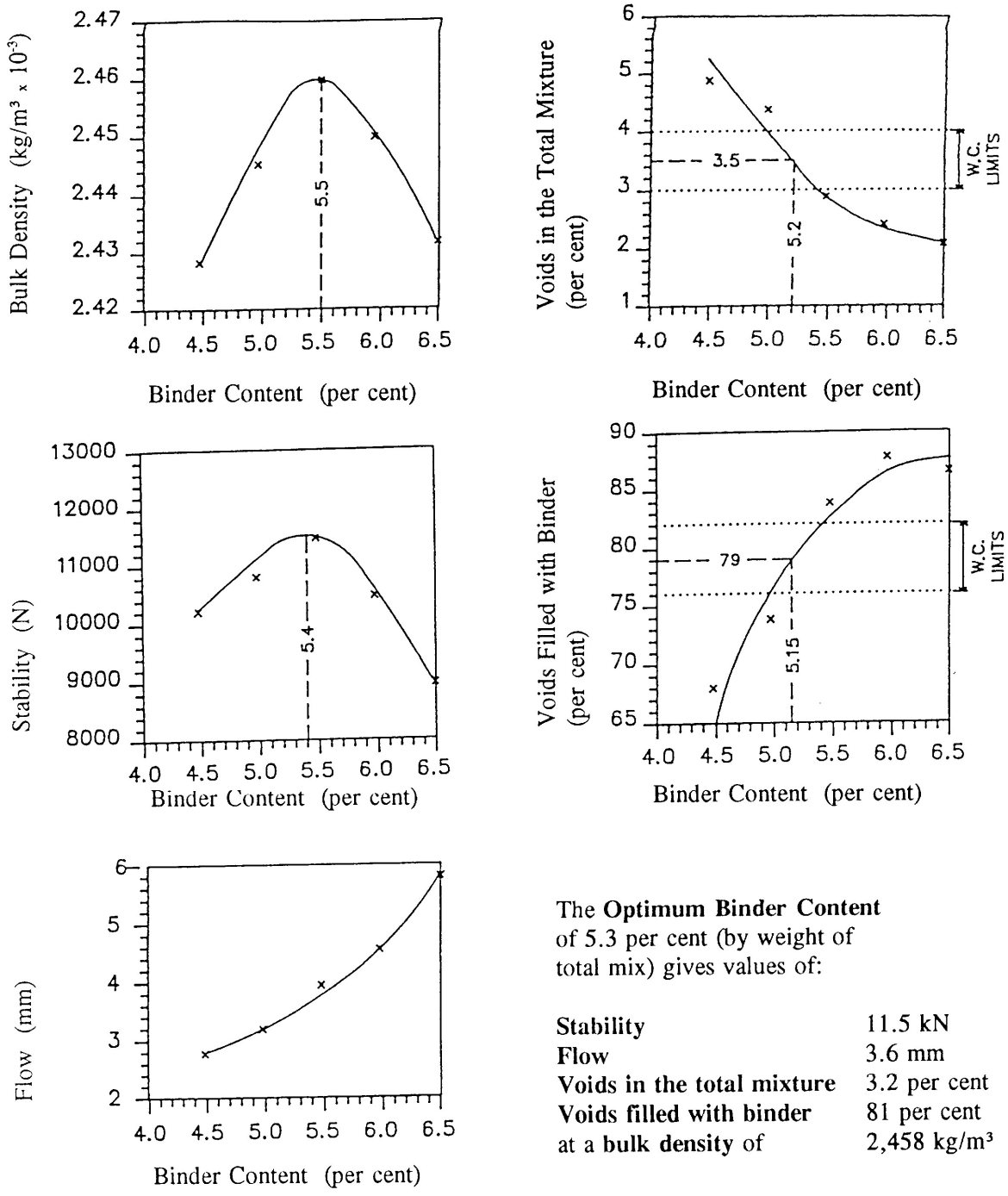
Calculate the optimum binder content as the mean of the four values.

A.11.3 If the stability/binder curve exhibits more than one peak, select the binder content which most nearly coincides with the voids requirements.

A.11.4 Some difficulty may arise in the selection of the bulk density value when absorbent aggregates are incorporated into the mixtures. In such cases, adopt the binder content at which the increase in bulk density shows a marked falling off.

A.11.5 If the values for stability, flow, voids in the total mixture and voids filled with binder, at the optimum binder content determined in Sub-Clause A.11.2, fall within the limits of the table in Sub-Clause 4.2.4, the binder content so determined shall be approved for the 'Laboratory Design Mixture'.

