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DRAFT EAST AFRICAN STANDARD

Bitumen emulsion-based paving — Code of practice

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EAST AFRICAN COMMUNITY

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Foreword

Development of the East African Standards has been necessitated by the need for harmonizing requirements governing quality of products and services in the East African Community. It is envisaged that through harmonized standardization, trade barriers that are encountered when goods and services are exchanged within the Community will be removed.

The Community has established an East African Standards Committee (EASC) mandated to develop and issue East African Standards (EAS). The Committee is composed of representatives of the National Standards Bodies in Partner States, together with the representatives from the public and private sector organizations in the community.

East African Standards are developed through Technical Committees that are representative of key stakeholders including government, academia, consumer groups, private sector and other interested parties. Draft East African Standards are circulated to stakeholders through the National Standards Bodies in the Partner States. The comments received are discussed and incorporated before finalization of standards, in accordance with the Principles and procedures for development of East African Standards. XXXXXX.

East African Standards are subject to review, to keep pace with technological advances. Users of the East African Standards are therefore expected to ensure that they always have the latest versions of the standards they are implementing.

The committee responsible for this document is Technical Committee EASC/TC 028, *[Construction of roads, rails, air and water transport infrastructure]*.

Attention is drawn to the possibility that some of the elements of this document may be subject of patent rights. EAC shall not be held responsible for identifying any or all such patent rights.

EAS 982 consists of the following parts, under the general title *Bitumen and bituminous binders — Specifications*:

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Bitumen emulsion-based paving — Code of practice

1 Scope

This Draft East Africa Standard specify the application, for emulsified bitumen used for pavement in roads construction. It covers 15 grades of emulsified bitumen and 11 grades for polymer modified emulsified bitumen for use in the manner designated.

It provides recommendations on selecting the proper grade and type of emulsified bitumen for various uses. Emulsified asphalt must be selected for the proper application.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EAS 982-3 Bitumen and bituminous binders — Specification — Part 3: Anionic bitumen emulsion

EAS 982-4 (IDT) Bitumen and bituminous binders — Specification — Part 4: Cationic bitumen emulsion

ISO 3310-1:2016 Test sieves — Technical requirements and testing — Part 1: Test sieves of metal wire cloth

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at http://www.iso.org/obp

3.1
Emulsified bitumen
a liquefied type of bitumen with a low viscosity produced by mixing bitumen binder, water, and emulsifying agents.

3.3
rapid setting emulsified bitumen
emulsified bitumen with low viscosity and fast setting time which is designed to react quickly with aggregate and revert from the emulsion state. Rapid hardening emulsified bitumen contains the CRS, CHFRS, HFRS, or RS designation as in EAS 982-3 and EAS 982-4

3.2
medium setting
emulsified bitumen in which rate of deposition of bond is sufficiently delayed to permit mixing with certain fine aggregates before breaking to form a continuous adhesive film without stripping. Medium setting emulsified bitumen contains the MS or HFMS designation as in EAS 982-3 and EAS 982-4.

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3.4
slow setting
Slow setting emulsions are manufactured by using special type of emulsifier, which makes the setting process very slow. These types of emulsion are relatively stable. Slow setting emulsified bitumen contains the designations CSS-1, CSS-1h, SS-1, and SS-1h as in EAS 982-3 and EAS 982-4.

3.5
prime coat
a uniform, sprayed application of bitumen material to an untreated subgrade or a granular base to seal the base before paving, and to promote bonding to the upper layers.

3.6
tack coat
a uniform, sprayed application of bitumen material placed between bitumen mix layers to promote bonding.

3.7
cape seal
a surface treatment that involves the application of a slurry seal to a newly constructed surface treatment or chip seal. Cape seals are used to provide a dense, waterproof surface with improved skid resistance.

3.8
chip seal/Surface dressing
a surface treatment in which a pavement surface is sprayed with bitumen (generally emulsified) and then immediately covered with aggregate and rolled. Chip seals/Surface dressing are used primarily to seal the surface of a pavement with non-load-associated cracks and to improve surface friction, although they also are commonly used as a wearing course on low-volume roads.

3.9
crack filling

the placement of materials into non-working cracks to substantially reduce infiltration of water. Non-working cracks are defined as those that experience minor horizontal movements, generally less than 2 mm (0.1 in.). Crack filling should be distinguished from crack sealing.

3.10
crack sealing
a maintenance procedure that involves placement of specialized materials into working cracks using unique configurations to reduce the intrusion of incompressible materials into the crack and to prevent intrusion of water into the underlying pavement layers. Working cracks are defined as those that experience significant horizontal movements, generally greater than about 2 mm (0.1 in.).

3.11
dense-graded bitumen overlay
an overlay course consisting of a mix of bitumen binder and a wellgraded (also called dense-graded) aggregate. A well-graded aggregate is uniformly distributed throughout the full range of sieve sizes.

3.12
fog seal
a light application of slow-setting emulsified bitumen diluted with water is commonly used, although other types of emulsified bitumen may be used. It is used to renew old bitumen surfaces and to seal small cracks and surface voids.

3.13
micro surfacing
a mixture of polymer-modified emulsified bitumen, mineral aggregate, mineral filler, water, and other additives; properly proportioned, mixed, and spread on a roadway surface.

3.14

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sand seal
an application of bitumen material covered with fine aggregate. It may be used to improve the skid resistance of slippery pavements and to seal against air and water intrusion.

3.15
sandwich seal
a surface treatment that consists of an application of a large aggregate, followed by an application of emulsified bitumen that is in turn covered with an application of smaller aggregate. Sandwich seals are used to seal the surface and improve skid resistance.

3.16
scrub seal
application of a emulsified bitumen to the pavement surface followed by the broom scrubbing of the bitumen into cracks and voids, then the application of an even coat of sand or small aggregate, and finally a second brooming of the aggregate and bitumen mixture. This seal is then rolled with a pneumatic tire roller.

3.17
slurry seal

a mixture of slow-setting emulsified bitumen, well-graded fine aggregate, mineral filler, and water. It is used to fill cracks and seal areas of old pavements, to restore a uniform surface texture, to seal the surface to prevent moisture and air intrusion into the pavement, and to provide skid resistance.

4. Requirements

4.1 Emulsified bitumen shall conform to the requirements given in EAS 982-3 for Anionic bitumen emulsion and EAS 982-4 for Cationic bitumen emulsion, for the type and grade specified.

4.2 The polymer-modified bitumen shall conform to the requirements of East Africa Standard on Polymer modified emulsified bitumen.

5. Significance and uses

1.1 General

5.1.1. Emulsified bitumen are mixtures of bitumen binders, water, and emulsifying agents. They may contain other additives to meet certain grades. Emulsified bitumen grades and types have different uses.

5..1.2. Emulsified bitumen are named using a prefix and a suffix. The prefix identifies the type and class of emulsified bitumen and the suffix identifies the grade.

5.1.3. There are four types of emulsified bitumen that are distinguished by how fast the emulsified bitumen will set or coalesce. However, in this standard gives the specification for three types. The four types are designated with the prefix:

a) SS-slow set,

b) MS-medium set,

c) RS-rapid set, and

d) QS-quick set.

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1.2 Class:

5.2.1 Emulsified bitumen is classified based on particle charge of the bitumen droplets within the water phase of the suspension. Anionic emulsified bitumen has a negative charge and cationic emulsified bitumen has a positive charge.

5.2.2 There are also a limited number of emulsified bitumen with no appreciable charge and they are classified as nonionic.

5.2.3. Cationic emulsified bitumen are designated by including the letter “C” before the prefix (i.e., CRS-2). Anionic emulsified bitumen is designated without including an additional letter or number in the prefix (i.e. RS-2).

5.2.4 High-float emulsified bitumen is a class of emulsified bitumen that can be either anionic or cationic. High-float emulsified bitumen is formulated with a gel structure to produce a thicker bitumen coating on aggregates. They are designated with the letters “HF” before the prefix (i.e., HFRS-2).