A.11.6 In the example given at Figure A.1, the results of these values at optimum binder content of 5.3 % are given in the bottom right hand corner of the figure. They satisfy the specification requirements, and would be acceptable for the purposes of approval.



The **Optimum Binder Content** of 5.3 per cent (by weight of total mix) gives values of:

Stability	11.5 kN
Flow	3.6 mm
Voids in the total mixture	3.2 per cent
Voids filled with binder	81 per cent
at a **bulk density** of	2,458 kg/m³

NOTE: The plotted points through which the curves are drawn are average values of four specimens for each binder content.

Figure A.1 – Example of Mixture Design for Marshall Asphalt

Appendix B – Use of Magnesium Sulfate Test with Non-Standard Aggregate Fractions

B.1 SCOPE

This Appendix specifies a procedure extending the method in BS EN 1367-2 for assessing how an aggregate behaves when subjected to the cyclic action of immersion in magnesium sulfate, followed by oven drying, to all fractions.

B.2 APPARATUS AND REAGENTS

Apparatus and reagents as detailed in BS EN 1367-2, Clauses 7 and 8, (except that the balance for coarse aggregate, Sub-Clause 6.2, to be accurate to 1 g) together with:

- 20 mm and 6.3 mm sized square hole perforated plate test sieves and 2 mm, 1 mm, 0.5 mm and 0.25 mm sized woven wire test sieves; the additional test sieves shall comply with BS EN 933-2; and
- at least two brass or stainless steel mesh baskets for immersing aggregate specimens for fractions other than 10 to 14 mm with the maximum dimension of the apertures not more than half the maximum aperture of the sieve on which the specimen is retained, but not less than 0.125 mm.

B.3 PREPARATION OF TEST PORTIONS

B.3.1 Bulk samples from each nominal size of aggregate being delivered from each source of supply to be used shall be tested separately and the procedure described hereafter shall be applied to each separate sample.

B.3.2 Prepare two test portions from the bulk samples of each aggregate supplied as in BS EN 1367-2, Clauses 8.1 and 8.2, replacing "*minimum mass of 500 g of the 10 mm to 14 mm size*" in Clause 8.1 by the relevant masses from Table B.1.

B.4 PREPARATION OF AGGREGATE TEST SPECIMENS FOR EACH FRACTION

B.4.1 The grading of the test portion shall be determined by the dry sieving method described in Clause 8.3 of BS EN 1367-2 using the 20 mm, 10 mm, 6.3 mm, 2 mm, 1 mm, 0.5 mm and 0.25 mm sieves. For coarse aggregate test specimens, the fractions retained on the 20 mm sieve and passing the 1 mm sieve shall be discarded and not taken into account in the calculation of the test result. The remainder of the reduced sample shall be considered as the test portion. The grading shall be recorded giving the percentage of the mass of the test portion retained between each pair of sieves, together with that passing the 0.25 mm sieve for fine aggregate test specimens, to the nearest whole number.

B.4.2 Those fractions retained whose proportions are less than 5 % by mass of the test portion shall be discarded. Nevertheless, the proportions that the discarded fractions represent shall be taken into account in the calculation of the test result.

B.4.3 One test specimen, of mass in accordance with Table B.1, shall be taken out of each fraction retained after completion of sub-Clause B.4.2. If there is insufficient material in any of these fractions to provide a test specimen of the required size, the procedure shall be repeated starting from sub-Clause B.3.2. The grading recorded shall be that obtained from all the material sieved out.

TABLE B.1 REQUIRED MASS OF COARSE AGGREGATE TEST SPECIMENS

Sieves		Mass of specimen before test (g)
Passing	Retained	
20 mm	10 mm	1000 ± 10
10 mm	6.3 mm	300 +10 / –0
6.3 mm	2 mm	100 +10 / –0
2 mm	1 mm	100 +10 / –0
1 mm	0.5 mm	100 +10 / –0
0.5 mm	0.25 mm	100 +10 / –0

B.5 PROCEDURE

Procedure for each test specimen as in BS EN 1367-2, Clause 9, replacing "*10 mm sieve*" in Clause 9.6 by the sieve relevant to the lower size of the aggregate fraction.

B.6 CALCULATION AND EXPRESSION OF TEST RESULTS

B.6.1 Calculate the magnesium sulfate value of each test specimen as in BS EN 1367-2, Clause 10.1, replacing "*10 mm sieve*" by the sieve relevant to the lower size of the aggregate fraction.