1.3 Grade:

5.3.1 Emulsified bitumen are produced in two viscosity grades. The suffix “1” indicates low-viscosity emulsified bitumen and suffix “2” indicates high-viscosity emulsified bitumen.

5.3.2 Emulsified bitumen are designated in three stiffness categories:

5.3.3 Hard bitumen residue (lower penetration) is designated with an “h” (i.e., CRS-1h).

5.3.4 Soft bitumen residue (higher penetration) is designated with an “s” (i.e., CRS 1s).

5.3.5 The intermediate stiffness category, between hard and soft, is designated without an additional letter or number (i.e., CRS-1).

5.3.6 “P” is used to designate polymer-modified emulsified bitumen (i.e., CRS-2P). The modifier may be either a solid or latex polymer. The modifier may be added either to the bitumen binder or emulsifier solution prior to the emulsification process.

1.4 Uses

5.4.1 Typical uses of different grades of emulsified bitumen are shown in Tables 1 and 2. Note that other factors that need to be considered include:

5.4.2 Ambient temperature at time of use,

5.4.3 Aggregate type and gradation,

5.4.4 Available application equipment,

5.4.5 Traffic, and

5.4.6 Potential environmental considerations.

5.4.7 It is recommended to evaluate aggregate and emulsified bitumen compatibility in the laboratory before placing on the roadway.

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Table 1—Typical Uses, Rapid-Set and Slow-Set Emulsified bitumen

Class	Anionic				Cationic			
Grade	RS-1	RS-2	HFRS-2	SS-1, SS-1h	CRS-1	CRS-1	CSS-1	CSS-1h
Plant Mix (Cold) or Mixed in Place								
Dense-Graded				x			x	x
Emulsified bitumen **–Aggregate Combination**								
Chip Seal	x	x	x		x	x		
Sand Seal	x	x	x		x	x		
Slurry Seal				x			x	x
Sandwich Seal		x	x			x		
Scrub Seal							x	x
Straight Emulsified bitumen								
Fog Seal			x	x[a]		x	x[a]	x[a]
Prime Coat				x[b]			x[b]	x[b]
Tack Coat	x	x		x[a]	x	x	x[a]	x[a]
Crack Filler				x			x	x

[a] Diluted with water at point of manufacture.

[b] Mixed-in prime only

x Applicable

Table 2—Typical Uses, Medium- and Quick-Set Emulsified bitumen and Polymer Modified Emulsified bitumen

Class	Anionic			Cationic			Polymer-modified (Anionic/Cationic)		
Grade	MS-1, HFMS-1	MS-2, HMS-2	HFMS-2s	CQS-1	CQS-1h	CMS-2	CRS and CHFRS (2hP, 2P, 2sP)	CQS-1hP, CQS-1P	CRS-1P, SS-1hP, CSS-1hP
Plant Mix (Cold) or Mixed in Place									
Dense-Graded			x						
Emulsified Bitumen –Aggregate Combination									
Chip Seal							x		
Sand Seal	x								
Slurry Seal			x		x				
Micro Surfacing								x	
Sandwich Seal							x		
Straight Emulsified Bitumen									
Fog Seal	x	x	x			x			
Prime Coat		x							
Tack Coat	x			x	x				X

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Crack Filler			x						
[a] Diluted with water at point of manufacture.									
[b] Mixed-in prime only									
x Applicable									

6. Application of bitumen emulsions

6.1 Information to be supplied by the purchaser

6.1.1 The guidance given in this clause is intended to assist the purchaser in clearly indicating his requirements to the supplier for the purpose of either a quotation or an order.

6.1.2 When the purchaser is in no doubt as to the type of treatment required, the emulsion supplier need only be provided with the following information:

a) The class and binder content of emulsion;

b) Quantity and type of container;

c) The date and place of delivery.

6.1.3 When the purchaser requires advice as to the most suitable treatment, the following general information shall be given to the emulsion supplier:

a) The location and area to be treated;

b) The type of treatment;

c) The condition and nature of existing surfacing and the type of traffic carried;

d) The approximate date (time of year) when the work is to be carried out.

6.1.4 When the roadwork is to be carried out by the contractor, works shall be carried out as directed by the engineer in accordance with specifications.

The time schedule shall include dates for:

a) The completion of preliminary work, if any;

b) The delivery of materials;

c) The start of various sections of the roadwork;

d) The completion of various sections of the roadwork.

6.2 Materials

6.2.1 Emulsion

The class or classes of emulsion for normal uses are given in Table 3for convenience, but reference shall be made to the detailed recommendations given in the remainder of this standard.

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6.2.2 Aggregate

In cases where the purpose of the aggregate is also to provide a skid resistant wearing surface, the minimum polished stone value of the aggregate appropriate to the intensity and speed of traffic carried shall be specified.

Table 3—Classes of emulsion for normal uses

Use	Clause	Emulsion class anionic	Emulsion class cationic
Coated stone	6.11	MS-1	CMS, CSS-1H/CMS-2
Concrete curing	6.14	RS-1RS-1, RS-1RS-1	CRS-1, CRS-1/CRS-1H
Grouting	6.8	RS-2, RS-1RS-1	CRS-1/CRS-1H, CRS-2
Lean mix sealing	6.7	RS-1RS-1, RS-1RS-1	CRS-1, CRS-1/CRS-1H
Fog spraying	6.12	RS-1RS-1	CRS-1
Patching	6.5	RS-2, RS-1RS-1	CRS-1/CRS-1H
Premixing	6.10	MS-1	CSS-1H/CMS-2
Retreading	6.9	A2-50, A3	CMS
Sealing formation and sub-base	6.7	RS-2, RS-1RS-1	CRS-1/CRS-1H, CRS-2
Slurry sealing	6.15	A4	CSS-1H/CMS-2
Surface dressing and sealing	6.6	RS-2, RS-1RS-1	CRS-1/CRS-1H, CRS-2, CSS-1H/CMS-2
Tack coating	6.13	RS-2	CRS-1, CRS-1/CRS-1H
Miscellaneous	6.16	Approved by engineer and supplier	Approved by engineer and supplier

6.3 Design

6.3.1 General

Except for class CRS-2, bitumen emulsions are fluid enough to be applied at atmospheric temperatures without heating and their viscosities are not materially affected by changes of temperature. Unlike hot-applied binders, they remain fluid immediately after application. The viscosity of emulsion used on a steep gradient shall therefore be as high as is compatible with the conditions and method of application, in order to prevent undue flow of emulsion down the gradient.

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Bitumen emulsions can normally be applied to damp surfaces with satisfactory results but, since they contain water, they are liable to be adversely affected by rain during or immediately after application. Work shall therefore not be carried out in wet weather. However, cationic emulsions tend to break more rapidly than anionic and, particularly class CRS-2, are less susceptible to rain. In surface dressing and premix work, abnormally hot weather may also cause difficulty and traffic shall if possible, be kept off the road for a minimum of 24 hours after the work is completed.

Special attention is drawn to the fact that anionic and cationic emulsions cause mutual coagulation if mixed together. Therefore, any equipment which has or may have been employed for cationic emulsions shall be thoroughly cleaned before it is again used for anionic emulsions or vice versa.

6.3.2 Breaking of Emulsions

6.3.2.1 Breaking is indicated by a change in colour of the emulsion from brown to black. The rate of break of an emulsion is dependent upon the following factors:

a) The composition of the emulsion;

b) The rate of evaporation of the water, which in turn is dependent upon wind conditions, relative humidity, atmospheric temperature, rate and method of application;

c) The porosity of the surface to which the emulsion is being applied and the consequent remove of water by capillary attraction;

d) The chemical and physical influences of the aggregate with which the emulsion comes in contact;

e) The mechanical disturbance of the emulsion/aggregate system during laying and rolling or by the action of traffic.

6.3.2.2 When the breaking of the emulsion is likely to be delayed, for instance when evaporation is slow, it is desirable that traffic shall be kept off the work as long as possible after rolling, or at least until it is clear that the emulsion has broken. If the treated section cannot be closed to traffic, then the speed of the traffic should be kept as low as possible and shall not exceed 30 km/h until the emulsion has broken.