B.6.2 Fractions not tested because they represent less than 5 % by mass of the test portion shall be assumed to have a magnesium sulfate value equivalent to:

a) the mean of the magnesium sulfate value found by the tests on specimens of the two fractions immediately adjacent to it in size; or
b) the magnesium sulfate value found by the test on a specimen of the fraction, either larger or smaller, immediately adjacent to it if only one of these fractions were tested; or
c) the mean magnesium sulfate value found by the tests on specimens of the two fractions next but one adjacent to it if both these fractions were tested and the adjacent fractions were not; or
d) the magnesium sulfate value found by the test on a specimen of the fraction, either larger or smaller, in this order of priority, most nearly adjacent to it.

B.6.3 For samples of fine aggregate, the material passing the 0.25 mm sieve shall not be tested but shall be taken as having a magnesium sulfate value equivalent to that of the specimen passing the 0.5 mm sieve but retained on the 0.25 mm sieve.

B.6.4 The magnesium sulfate value of each test portion of aggregate shall be the sum of the magnesium sulfate values found for each aggregate fraction times the proportion by mass of that fraction in the test portion.

B.6.5 The magnesium sulfate value for the aggregate shall be the mean of the two results for the test portions to the nearest whole number. The magnesium sulfate value for each fraction of the aggregate shall be the mean of the magnesium sulfate values for the two results for the test specimens to one decimal place.

(NOTE. A suitable worksheet (with two examples, one fine aggregate and one coarse aggregate) is shown on the following pages.)

B.7 PRECISION

As in BS EN 1367-2, Annex A.

B.8 TEST REPORT

As in BS EN 1367-2, Clause 11, together with:

g) The magnesium sulfate value and the individual magnesium sulfate values of the two specimens for each aggregate fraction tested.

EXAMPLE B.1

Blackstone Quarry, 6 mm nominal single size. Tested 8-25 August 2003						
Sieve Size		Grading of Test Portion (% of total mass)	Mass of Test Specimen		Magnesium Sulfate Value (% of original mass)	Weighted Mag. Sulfate value (%)
Passing (mm)	Retained (mm)		Before Test (g)	After Test (g)		
First Test Portion						
37.5	20	*0*	–	–	–	*0*
20	10	*0*	–	–	–	*0*
10	6.3	*26.4*	*303.2*	*278.2*	*8.2*	*2.18*
6.3	2	*69.4*	*104.9*	*98.6*	*6.0*	*4.17*
2	1	*4.2* †	–	–	*6.0* ‡	*0.25*
Total		*100*			Total	*6.60*
Second Test Portion						
37.5	20	*0*	–	–	–	*0*
20	10	*0*	–	–	–	*0*
10	6.3	*28.7*	*296.1*	*272.3*	*8.0*	*2.31*
6.3	2	*66.2*	*98.4*	*92.5*	*6.0*	*3.97*
2	1	*5.1*	*104.1*	*98.2*	*5.7*	*0.29*
Total		*100*			Total	*6.57*
					Mean	7

† Less than 5 % by mass of total sample, no test specimen.
‡ Taken as equivalent to that for 6.3 mm to 2 mm size under Sub-Clause B.6.2, indent (b).

EXAMPLE B.2

Sandy Heath Pit, Coarse Sand. Tested 8-12 August 2003						
Sieve Size		Grading of Test Portion (% of total mass)	Mass of Test Specimen		Magnesium Sulfate Value (% of original mass)	Weighted Mag. Sulfate value (%)
Passing (mm)	Retained (mm)		Before Test (g)	After Test (g)		
First Test Portion						
10	6.3	*4.6* †	–	–	*11.9* ‡	*0.55*
6.3	2	*10.8*	*97.2*	*85.6*	*11.9*	*1.29*
2	1	*17.0*	*101.8*	*94.2*	*7.5*	*1.27*
1	0.5	*25.2*	*92.9*	*89.0*	*4.2*	*1.06*
0.5	0.25	*26.2*	*104.1*	*99.3*	*4.6*	*1.21*
0.25	–	*16.2*	–	–	*4.6* *	*0.75*
Total		*100*			Total	*6.12*
Second Test Portion						
10	6.3	*4.4* †	–	–	*11.2* ‡	*0.49*
6.3	2	*10.9*	*104.1*	*92.4*	*11.2*	*1.23*
2	1	*17.3*	*106.8*	*98.3*	*8.0*	*1.38*
1	0.5	*25.1*	*101.7*	*96.8*	*4.8*	*1.21*
0.5	0.25	*26.1*	*100.3*	*96.1*	*4.2*	*1.09*
0.25	–	*16.2*	–	–	*4.2* *	*0.68*
Total		*100*			Total	*6.08*
					Mean	6

† Less than 5 % by mass of total sample, no test specimen.
‡ Taken as equivalent to that for 6.3 mm to 2 mm size under Sub-Clause B.6.2, indent (b).
* No test but mass loss taken as equivalent to that for 0.5 mm to 0.25 mm size under Sub-Clause B.6.3.

Appendix C – Straightedge Test

C.1 SCOPE

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

C.2 APPARATUS

C.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.

C.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.

C.3 PROCEDURE

C.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.

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

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

Appendix D – Guidance on Suitable Temperatures and Wind Speeds for Laying

D.1 In addition to the requirements in Clause 5.10, Table D.1 gives recommended wind speed and air temperature limits for the laying of Marshall Asphalt surface courses, binder courses and regulating layers.

D.2 Wind speed can be measured by either:

- an anemometer erected at a height of (10 ± 0.5) m situated on the airfield; or
- a portable anemometer erected at a height of (2.0 ± 0.1) m situated in close proximity to the laying works.

The anemometer should be fitted with a digital accumulative device. The average wind speed over the previous hour should be used to define the prevailing wind speed.

(NOTE 1. If the wind speed is increasing, anemometer readings should be made at 15 min intervals.)

(NOTE 2. To aid planning works, weather forecasts may be obtained from the nearest Regional Weather Centre.)

D.3 Meteorological records for the airfield are available.

OR

No clause.

(NOTE. Project Manager to select alternative for specific job specification; advice given in Clause Z.10 of Appendix Z.)

TABLE D.1 WEATHER CONDITIONS FOR LAYING

Course	Bitumen Grade	Thickness (mm)	Maximum Wind Speed (km/h) 2 m height	10 m height	Minimum Air Temperature (°C)
Surface Course	70/100	40	See Figure D.1		
	70/100	50	40	50	0
	100/150	40 or 50	40	50	0
Binder course	70/100	50, 60 or 80	40	50	0
	100/150	50, 60 or 80	40	50	0
Regulating / Ramping	70/100	up to 20	See Note 3		
	100/150				

(NOTE 1. Where two sets of limiting wind speed and air temperatures are given, laying can proceed provided the weather conditions conform to either set.)

(NOTE 2. The limiting wind speed and air temperatures relate to a compaction time of 8 min for the mid-layer temperature to fall from the specified maximum to minimum compaction temperatures.)

(NOTE 3. Very thin asphalt layers cool very quickly. At 15 mm thickness less than 2 min is theoretically available for compaction within the specified compaction temperature limits. Prompt rolling is essential and it is recommended that this material should only be laid in still conditions.)

(NOTE 4. The values and graphs were calculated using the previous grades of bitumen, and the results for mixtures with 70/100 and 100/150 bitumen may need to be revised.)

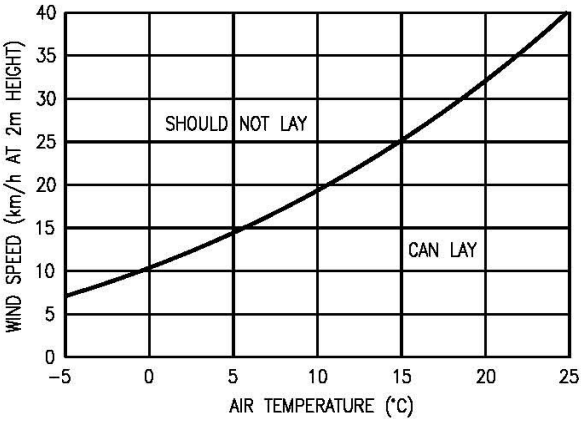


Figure D.1 – Acceptable weather conditions for laying 40 mm thickness of Marshall Asphalt surface course with 70/100 bitumen

Appendix E – Recommended Roller Types and Sequence

The recommended roller types and sequence are as detailed in Table E.1.

TABLE E.1 RECOMMENDED ROLLER TYPES AND SEQUENCES

Order in sequence	Roller Type	Rollers Required							Remarks
		Mass (tonnes)		Rear Wheel Width (mm)	Rear Wheel Static Force (kN/100 mm width)		Tyre Pressures (N/mm²)		
		Min.	Max.		Min.	Max.	Min.	Max.	
1	Three-wheeled smooth	8*	12	450	5.5	7.0	–	–	Driving wheels to face spreader
2	Self-propelled pneumatic-tyred smooth tread	8*	–	–	–	–	0.58	0.62	Between the two smooth-wheeled rollers
3	Three-wheeled smooth or tandem	8*	14	450	3.5	7.0	–	–	Finishing roller
1	Mechanical tamper	25 kg	–	–	–	–	–	–	For compaction of areas inaccessible to a roller

* For compaction of layers during hot weather, the roller mass may be reduced to 6 tonnes if excessive longitudinal movement of the mat occurs.