6.3.2.3 Lightly coated chippings may be used with the emulsion but, as this can delay the breaking, allowance shall be made for this by suitable traffic control.

6.4 Work on site

6.4.1 Health and Safety when Handling

6.4.1.1 General Principles

Bitumen emulsions are safe and without risk to health when properly used. This does not obviate the need for working methods that avoid direct skin contact with the emulsions and adequate protective clothing (overalls, gloves, etc.) shall be worn. Protective clothing shall be maintained in a sound condition and cleaned or washed regularly. Drums of emulsion shall not be heated without reference to the manufacturer for instructions.

6.4.1.2 Cleaning Methods

Unbroken emulsion may be removed from any surface by washing with cold water but the method is ineffective for the removal of residual bitumen adhering to tools or appliances or to the person. In such cases, kerosene will assist the removal of the bitumen and protective gloves shall be worn to minimize skin contact.

Where kerosene is used on the skin, it shall be removed by thorough washing with soap and water, and that disposal of kerosene and related waste materials shall be carried out in accordance with relevant regulations and environmental requirements.

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6.4.1.3 Protection and Storage of Materials

Drums or other containers shall be stored under clean conditions. Emulsions can be damaged by the freezing of the water contained within them and therefore the drum shall be protected from freezing. If the storage period exceeds 1 month, the drums shall be turned or inverted at least once a month.

Containers shall be well rolled to agitate the contents before use. This applies particularly to emulsion Classes RS-1RS-1 and CRS-1.

Care shall be taken to prevent damage to the containers when handling them and removing the bungs. Immediately after use, returnable containers shall be completely emptied and the bungs and vent plugs replaced.

The emulsion should be stored at a minimum temperature of 10 ºC and a maximum temperature of 80 ºC. The manufacturer should advise the purchaser on the storage and application temperatures.

6.4.1.4 Preparation of Surface

All mud, dust, leaves, loose material, and other detrimental materials on the surface,. shall be removed from the surface to be treated, by brushing with hand brooms or with mechanical brooms. In very hot weather, it may be advisable to dampen the road surface with water in order to retard the loss of water from the emulsion, to reduce the rate of break and to encourage wetting of the surface by the emulsion. It is essential that the road surface is free from standing water before the emulsion is applied.

6.4.2 Application

6.4.2.1 Hand Application

6.4.2.1.1 Buckets and brooms — The emulsions may be applied from lipped buckets or cans fitted with duckbill spreaders baffles and then evenly spread with medium-long bristled brooms or with squeegees. It is advisable to spread the emulsion in one direction only so as to avoid scrubbing action.

NOTE Pitch-set brooms cannot be cleaned with solvent without the risk of damage. Wire-set brooms are therefore preferred.

6.4.2.1.2 Barrel trucks — Many different kinds of barrel trucks are available from which the emulsion is discharged directly from the barrel on to an apron, which aids even distribution.

6.4.2.2 Machine Applications

6.4.2.2.1 Small machine for pressure spraying by hand: These may be of two types, either those where the pressure is applied to the emulsion indirectly by means of compressed air, or those where the emulsion itself is pumped. All hoses and seals shall be manufactured of materials resistant to the effects of emulsion and kerosene.

6.4.2.2.1 Bulk spraying distributors: Where the surface to be covered is of any considerable extent, specially designed bulk spraying distributors shall be used for the application of the material. These are generally operated by the manufacturer of the emulsion or by specialist contractors.

NOTE: It is not possible to lay down a precise viscosity range for emulsion for spraying as this is partly dependent upon the characteristics of the spraying machine. If difficulty is experienced, reference shall be made to the manufacturer of the emulsion and otherwise spraying equipment.

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6.4.3 Maintenance of Equipment

All mechanical spraying plant shall be kept in a clean and sound condition, or inefficient spraying may result.

6.5 Repair of potholes and depressions

The emulsion shall be class RS-2, RS-1RS-1 or CRS-1/CRS-1H. Potholes and deep depressions shall first be cleaned of all loose material and the area shall be cut out to a regular shape with all the sides vertical or slightly undercut. If the exposed surface is very dry, they shall be moistened with water in order to ensure better penetration of the emulsion. The bottom and sides of the hole or depression shall be thoroughly coated with emulsion. Clean aggregate of the appropriate size (not larger than two-thirds of the depth of the hole for complying with nominal aggregate size 28 mm, whichever is the lesser) shall be placed in the hole to a thickness slightly greater than its depth and well rammed or rolled in. the minimum amount of emulsion required to coat the stone shall then be poured on. The patch shall then be covered with clean 10 mm or 6 mm chippings and again rolled or rammed. Shallow depressions shall first be brushed clean and then levelled by the application of a coating of emulsion. Clean chippings of a size approximating to the depth of the depression shall be placed in the hole and well rolled in.

NOTES 1 It is strongly emphasized that the minimum quantity of emulsion necessary shall be used, for both potholes and depressions, so as to avoid a 'fat' spot in the road.

NOTE 2 If repairs are to be made using asphalt or macadam, emulsion shall be used to coat the bottom and sides of the prepared hole before infilling.

6.6 Surface dressing

6.6.1 General

6.6.1.1 Preparation of the Surface

Preparation of the surface shall be carried out in accordance with 6.4.1.4. All potholes and depressions shall be made good and allowed to settle down thoroughly under traffic before surface dressing.

6.6.1.2 Rate of Application of Emulsion

The rate of application of emulsion will depend upon the following:

(a) The density of traffic;

(b) The nature of the surface to be dressed, e.g. roughness, porosity and hardness;

(c) The type and size of chipping to be used.

The density of traffic is considered in terms of the number of commercial vehicles a day in the lane under consideration, a commercial vehicle being defined as any vehicle of unladen mass greater than 1.5 t. Traffic in each direction may be assumed to be half the sum in both directions where the latter only is known. Lane traffic categories are as follows:

Category 1: 2,000 and above commercial vehicles per day per lane (one direction)

Category 2 = 1 000 to 2 000, Commercial vehicles per day per lane in one direction

Category 3 = 200 to 1 000, Commercial vehicles per day per lane in one direction

Category 4 = 20 to 200, Commercial vehicles per day per lane in one direction

Category 5 = 0 to 20, Commercial vehicles per day per lane in one direction

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The hardness of the road surface is defined as follows:

a) **Very hard —** Surfaces such as concrete or exceptionally lean bituminous mixtures. Negligible penetration of chippings will occur even under the heaviest traffic.

b) **Hard —** Surfaces containing some hard bituminous mortar into which chippings will penetrate only slightly under heavy traffic.

c) **Normal —** Surfaces into which chippings will penetrate moderately under medium and heavy traffic.

d) **Soft —** Surfaces into which chippings will penetrate considerably under medium and heavy traffic.

e) **Very soft —** Surfaces into which even the largest chippings will be submerged under heavy traffic. Usually rich in binder.

6.6.1.3 Application of Chippings

6.6.1.3.1 An even layer of clean single-size chippings shall be spread over the film of emulsion as soon as possible after spraying and before breaking occurs. The chippings shall preferably be spread by a mechanical spreader or a synchronized distributor to ensure uniformity of distribution.

6.6.1.3.2 Lightly coated chippings may be used with emulsion but, as this can delay the breaking, allowance shall be made for this by suitable traffic control.

The surface shall then be rolled. Pneumatic-tyred rollers are strongly recommended for compaction of surface dressings.

Where steel-tyred rollers are to be used, they shall be of the lightest type and the frequency of vibration adjusted to ensure that the chippings are pressed into the binder film and initial compaction achieved in two or three passes without crushing the chippings

6.6.1.3.43 The recommended rates of application of chippings are as given in Table 4.

6.6.1.3.4 Excess chippings shall be swept up and taken away as soon as possible. Further sweeping to remove chippings disturbed by traffic shall be carried out as required.