Appendix F – Retained Marshall Stability Test

F.1 SCOPE

This Appendix details the procedure to be followed to measure the loss of cohesion resulting from the action of water on Standard Marshall Specimens. A numerical index of reduced cohesion is obtained by comparing the Marshall stability of duplicate specimens that have been immersed in water under prescribed conditions. This method is useful as an indicator of the susceptibility to moisture of compacted bitumen-aggregate mixtures.

F.2 APPARATUS

Apparatus as detailed in Clause A.2 of Appendix A.

F.3 TEST SPECIMENS

Six Marshall test specimens made at the target binder content as in Clause A.6 of Appendix A.

F.4 PROCEDURE

F.4.1 Sort each set of six test specimens into two groups of three specimens each so that the mean bulk density of the specimens in Group 1 is essentially the same as for Group 2. Test the specimens in Group 1 as described in Sub-Section F.4.2. Test the specimens in Group 2 as described in Sub-Section F.4.3.

F.4.2 Bring the Group 1 specimens to the test temperature (60 ± 1) ℃ by storing them in an air bath maintained at the test temperature for not less than 4 h and determine their Marshall stability in accordance with Appendix A.

F.4.3 Immerse the Group 2 test specimens in water for 24 h at (60 ± 1) ℃. Determine the Marshall stability of the specimens in accordance with Appendix A.

F.5 CALCULATION

Calculate the numerical index of resistance of asphalt mixtures to the detrimental effect of water (Index of Retained Strength, I_{RS}) as the percentage of the original stability that is retained after the immersion period in accordance with Equation D.1.

$$I_{RS} = \left(\frac{S_2}{S_1}\right) x\,100\ \% \qquad \text{..... (D.1)}$$

where S_1 = Mean Marshall stability of the dry specimens (Group 1)

S_2 = Mean Marshall stability of immersed specimens (Group 2)

Appendix Y – Guidance Notes on Quality Systems for Project Managers

Y.1 INTRODUCTION

These Guidance Notes are intended to assist Project 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.

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 United Kingdom Accreditation Service (UKAS) 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 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 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 asphalt materials;
- off-site supply and mixing of asphalt materials;
- storage and transportation of asphalt materials prior to use/despatch;
- laying and compaction of asphalt 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 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 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 Management 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 Manager's own QA staff.

Y.5.5 It is the responsibility of the Project 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 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 the work to the required standard. Where only part of the required elements is 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 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 made 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 extend his own to include the sub-contractor. The Project 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 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 will be 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 United Kingdom Accreditation System (UKAS) 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 UKAS accredited or, subject to the Project 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 asphalt 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 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 Manager for the duration of the Contract; and
- handed over to the Project Manager on completion of the Contract.

Appendix Z – Guidance Notes on the Preparation of Job Specifications

Z.1 RESISTANCE TO FREEZING AND THAWING OF AGGREGATES

For small works, the magnesium sulfate test on all fractions can be omitted provided there is local evidence that the aggregate has adequate resistance to freezing and thawing. In such cases, the standard BS EN 1367-2 magnesium sulfate test conducted on the 10/14 mm size fraction may be considered satisfactory and it is unnecessary to require testing in accordance with Appendix B.

Z.2 PSV CATEGORY FOR SURFACE COURSES

Z.2.1 The requirement for the resistance to polishing of coarse aggregate on runway surface courses should normally be Category PSV_{50}. For high frequency traffic (as defined in Sub-Clause 0), a requirement for PSV of Category $PSV_{declared\ 55}$ should be set.

Z.2.2 The requirement for the resistance to polishing of coarse aggregate on taxiway surface courses should be Category PSV_{44}. However, for low frequency traffic (as defined in Sub-Clause 0), the category PSV_{NR} may be used except for fast exit taxiways.

Z.3 FINES QUALITY

F.5.1 There is no history of harmful fines (e.g. swelling clay) with aggregates used in the UK and, therefore, MB_FNR is the category normally required. If there is any reason to suspect non-established aggregate sources may be employed, a higher category can be specified.

F.5.2 If MB_F25 is the category required, that category can be eased for small proportions of natural fine sand (i.e. comprising less than 10 % of total aggregate) subject to all other requirements of the Specification being met.

Z.4 MINIMUM STABILITY

Z.4.1 The minimum stability requirement for Marshall Asphalt for surface courses in relation to aircraft tyre pressures and frequency of trafficking should be in accordance with Table Z.1.