Table 4— Rates of application of chippings

Nominal size of chippings mm	Rate of application kg/m^2
14	13 ± 2
10	10 ± 1
6	7 ± 1
3	6 ± 1

6.6.2 Cold Application

6.6.2.1 Cold application shall apply for bitumen emulsion with binder content less than 65%.

Type of Emulsion: The emulsion shall be class RS-2, RS-1RS-1 or CRS-1/CRS-1H and shall be applied by spraying using a distributor, classes RS-2 or CRS-1/CRS-1H are more suitable for use on open textured surfaces and where chippings larger than 10 mm are specified.

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Rate of Application of Emulsion and Size of Chipping — The rate of application of emulsion for the chipping sizes recommend for various types of surface and traffic densities shall be as given in Table 5.

6.6.3 Hot Application

6.6.3.1. Hot application shall apply for bitumen emulsion with binder content greater than 65%.

6.6.3.2 Type of Emulsion: The emulsion shall be class CRS-2 and shall be applied by spraying at a temperature of 75 °C to 85 °C using a hot binder distributor.

Rate of Application of Emulsion and Size of Chipping

6.6.3.2 Traffic lanes: The rates of application of emulsion for the chipping sizes recommended for various types of surface and traffic densities shall be as given in Table 5.

6.6.3.3 Hard shoulders: Where bitumen emulsion is to be used on the surface dressing of impervious hard shoulders, class CRS-2 shall be used. Where the dressing is expected merely to carry isolated vehicles in emergencies, rates of application shall be as given in Table 6.

NOTE: If the dressing is needed to provide a new skid resistant surfacing for use by heavy traffic during motor way maintenance work, the chippings size and rate of application of CRS-2 emulsion shall be in accordance with Table 5.

Where delays are expected between applying the dressing and the passage of traffic, the appropriate rates of spread given in Table 8 shall be increased by 0.2 L/m2 to ensure retention of chippings during the untrafficked period.

Table 5 — Target rate of application for lane traffic categories 4 and 5 (cold emulsion)

Type of surface	Lane traffic category			
	4		5	
	Nominal size of chippings mm	Emulsion rate L/m^2	Nominal size of chippings mm	Emulsion rate L/m^2
Very hard	Double dressing recommended *			
Hard	6	1.5	6	1.6
Normal	10	1.5	6	1.5
Soft	14	1.5	10	1.5
Very Soft	14	1.4	10	1.4

6.6.3.4 When bulk spraying distributors are used, rates of spread of binder shall not vary by more than ± 10 per cent of the target figure. When hand spraying, a wider variation can be expected.

Target rates of emulsion application shall be increased in the following circumstances:

(a) When using gravel aggregate: by 0.1 L/m2;

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(b) On porous or rough surfacing: by 0.2 L/m2;

6.6.3.5 When both conditions apply, the increase shall be 0.3 L/m2. The use of gravel aggregates larger than 10 mm is not recommended.

Pedestrian and slow moving traffic areas such as paths, drives, car-parks, etc., shall be dressed with 6 mm or smaller chippings as normal surfaces, lane traffic category 5.

Table 6 — Target rates of application for lane traffic categories 2,3,4 and 5 (CRS-2 emulsion applied hot)

Type of Surface	Lane traffic category							
	2		3		4		5	
	Nominal size of chippings mm	Emulsion rate l/m^2	Nominal size of chippings mm	Emulsion rate l/m^2	Nominal size of chippings mm	Emulsion rate l/m^2	Nominal size of chippings mm	Emulsion rate l/m^2
Very hard	Not recommended		6	1.3	6	1.5	6	1.6
Hard	14	1.5[2]	10	1.3	6	1.3	6	1.4
Norminal	14	1.4[2]	10	1.3	10	1.3	6	1.3
Soft	20[1]	1.3	14	1.2	14	1.3	10	1.3
Very soft	Not suitable for surface dressing		20*	1.2	14	1.2	10	1.2

[1] Surface dressing in these conditions is not recommended but at the discretion of the engineer, 20 mm chippings may be used where traffic speeds are low.

[2] Further evidence is being sought for successful use of CRS-2 emulsion in these categories.

Table 7 — Target rates of application of CRS-2 emulsion for impervious

Type of chippings	Nominal size of chippings mm	Emulsion rate L/m^2
Crushed rock and slag aggregate	10 6	1.6 1.4
Crushed gravel	10 6	1.8 1.6

6.6.4 Treatment of Surfaces Requiring Pre-treatment

6.6.4.1 Sealing Open Textured Coated Macadam: When surface dressing open textured macadam, it is essential that excessive penetration of the emulsion is prevented by first brushing in clean chippings (6 mm maximum), sand or fine coated macadam used in just sufficient quantity to fill the surface interstices. The chippings or fine coated macadam shall be rolled in and emulsion applied, followed by 10 mm or 6 mm

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chipping but using approximately 0.2 L/m2 more emulsion than the appropriate recommendation given in Table 5 (cold) or Table 9 (hot) (0.3 L/m2) when gravel chippings are used.

It is usually desirable to give a second surface dressing, using 14 mm or 10 mm chippings and emulsion applied according to the recommendations given in Table 8 (cold) or Table 9 (hot) for the appropriate lane traffic category. The second surface dressing shall not be applied until the first has had sufficient time at least 2 hours to settle down to become a stable wearing surface.

6.6.4.2 Concrete and other Very Hard Surfaces: Because of the nature of these surfaces, it is necessary to treat them in two stages. First, the surface shall be cleaned and emulsion applied either at the rate of 1.4 L/m2 and then covered with 6 mm chippings or at the rate of 1.0 L/m2 and then covered with 3 mm chippings.

Secondly, the normal surface dressing treatment shall be carried out using 10 mm or 6 mm chippings as appropriate.

It is recommended that chippings known to have good adhesion to bitumen shall be used e.g. limestone.

6.6.4.3 Other Surfaces: Recommendations for surface treatment of other surfaces shall be obtained from the manufacturers of emulsions.

6.7 Formation — Sub-base and base sealing

6.7.1 General

This clause covers the surface application of emulsions to freshly cut or placed formation and/or freshly cut or placed formation and/or freshly laid sub-bases, with the object of retaining the volume and strength by maintaining the moisture equilibrum or curing of cement bound materials. The dual role of the emulsion is to prevent evaporation in dry weather and the ingress of water in wet weather.

6.7.2 Treatment of Cement Bound Sub-bases and Bases

Sub-bases and bases such as cement stabilized soil, lean mix concrete or others which contain cement shall be covered within 1 hour of laying, using Class RS-1RS-1, RS-1RS-1, CRS-1 or CRS-1/CRS-1H emulsion at a rate dependent on the class of emulsion and the nature of the surface being treated. The cationic grades are particularly suitable in conditions of low temperatures and high humidity.

6.7.3 Treatment of Non-Cement Bound Sub-bases and Bases

6.7.2.1 Time of Application — Fresh formation, granular sub-base and base materials such as wet-mix macadam shall be sprayed as directed by the engineer.

6.7.2.2 Emulsion — The emulsion used for this work shall be Class RS-2, RS-1RS-1, CRS-1/CRS-1H or CRS-2, applied at 0.9 L/m2 directly on the formation and allowed to break. When a period of wet weather is

encountered or in the situation where there is little or no evaporation, it is advisable to use Class CRS-1/CRS-1H or CRS-2. Where the surface is not being surface dressed, the rate of emulsion application shall be increased by 0.4 L/m2 for Class RS-2, RS-1RS-1 or CRS-1/CRS-1H and by 0.2 L/m2 for Class CRS-2.

6.7.4 Surface Dressing

If the sealed surface, sub-base or base is required to be surface dressed, it shall be given a second application of emulsion within 2 to 3 days of the first spray and at the same rate of spread. This second spray shall be covered with 6 mm chippings at 6 kg/m2 to 8 kg/m2 (see Clause 7).

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6.8 Grouting

6.8.1 General

This clause covers the preparation of a surfacing from 50 mm to 75 mm thick in one course or up to 100 mm thick in two courses, as may be specified, by the application of emulsion into the interstices of mineral aggregates after the latter have been spread on the foundation.

The emulsion shall be Class RS-2, RS-1RS-1 or CRS-1/CRS-1H, Class RS-2 or CRS-1/CRS-1H is preferable when compacted stone layer is usually open or wet. Class CRS-2 may be used as an alternative material.

9.1.1 Preparation of Base — Clean sand or quarry fines shall normally be laid upon the prepared foundation to a depth not exceeding 13 mm. For scarified surfaces this preparation may be omitted.

Satisfactory foundations and drainage are presupposed.

9.1.2 Aggregates — Any clean, angular, but not necessarily dry, aggregate can be used, provided that it has sufficiently high crushing strength with regard to the traffic to be carried. The grading shall be selected with reference to the character of the aggregate to be used and the depth of the compacted layer of layers; for example, suitable gradings would be:

(a) For a 50 mm compacted thickness:

60 per of 40 mm nominal single-sized material; 30 per cent of 28 mm nominal single-sized material; 10 per cent 14 mm to 20 mm nominal single-size.

(b) For a 65 mm to 75 mm compacted thickness:

60 per of 50 mm nominal single-sized material;

30 per cent of 40 mm nominal single-sized material; 10 per cent 14 mm to 20 mm nominal single-sized material.

It is important to ensure that the various sizes are thoroughly mixed. Alternatively, the 14 mm to 20 mm material may be spread over the larger material after the latter has been placed in position and vibrated into the interstices.

6.8.2 Spreading and Compacting the Aggregate

6.8.2.1 General

For a finished thickness up to 75 mm, the aggregate shall be spread to the required contour and to such a thickness that, after being compacted by rolling, its minimum thickness is not less than specified.

6.8.2.2 Hand Spreading

Preferably, each load of aggregate shall be unloaded outside the area upon which it is to be spread and every precaution shall be taken to prevent the aggregate becoming contaminated with dust or foreign matter during all of the operations. The spreading shall be carried out with shovels and not forks, care being taken to avoid segregation of the different sizes of aggregate.

6.8.2.3 Mechanical Spreading

Alternatively, the aggregate may be spread by mechanical means such as a spreader box. It is advisable to spread the coarse aggregate first and to superimpose 14 mm to 20 mm material as a separate operation.

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6.8.2.4 Rolling

The rolling shall be carried out with a roller of mass 6 t to 10 t or such other mass as may be approved by the purchaser or his representative. Longitudinal rolling shall progress from the sides towards the centre of the road. The rolling shall be continued until there is no appreciable movement of the aggregate under the roller. If necessary, to achieve this result further 14 mm to 20 mm chippings may be applied to the surface as required.

In the case of semi-grouted work, the minimum quantity of water shall be applied during rolling to bring up a slurry evenly in the aggregate within such a depth of the surface of the road as may be specified. It is preferable that the lower or slurried layer, which is thus waterbound, shall not exceed two-thirds of the total thickness of the compacted thickness of the surfacing.

6.8.3 Application of Emulsion

6.8.3.1 Rate of Application

For a full grout, the quantity of emulsion shall be sufficient to coat the aggregate of the full depth of the course, it is an advantage to apply the emulsion in two stages. For semi-grouted work, the quantity of emulsion used shall be sufficient to coat the aggregate to full depth of the layer above the slurried or waterbound layer (see Table 8).

Table 8 — Typical rates of application for grouting

Thickness of course mm	Full grout L/m^2	Semi-grout L/m^2
50	5.5 to 7.0	3.0 to 5.5
65	7.0 to 9.5	4.0 to 7.0
75	9.5 to 11	5.5 to 8.0

6.8.3.2 Procedure

As soon as the emulsion has been applied, clean 6 mm or 10 mm chippings shall be spread uniformly over the surface in sufficient quantity to fill up all the surface interstices, but not in excess of this. The surfaces shall then be rolled again.

Shall have finished thickness of over 75 mm be specified, the aggregate shall be spread, compacted and grouted with emulsion in two separate layers. The bottom, or first, layer shall not have a thickness less than the top, or second, layer and the size of the aggregate shall be appropriate to the thickness of each layer. The first layer of aggregates shall be compacted and grouted as in the case of single course work, except that, after grouting, chippings shall not be applied to fill the surface interstices.

The second layer of aggregate shall be spread immediately after grouting of the first course has been completed, and chippings shall then be applied, grouted, and rolled as in the case of single course work

6.8.3.3 Joints

The end of each day's work shall be finished by laying and rolling a feathered edge not less than 300 mm in width. This shall be cut back to well compacted material and shall have a clean vertical face before further laying-up to its proceeds. Similarly, when surfacing in half-widths, longitudinal joints shall be feathered off and subsequently cut back to a clean vertical face immediately before laying the second half-width. Areas inaccessible to the roller shall be thoroughly compacted by tampers.

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6.8.3.4 Surface Dressing

After an agreed interval, the surface shall be swept, and a surface dressing of emulsion and 14 mm or 10 mm chippings applied according to previous recommendations (see Clause 6.6); the purpose of this surface dressing is to seal the surface.

6.9 Retreading

6.9.1 General

This clause covers a method of reconstituting old, waterbound macadam, coated macadam and grouting and surface dressed roads which involves the minimum quantity of new materials.

The emulsion shall be Class CMS; the degree of stability required depends upon the grading and type of surface to be treated. The manufacturer of the emulsion shall be consulted before undertaking any retread work so that the correct class of emulsion may be supplied.

6.9.2 Preparation of Surface

The existing surface shall be scarified, for example by tines fitted to an ordinary road roller of mass 8 t to 10 t, to a depth of approximately 75 mm.

It is essential that the material to be used shall be broken down to less than 75 mm in size. If it has not been reduced to the desired size by the initial scarifying, this can often be effected by harrowing. Any larger lumps of coated macadam or stone shall be broken down by other means or rejected. It is also necessary to make up depressions or places deficient in aggregate with fresh stone graded 40 mm to 14 mm. Any fresh aggregate required shall be added at this stage and mixed with existing materials by means of cultivators, harrows or other suitable equipment.

Any necessary reshaping shall then be carried out either by hand or mechanically with a blade grader.

6.9.3 Application of Emulsion

The total rate of application shall usually be 5.5 L/m2 to 8.0 L/m2. it is generally necessary to apply the emulsion in two or more applications and to mix it with the aggregate by harrows or other means after each application except the last. If there is any doubt regarding the number of applications which shall be applied the emulsion supplier shall be consulted.

Mixing shall not be more than necessary to distribute the emulsion; excessive mixing may cause premature breakdown and bring to the surface too high a proportion of the larger sized stones.

6.9.4 Reshapping and Sealing

After any reshaping necessary to restore any loss of profile caused by the mixing operations, the surface shall be rolled immediately. Preferably with a roller of mass 8 t to 10 t; one passage with the roller followed by back-rolling next day, is normally adequate. If desired, chippings may be lightly scattered on the surface prior to rolling to help fill any voids and to prevent the binder from sticking to the roller; watering of the roller for this purpose shall be kept to a minimum. Chippings ranging from 14 mm to 3 mm may be used according to the texture of the surface. If the surface is still too open textured after the first passage of the roller, further chippings, preferably 10 mm or 6 mm, may be applied after spraying the surface lightly with Class RS-2, RS-1RS-1, CRS-1/CRS-1H or K170 emulsion at a rate of application of 0.7 L/m2 to 0.9 L/m2.

6.9.5 Surface Dressing

After a period, which may vary from a few days to a few weeks, depending on weather conditions, traffic, etc., the retreaded surface shall be surface dressed with class RS-2, A155, CRS-1/CRS-1H or CRS-2 emulsion and covered with 6 mm or 10 mm chippings (see Clause

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7). The rate of application of the emulsion shall be increased by approximately 0.2 L/m2 over the appropriate recommendation for hard surface given in Tables 3 and 4. 6.10 Premixing

6.10.1 General

This covers the production of bitumen coated macadam which are laid immediately after mixing and while the emulsion is still substantially in an unbroken state. Emulsions of sufficient stability for mixing with the particular graded aggregate shall be used.