TABLE Z.1 MINIMUM STABILITY REQUIREMENTS

Tyre Pressure MPa (psi)	Minimum Stability (kN)		
	Frequency of Trafficking		
	Low	Medium	High
Up to 1.4 (200)	6	8 (6)	10 (8)
More than 1.4 (200)	8	10	10

( ) bracketed values may be specified for cooler regions of the UK.

Z.4.2 The frequency of trafficking is defined in "*A guide to airfield pavement design and evaluation*" (Property Services Agency 1989) but with the overriding requirements as follows:

Low frequency	Maximum of 50 movements per week by aircraft in the critical tyre pressure range; and
Medium frequency	Maximum of 500 movements per week by aircraft in the critical tyre pressure range.
High frequency	Greater than 500 movements per week by aircraft in the critical tyre pressure range.

Z.4.3 Binder course mixtures should be made with bitumen of 70/100 or 100/150 grade. Where the surface course is specified to have a stability of 10 kN, the choice should be restricted to 70/100 grade bitumen.

Z.5 OFF-SITE MIXING

Z.5.1 Off-site mixing of Marshall Asphalt should only permitted with prior agreement. That approval should only be made for plants that will be engaged solely on the Defence Estates during the contract period. Off-site mixing should be carried-out by a Contractor (or Supplier on his behalf) who has Quality Assurance registration to the BS EN ISO 9000 series incorporating "Sector Scheme 14", Production of Asphalt Mixes, for the Quality Assurance of the Production of Asphalt with an appropriate scope of application for all aspects of the mixing and supply of asphalt materials.

(NOTE 1. See Clause 5.4)

(NOTE 2. Many static plants stock several different penetration grades of bitumen. Therefore, it is necessary to ensure that the correct grade of binder is used throughout.)

(NOTE 3. The costs of transporting and erecting asphalt mixing plants on site can be a disproportionately high percentage of the total cost of a surfacing contract, particularly for small works. Marshall Asphalt should normally be mixed on site, but consideration may be given to mixing off site. The following points should be considered in relation to off-site mixing:

- Effect on competitive tendering;
- Haulage distance;
- Suitability of static mixing plants including storage areas;
- Testing facilities;
- Exclusive use of plant during contract period;
- Inspection, approval and Quality Assurance of off-site mixing plants; and
- Previous experience of mixing Marshall Asphalt.

Z.5.2 The minimum requirements for the batching and mixing plant are set out in Clause 5.4. The mixing plant should carry a temperature measuring device at their output end and this should be checked during a production run to ensure that there are not wide fluctuations in temperature. Excessive feedback of the fines is to be avoided. The fines/filler should be weighed into the mixture at the pug mill, and the discharge gate should extend for the full width of the pug mill box. Accurate binder temperature controls should be maintained. The flights in the drier drum and the plates and blades in the pug mill should be examined to ensure that they are in good condition, as should be the hot bin screens for wear and clogging. All discharge gates and the binder control valves should be checked against leakage.

(NOTE 1. A mixer capable of producing the full specified range of Marshall mixtures should have:

- a cold bin for each aggregate size (typically 5) with upstand plates to ensure that there is no overspill from one bin to another;
- not less than 3 hot bins with overflow discharges;
- facilities for sampling; and
- a corresponding 4 deck screening over them.

The screens themselves are typically 40 mm, 20 mm, 10 mm and 5 mm, but may vary. Generally, the screens should be one size larger than the nominal size of the hot bins they are feeding.)

(NOTE 2. The drying drums can quite often determine the practical throughput of the plant, and their throughput capacity can vary considerably from one manufacturer to another, size for size. In general they average about 8 to 9 metres in length. A 1.50 m internal diameter drum will have a maximum throughput of about 100 t/h, and a 1.8 m diameter drum about 150 t/h.)

(NOTE 3. The binder addition may be either by volume or weight, preferably the latter discharging via a heat jacketed spray bar extending the full width of the pug mill.)

Z.5.3 The supply of Marshall Asphalt mixed off site should comply with this Standard as if it were mixed on site.

Z.5.4 The haulage distance of mixed material should not normally exceed 50 miles. As part of the laying trials as specified in Clauses 6.2 and 6.3, the ability to have the material laid within 3 h of being mixed and with a maximum temperature drop of 10 °C in the delivered load at the time of laying should be checked.