Satisfactory foundations and drainage are presupposed.

6.10.2 Materials

6.10.2.1 Emulsion: The emulsion used for this work shall be Class MS-1 or CMS though under some circumstances, e.g for 6 mm nominal size wearing course and especially for fine coated macadam, CSS-1H/CMS-2 my be necessary. The degree of stability required depends upon the grading and type of aggregate to be treated.

For mixing coarse graded aggregate, it is necessary for the viscosity of the emulsion to be sufficiently high to ensure that no undue draining away of the emulsion occurs during and after mixing, and that an adequate film of bitumen is deposited on the stone. For fine graded aggregate, and emulsion of lower viscosity is required in order to ensure an adequate coating with bitumen of the fine particles of the aggregate, and for this purpose it may be necessary to add a suitable proportion of water.

The manufacturer of the emulsion shall be consulted so that the correct grade of emulsion may be supplied.

6.10.2.2 Aggregate: Any normal, clean, but not necessarily dry, aggregate can used, provided that it has a sufficiently high crushing strength with regard to the traffic to be carried. Typical gradings for coarse and fine aggregates are given in Table 9 to 13.

6.10.3 Mixing

Mixers may be either:

(a) Rotary drum type concrete mixers; or

(b) Single or twin shaft concrete or macadam mixers.

The appropriate emulsion shall be added to the mixer in the approximate amounts shown in Table 9 to 13.

If additional water is required with fine graded aggregates it shall be added either to the aggregate or preferably to the emulsion prior to mixing.

It is essential that the time of mixing be carefully controlled and over-mixing avoided because this will result in stripping of the bitumen film. For the aggregates used, water content shall be determined.

6.10.4 Laying

The mixed material shall be spread to the required contour immediately after preparation and lightly rolled. It shall then be allowed to set for a few hours depending upon the drying conditions, after which final compaction may be effected. A suitable roller for this purpose shall be of mass 6 t to 8 t.

Table 9 — Typical mixtures (Nominal size 40 mm, single course macadam)

Test sieve complying with ISO 3310-1	Aggregate: crushed rock. Percentage by mass passing

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50 mm	100
37.5 mm	90 to 100
28 mm	55 to 90
14 mm	35 to 55
6.3 mm	20 to 30
3.35 mm 300 µm	10 to 20
75 µm	2 to 10

NOTE For 40 mm nominal size single course macadam, use 55 L to 70 L of emulsion per tonne of aggregate.

Table 10 — Typical mixtures (Nominal size 40 mm, open textured base course macadam)

Test sieve complying with ISO 3310-1	Crushed rock percentage by mass passing
50 mm	100
37.5 mm	90 to 100
28 mm	55 to 85
14 mm	15 to 35
3.35 mm	0 to 10

NOTE: For 40 mm nominal size open textured base course macadam, use 45 L to 65 L of emulsion per tonne of aggregate.

Table 11 — Typical mixtures (Nominal size 14 mm, open textured wearing course macadam)

Test sieve complying with ISO 3310-1	Aggregate: crushed rock. Percentage by mass passing
20 mm	100
14 mm	90 to 100
10 mm	55 to 75
6.3 mm	25 to 45
3.35 mm 75 µm	15 to 25 2 to 6

NOTE: For 14 mm nominal size open textured wearing course macadam, use 70 L to 90 L of emulsion per tonne of aggregate.

Table 12 — Typical mixtures (Nominal size 6 mm, medium textured wearing course macadama)

Test sieve complying with ISO 3310-1	Aggregate: crushed rock. Percentage by mass passing
10 mm	100
6.3 mm	90 to 100
3.35 mm	45 to 65
1.18 mm	10 to 30

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75 μm	2 to 8

NOTE: For 6 mm nominal size open textured wearing course macadam, use 85 L to 100 L of emulsion per tonne of aggregate.

Table 13 — Typical mixtures (Fine coated macadam)

Test sieve complying with ISO 3310-1	Aggregate: crushed rock. Percentage by mass passing
6.3 mm	100
2.36 mm	75 to 100
600 μm	30 to 55
150 μm	10 to 25
75 μm	5 to 15

NOTE For fine coated macadam, 100 L to 120 L of emulsion per tonne of aggregate is normally used; with coarser grading, the emulsion may sometimes be reduced to 80 L/t and with finer grading or more rugous aggregates, e.g blast-furnace slag, the emulsion may be increased up to 135 L/t.

For fine coated macadam, up to 70 L of water per tonne of aggregate depending on the type, grading and natural water content of the aggregate.

6.10.5 Surface Dressing

After a few weeks, open-texture surfaces shall be sealed by surface dressing with Class RS-2, RS-1RS-1, CRS-1/CRS-1H or CRS-2 emulsion and covered with 10 mm chippings (see Clause 7). The rate of application of the emulsion shall be that normally used for 14 mm chippings (see Tables 3 and 4). Finer graded materials, such as the 6 mm wearing courses or fine coated macadam, do not normally require surface dressing.

6.11 Coated stone

6.11.1 General

This clause covers the production of coated macadam having a shiny coating of bitumen similar to hot coated material. It differs from premixed materials (see Clause 6.10) which are laid immediately after mixing and while the emulsion is still substantially in an unbroken state. The coated stone may be stockpiled for a period before laying and is particularly suitable for such work as trench reinstatement and remedial patching.

6.11.2 Materials

6.11.2.1 Emulsion: The emulsion used for this work shall be Class CMS, CSS-1H/CMS-2 or modified MS-1, depending on the activity of the aggregate to be coated and the amount of fines present. It is not normally necessary to add water to the mix. The manufacturer shall be fully consulted so that the correct grade of emulsion to produce a coating on the particular stone may be supplied.

6.11.2.2 Aggregate — A large range of aggregates can be used but not all stone is suitable for coating by this process. Aggregates need not be dry but excessive moisture and/or fines may prevent coating or cause stripping. Grading given in Table 9 to 13 are normally suitable, provided that the fraction passing 75 μm is below 5 per cent in all cases.

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6.11.3 Mixing

Mixing shall be carried out as in 11.3, except that addition of water to the emulsion is normally unnecessary. Mixing time shall be kept to a minimum, coating is usually achieved in 15 s to 25 s. Longer mixing may lead to stripping.

6.11.4 Laying

Freshly prepared coated material or that obtained from a stockpile shall be spread to contour and compacted. A suitable roller shall be of mass 6 t to 8 t. For reinstatement work, coated stone shall be laid as required and compacted by any suitable means. Convex patching is done to allow for subsequent compaction.

6.12 Fog spraying

6.12.1 General

This clause covers the treatment of road surfaces showing signs of fretting or incipient disintegration. The life of such a surface may often be prolonged without detriment to the non-skin and riding qualities of the road by the application of a light dressing of low viscosity emulsion.

6.12.2 Emulsion

The emulsion used for this work shall be either class RS-1RS-1 or CRS-1. Because of the low viscosity of these emulsions, it is important that they shall be used as soon as possible after delivery. If this has not been possible, the drums shall be very thoroughly rolled before use.

The emulsion shall be sprayed at the rate of 0.40 L/m2 to 0.45 L/m2. It is essential that the emulsion shall be evenly sprayed so as to avoid ponding in the hollows, since this may lead to local fatting-up of any subsequently applied carpet.

The emulsion shall be allowed to set before blinding (see 6.12.3).

NOTE Other grades of emulsions may be used provided suitable adjustments are made in consultation with the manufacturer.

6.12.3 Blinding

After the emulsion has started to break, it is recommended that there shall be a light dressing of bitumen coated grit, 3 mm to dust aggregate, with not more than 10 per cent passing a 75 µm sieve complying with ISO 3310-1 and binder content not exceeding 3.5 per cent. The rate of application shall be 2.5 kg/m2 to 5 kg/m2 according to the texture of the surface. Richly coated grit shall be avoided since it cannot be spread uniformly by mechanical gritter and may not work into the carpet satisfactorily.

NOT When the rate of application for bitumen coated grit is at 5 kg/m2, it is advisable to increase the rate of application of the emulsion to 0.55 L/m2 to 0.7 L/m2 to, preferably employing Class CRS-1 emulsion.

6.13 Tack coating

6.13.1 General

This clause covers the provision of an adhesive film between a coated macadam or other carpet and the surface on which it is laid.

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6.13.2 Emulsion

The emulsion used for this work shall be either Class RS-1RS-1 or CRS-1, RS-1RS-1, RS-2, K160.

Because of the low viscosity of these emulsions, it is important that they shall be used as soon as possible after delivery. If this has not been possible, the drums shall be very thoroughly rolled before use.

The emulsion shall be evenly sprayed so as to avoid ponding in the hollows, since this may lead to local fatting up of the subsequently applied carpet. The rate of application shall generally be between 0.3 L/m2 and 0.5 L/m2 but the actual rate of applications shall be decided for each job after consideration of the individual circumstances of use. For example, the lower rate is appropriate for a dense substrate and the higher rate for a rugous substrate. A lower rate of application than 0.3 L/m2 will possibly be necessary for a tack coat applied prior to slurry sealing, whilst a heavier rate of spread than 0.5 L/m2 might be considered necessary for some concrete substrate. Higher binder content emulsions require suitable adjustments to allow for the given rate of application. The emulsion shall break completely before starting to lay the carpet.

6.13.3 Gritting

The emulsion applied as in 6.13.2 may be covered with a very light scattering of bitumen coated grit as in 6.12.3, or fine coated macadam, to prevent picking up.

6.14 Curing of pavement quality concrete

6.14.1 General

This clause covers the use of emulsion as a convenient and effective method for curing concrete.

6.14.2 Emulsion

The emulsion shall normally be Class RS-1RS-1 or CRS-1. Within 1 h of being laid, the concrete shall be given a coating of emulsion at the rate of 0.5 L/m2 to 0.9 L/m2 followed soon afterwards by the application of sand or other small grit. The road may be opened to traffic as soon as the concrete has attained the required strength.

NOTE Other emulsions such as RS-1RS-1, RS-2, CRS-1/CRS-1H may be used provided quantities are adjusted accordingly.

6.15 Slurry sealing

6.15.1 General

This Clause covers a process for treating airfield and road surfaces by applying a slurry composed of fine aggregate and bitumen emulsion which seals cracks, arrests fretting and fills voids and minor depressions to provide a more even riding surface or a base for further treatment, e.g surface dressing, thin carpet coat or friction courses. It does not cover propnetary premixed material and advice on the use of such material shall be obtained from the supplier.

6.15.2 Materials

6.15.2.1 Emulsion — For the production of slurry which, on laying develops early resistance to traffic and rain, the emulsion shall be Class A4 rapid setting or Class CSS-1H/CMS-2.

For less rapid setting slurry, the emulsion shall be Class A4 slow setting.

6.15.2.2 Additives — it is usual to use ordinary portland cement, hydrated lime or other additives to control consistency, mix segregation and setting rate. It is advisable to consult the manufacturer of the emulsions who can advise on this point.

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6.15.2.3 Aggregate — It is essential that aggregates shall be laboratory tested to determine their suitability for the process both as regards compatibility with the emulsion and compliance with the wet track abrasion test in Annex B. When tested in accordance with Annex B, the loss in mass on the specimen shall not exceed 500 g/m2.

Requirements for aggregate grading are given in Table 14.

6.15.2.4 Water — If water is to be used for controlling the consistency of slurry it shall be clean and free from deleterious materials.

TABLE 14 — Grading of aggregate for slurry sealing

Test sieve complying with ISO 3310-1	Finished thickness of sealing	
	Nominal 3 mm	Nominal 1.5 mm
	Percentage by mass passing	Percentage by mass passing
5.0 mm	100	100
3.35 mm	80 to 100	100
2.36 mm	75 to 100	95 to 100
1.18 mm	55 to 90	70 to 95
600 μm	35 to 70	55 to 75
300 μm	20 to 45	30 to 50
150 μm	10 to 25	10 to 30
75 μm	5 to 15	5 to 15

6.15.3 Mixing and Laying

Techniques vary according to the type of emulsion used, as follows:

a) For class A4 slow setting emulsion, mixing may be by hand, concrete mixer or other effective mixer.

   For larger areas, a bulk transit concrete mixture my be used into which the ingredients (including water) are measured and mixed as the mixer travels to the area to be treated. A screed box fitted with an adjustable rubber screed shall be towed by the mixer which feeds it during laying.

   Alternatively, a special mobile mixing machine as prescribed in (b) may be used.

b) For Class A4 rapid setting and CSS-1H/CMS-2 emulsions, only special mobile mixing machines shall be used. These carry supplies of aggregate, emulsion, water and filler (e.g. ordinary portland cement or hydrated lime) and are fitted with metering devices to feed the ingredients in their correct proportions to a mixer fitted to the rear of the machine. From the mixer the slurry is fed into the screed box towed by the machine.

c) The appropriate dosage of emulsion, water and filler shall be determined by laboratory examination of aggregate. In the case of Class CSS-1H/CMS-2 emulsion, the necessary dosage of prewetting solution, if used, shall also be determined and this dosage shall be sprayed on the aggregate feed in its passage through the machine to the mixing compartment. Site variations, in particular temperature variations, may require adjustment to the dosage of water or prewetting agent.

   The amount of emulsion used shall be 180 L/m2 to 250 L/m2 of dry aggregate.

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d) In some cases, the use of a cationic tack coat, Class CRS-1, is recommended before laying the slurry. The machines shall be equipped to give a light spray of water on to the tack coat film just before the slurry is spread.

e) The manufacturer of the emulsion shall be consulted on the desirability of rolling and also of tack coating. Where rolling is required, a pneumatic-tyred roller shall be used after the material has set sufficiently.

6.16 Miscellaneous uses

6.16.1 This clause covers uses of emulsions which may be of interest to the road engineer in connection with road construction and similar work but not necessarily a ppertaining to the trafficked surface.

6.16.2 In most cases, the emulsions used are those specified in Clause 4 but in some cases they may be modified by additions such as rubber latex or may incorporate harder bitumen.

6.16.3 As conditions vary considerably from site to site, it is recommended that the user consult the emulsion manufacturer who will advise on the most suitable method and grade of emulsion for carrying out work on a particular site.

6.16.4 Miscellaneous uses include the following:

a) **Grass growing:** The use of emulsion, usually in conjunction with a layer of sand, to assist germination of seed, and particularly on slopes to protect the surface from erosion and denudation until a sufficient grass root system to stabilize the surface has been established. Slow setting types of emulsions are used;

b) **Blowing sand stabilization:** The use of emulsion, give 25 mm to 50 mm depth of lightly stabilized surface on dunes and other areas where blowing sand creates problems. The treatment may be carried out in conjuction with the establishment of trees and other vegetation. Medium setting emulsions e.g MS-1 may be used;

c) **Slip-coat:** The use of emulsion to create a membrane of bitumen between layers of concrete. This retains the strength of the upper layer by preventing water seepage into the lower layer, and avoids rigid adhesion between layers of different ages and strengths so that they mature without setting up internal stresses;

d) **Butt-joint priming:** The use of emulsion to prime the surface of butt joints between bituminous or other materials;

e) **Protection:** The use of emulsion for the protection of exposed or buried concrete and iron work, chiefly against sulphate attack and corrosion. Emulsion incorporating rubber latex is normally used;

f) **Crack filling:** The use of emulsion containing rubber latex for penetrating cracks in asphalt and concrete surfaces and filling with an elastic resilient sealant;

g) **Water seepage sealing:** The use of emulsion to reduce or eliminate seepage of water through hair cracks in concrete ‘lakes’ and to reduce seepage loss on concrete irrigation or drainage ditches, etc., passing over porous soil.

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Annex A
(normative)

Sample conditioning for testing

A.1 General

This practice describes how to prepare the emulsified bitumen samples for testing.