(NOTE. Haulage distance can affect the loss of temperature in the mixture. The rate of arrival of delivery lorries can be affected by either delays due to traffic etc or a queue of lorries in front of the paver on site. Rapid changes in weather, such as a downpour, may lead to cessation of laying possibly resulting in dumping of mixed material. Day to day planning using local weather forecasting information is necessary. The loss of mix temperature during transit is usually less than 10 °C with modern well-insulated delivery lorries, and covering quilts are now commercially available that provide a better insulation than double sheeting. Haulage distances up to

100 miles are not unknown but 50 miles is more typical. It is recommended that, taking these factors into consideration, a maximum of 3 h is permitted between mixing the Marshall Asphalt and laying to minimise temperature loss and binder hardening in the mixture. This period should also include any time of the mixture in storage at the plant and in delivery lorries on site. It should also be assumed that 10 °C loss in temperature will occur during this period.)

Z.5.5 Laboratory facilities and the requisite level of expertise must be available to carry out the full range of test procedures.

(NOTE. Advice on equipment needed and, where possible, inspection services will be provided by Construction Support Team upon request.)

Z.6 PAVING MACHINES INCORPORATING EQUIPMENT TO APPLY TACK OR BOND COAT

The Project Manager should seek guidance from the Construction Support Team, DE. In the absence of more definitive information, approval would need to be subject to a laying trial and laboratory tests to demonstrate good adhesion, that the tack or bond coat had broken and that moisture had not been trapped.

Z.7 TEMPORARY RAMPS

Z.7.1 Phased working to allow aircraft operations to continue, either throughout or at intervals during the construction period (e.g. night working and daytime flying) may necessitate the provision of temporary ramps. Guidance is provided at Appendix 3A of CAP 168, *Licensing of Aerodromes* (Civil Aviation Authority).
Clause 5.29 may need to be modified or augmented for specific job specifications and must be subject to prior agreement with the Aerodrome Authority/Station staff.

Z.7.2 The choice of whether to cover over or ramp around manholes and aviation ground lighting fixtures will depend upon, respectively:

- the services located in the manhole and the importance of maintaining immediate access to them; and
- the needs of the airfield to maintain all ground lighting fixtures operational.

Agreement should be sought with the Aerodrome Authority/Station staff.

Z.7.3 Typical values that can be used in Sub-Clauses 5.29.3 to 5.29.5 subject to agreement with the Aerodrome Authority/Station staff are as given in Table Z.2.

Z.8 TEMPERATURE OF SURFACING

In assessing the temperature of the freshly laid surfacing, consideration should be given to the likelihood of the temperature at depth being greater than that at the surface. If the temperature is required to be taken, a hole should be drilled 40 mm deep, a measurement device with suitable accuracy (± 1 °C) inserted and the hole filled with glycerine. The temperature should be determined after the reading has stabilised whilst at different depths.

TABLE Z.2 DIMENSIONS OF RAMPS

	Sub-Clause 5.29.3	Sub-Clause 5.29.4	Sub-Clause 5.29.5
Distance from runway centre line: Limit of applicability of Sub-Clause Minimum for transverse ramps	 22.5 m 10.0 m	 22.5 m †	 n/a n/a
Maximum longitudinal gradient Maximum transverse gradient	1.0 % * 2.0 %	2.0 % * 2.5 %	2.0 % * 2.5 %
Minimum spacing of ramps Min. thickness of ramp material Maximum depth of ramp	110 m 40 mm 75 mm	† 40 mm †	n/a n/a n/a

* If the existing longitudinal gradient is at, or close to, the maximum permissible in the standard criterion then, depending on the direction of working, it may be necessary to obtain dispensation from the Aerodrome Authority/Station staff to increase this value for temporary ramps.

† Not normally applicable, but otherwise to be agreed with the Aerodrome Authority/Station staff on a job specific basis.

Z.9 REGULARITY FOR TAKING CORE SAMPLES

The minimum regularity for taking cores for monitoring should be set at 1000 m² and, for bulk density checks, additional core samples should be taken adjacent to the lane joints at not more than 150 m intervals. However, for small works the regularity may have to be increased to obtain sufficient result to make an assessment on.

Z.10 METEOROLOGICAL DATA

Z.10.1 In deciding whether to offer meteorological data about the site, the ease of availability of the data and the possible usefulness of the data (in terms of the expected season when the work is to be carried out and the size of the works) need to be considered.