A.2 Significance and Use

Before performing the tests listed in this standard, the test samples must be conditioned to ensure that the emulsified bitumen is in its optimal state for determining its true properties. Failure to condition the test samples according to the requirements of this standard will result in a nonconforming test situation.

A.3 Apparatus

A.3.1. ***A thermometer,*** meeting the suitable range (see Table A.1) having a maximum scale error of 1.0°C (2.0°F).

A.3.2. ***Water Bath or Oven***, a vessel for heating or maintaining the temperature of the samples.

A.3.3. ***Stirring Rod***, a glass or metal rod for stirring the sample. Alternatively, a non-mercury thermometer may be used as the stirring rod.

Table A.1 — Conditioning Temperatures and Suitable Ranges for Thermometers

Initial Sample Temperature	Required Viscosity Temperature	Conditioning Temperature Adjustment	Maximum Bath or Oven Temperature	Minimum Thermometer Temperature Range
Below 21°C (70°F)	25°C (77°F)	Bring sample to at least 21°C (70°F)	74°C (165°F), if used	19 to 27°C (66 to 80°F)
Above 25°C (77°F)	25°C (77°F)	Cool sample to appropriate test temperature identified in the test section of this standard	N/A	19 to 27°C (66 to 80°F)
Below 50°C (122°F)	50°C (122°F)	Bring sample to at least 50°C (122°F)	74°C (165°F)	49 to 57°C (120 to 134°F) or 19 to 27°C (66 to 80°F)
Above 50°C (122°F)	50°C (122°F)	Cool sample to appropriate test temperature identified in the test section of this standard	N/A	49 to 57°C (120 to 134°F)

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A.4 Procedure:

A.4.1 Condition the sample to the appropriate temperature in Table 1 based on the initial temperature and the viscosity temperature of the sample as noted.

A.4.2 Stir the sample before testing.

NOTE 1 Stirring prematurely can damage the emulsion and possibly alter test results. Some higher viscosity emulsions may require periodic stirring after reaching 21°C (70°F).

NOTE 2 The container may be vented to relieve pressure.

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Annex B
(normative)

Wet track abrasion test

B.1 Apparatus

B.1.1 Mechanical mixer: of the planetary type, equipped with an abrasion head which has a rubber strip holding device with 10 mm to 15 mm free vertical movement and a mass of 2 200 g when loaded, so that approximately 1.4 g per mm2 is exerted on the specimen via the rubber strip.

The speed s_b of the beater shaft, to which the abrasion head is attached, and the speed s_p of the planetary arm in r/min, together with the planetary arm diameter d_p (i.e. twice the radius), shall be such that:

a) s_b and s_p are in opposing motions (i.e one clockwise, the other anticlockwise);

b) d_p is less than 125 mm;

c) $\pi 125 \times s_b + \pi d_p \times s_p$ equal between 7 x 104 and 9 x 104 mm/min.

B.1.2 Strips of rubber: having a hardness of 66 IRHD to 75 IRHD when tested. The strips shall be 125 mm long, 12.5 mm wide and at least 20 mm deep. The depth shall be sufficient to allow the strip to be clamped (along the full length of 125 mm) in the abrasion head and to leave a distance of 10 mm uncontained rubber above the 125 mm x 12.5 mm abrasion face.

B.13 Balance: of 2 000 g capacity, readable and accurate to 0.5 g.

A1.4 Flat bottom specimen pan — 300 mm to 330 mm to 330 mm diameter with 80 mm to 150 mm vertical side wall at least 1 mm thick, having a means of securing specimens to the bottom of the pan.

B.1.5 Forced draught constant temperature oven: thermostically controlled at 60 ± 3 °C.

B.1.6 Water bath: thermostatically controlled at 25 ± 1 °C.

B.1.7 Roofing felt: cut either into approximately 300 mm diameter circles or into octagons formed by cutting triangles from the corners of approximately 300 mm square of felt, so that the distance between each pair of opposite sides is approximately 300 mm.

B.1.8 Metal sheets: at least 300 mm square and 1 mm thick, resistant to water, oil, and be rust proof.

B.1.9 Squeegee blade: 300 mm to 350 mm long.

B.1.10 Mask of impervious rigid material: approximately 300 mm square, 6 mm thick with a circular opening 280 mm diameter in the centre.

B.1.11 Suitable mixing can: approximately 130 mm high and 120 mm diameter.

B.1.12 Suitable mixing rod: approximately 10 mm in diameter, fitted with a handle.

B.2 Preparation of test specimens

B.2.1 Prepare specimens in duplicate with each of the slurry mixtures selected after laying trial strips. If no trial strips are to be laid, make a series of duplicate specimens over the range of 180 L to 250 L of emulsion

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per tonne of dry aggregate. Include the amount of filler and any additive recommended by the emulsion manufacturer in these mixes. Find the water addition by trial as that amount necessary to produce, after stirring for at least 30 s, a fluid slurry which spreads readily without segregation.

B.2.2 To make the specimen, lay a metal sheet on a level, firm surface, place centrally on top of this a sheet of roofing felt, and complete the assembly by placing the mask centrally on the felt. Weigh 675 g of the aggregate into the mixing can followed by the filler, water and additive (if recommended). Stir for 20 s, add the emulsion and immediately stir vigorously for between 30 s and 60 s before pouring into the mask assembly while stirring. Spread the slurry immediately to provide an even surface with minimum use of a squeegee.

NOTE When samples from a continues slury mixer are to be examined, it is convenient to place the assembly of the metal sheet, felt and mast beside the road ahead of the machine, to take from the chute of the mixer a sample in the mixing can and to keep it vigorously stirred until it is poured.

B.2.3 Remove the mast from the specimen as soon as this can be done without flow taking place, then allow the specimen to drain and place it, still on the metal plate, in the oven to dry to constant mass. Drying overnight is normally sufficient for complete drying. Weigh the specimen with the metal plate.

B.3 Procedure

B.3.1 Place the specimen, without the metal plate, in the water bath for not less then 60 min and not more than 75 min.

B.3.2 Remove the specimen from the bath and fit it securely to the bottom of the pan. Fix the pan to a rigid platform with the rubber strip abrasion head in position at the mid-point of its free vertical movement centrally on the specimen completely. Then abrade the specimen for the time T minutes from the formula:

$$\frac{2.387(125 + d_p)^2}{100\, s_b + 0.8\, d_p \times s_p} = T$$

B.3.3 Remove the specimen from the pan, wash it free from loose particles, replace it on its metal and dry in the oven to constant mass.

B.3.4 Number the metal plates in a series so that they can be identified when replacing the specimens on them after the abrasion has been carried out.

NOTE In some cases, the roofing felt sticks to the metal plate during drying. This can be prevented by inserting sheets of silicone treated paper between the felt and the metal sheets before placing the specimens in the oven. This applies both to the initial drying and to the drying after abrading. When silicone paper is used, it shall be treated as part of the metal sheet and weighed as such, but it shall be removed from the base of the sample before placing it in the wash bath.

B.4 Calculation

$$\text{Loss in g/m}^2 = \frac{4(w_2 - w_1)}{\pi(d_p + 125)} \times 10^6$$

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where,

w_2 is the mass of steel sheet + felt + specimen before abrasion (in g);

w_1 is the mass of steel sheet + felt + specimen after abrasion (in g);

d_p is the planetary arm diameter (in mm).

B.5 Reporting of results

Report the loss in mass as the mass lost per square metre of abraded area to the nearest 1 g.

NOTES 1 The proportions of aggregate, filler, bitumen emulsion and water used to form each specimen. Express the amount of emulsion used as the number of litres per tone of dry aggregate.

NOTE 2 The texture, setting time, cohesion and particle segregation of the specimen during formation.

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Bibliography

[1] AASHTO R 5-17 Standard Practice for Selection and Use of Emulsified Asphalts

[2] AASHTO M 140-20 Standard Specification for Emulsified Asphalt

[3] KS 865: 1993 Code of practice for use of bitumen road emulsions

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