References

Defence Estate, Ministry of Defence

FS 06	1994	Function Standard 06, Guide to Maintenance of Airfield Pavements
SPEC 12	2007	Specification 012, Hot Rolled Asphalt and Asphalt Concrete (Macadam) for Airfields
SPEC 13	2007	Specification 13, Marshall Asphalt for Airfields
SPEC 33	2005	Specification 33, Pavement Quality Concrete for Airfields
SPEC 35	2005	Specification 35, Concrete Block Paving for Airfields
SPEC 40	2007	Specification 40, Porous Friction Course for Airfields
SPEC 49	2007	Specification 49, Stone Mastic Asphalt for Airfields
DMG 27	2005	Design and Maintenance Guide 27, A guide to Airfield Pavement Design and Evaluation
DMG 33	2005	Design and Maintenance Guide 33, Reflection Cracking on Airfield Pavements – a design guide
JSB 554	2004	Military Aviation, Aerodrome Standards and Criteria

British Standards Institution

BS 434			Bitumen road emulsions (anionic and cationic)
	Part 2	1984	Code of practice for use of bitumen road emulsions
BS 2000			Methods of test for petroleum and its products
	Part 49	1993	Determination of needle penetration of bituminous material
BS 3136			Specification for cold emulsion spraying machines for roads
	Part 2	1972	Metric units
BS 594987		2007	Asphalt for roads and other paved areas – Specification for transport, laying and compaction and design protocols
BS EN 58		1984	Bitumen and bituminous binders – Sampling bituminous binders
BS EN 196			Methods of testing cement
	Part 6	1992	Determination of fineness
BS EN 197			Cement
	Part 1	2000	Composition, specifications and conformity criteria for common cements
BS EN 459			Building lime
	Part 1	2001	Definitions, specifications and conformity criteria
BS EN 932			Tests for general properties of aggregates
	Part 1	1997	Methods for sampling
	Part 2	1999	Methods for reducing laboratory samples
BS EN 933			Tests for geometrical properties of aggregates
	Part 1	1997	Determination of particle size distribution – Sieving method
	Part 2	1996	Determination of particle size – Test sieves, nominal size of apertures
	Part 3	1997	Determination of particle shape – Flakiness index
	Part 9	1999	Assessment of fines – Methylene blue test
	Part 10	2001	Assessment of fines – Grading of fillers (air-jet sieving)
BS EN 1097			Test for mechanical and physical properties of aggregates
	Part 2	1998	Methods for the determination of resistance to fragmentation
	Part 6	2000	Determination of particle density and water absorption
	Part 7	1999	Determination of the particle density of filler – Pyknometer method
	Part 8	2000	Determination of the polished stone value

BS EN 1367			Test for thermal and freezing and thawing properties of aggregates
	Part 2	1998	Magnesium sulfate test
BS EN 12591		2000	Bitumen and bituminous binders – Specifications for paving-grade bitumens
BS EN 12620		2002	Aggregates for concrete
BS EN 12697			Bituminous mixtures – Test methods
	Part 1	2005	Soluble binder content
	Part 2	2002	Determination of particle size distribution
	Part 3	2000	Bitumen recovery: rotary evaporator
	Part 4	2000	Bitumen recovery: fractionating column
	Part 5	2002	Determination of the maximum density
	Part 6	2003	Bulk density, measurement
	Part 8	2003	Air voids content
	Part 11	2006	Affinity between aggregates and binder
	Part 12	2003	Determination of the water sensitivity of bituminous specimens
	Part 13	2000	Temperature measurement
	Part 27	2000	Sampling
	Part 28	2000	Preparation of samples for determining binder content, water content and grading
	Part 30	2004	Specimen preparation by impact compactor
	Part 34	2004	Marshall test
	Part 35	2004	Laboratory mixing
	Part 36	2003	Thickness of a bituminous pavement
BS EN 13036			Road & Airfield Characteristics – Test methods
	Part 4	2003	Method for measurement of slip/skid resistance of a surface – The pendulum test
	Part 7	2003	Method of measuring surface irregularities – The straightedge test
BS EN 13043		2002	Aggregates for bituminous mixtures and surface treatments for roads, airfields and other trafficked areas
BS EN 13108			Bituminous mixtures – Material specification
	Part 1	2006	Asphalt concrete
	Part 21	2006	Factory production control
BS EN 13808		2005	Bitumen and bituminous binders – Framework for specifying cationic bitumen emulsions
BS EN 30011			Guidelines for auditing quality work
	Part 1	1993	Auditing
	Part 2	1993	Qualification criteria for quality systems auditors
	Part 3	1993	Management of audit programmes
BS EN ISO 3838		1996	Methods for determination of density or relative density of petroleum and petroleum products (pyknometer methods)
BS EN ISO 9000		2000	Quality management and quality assurance standards

Her Majesty's Stationery Office

DS 05-67	1980	Defence Standard 05-67, Guidance to Quality Assurance in Design
	1990	Environmental Protection Act 1990

American Society for Testing and Materials

ASTM D 2041 - 91	1991	Standard test method for theoretical maximum specific gravity and density of bituminous paving mixtures

Civil Aviation Authority

CAP 168	Licensing of Aerodromes