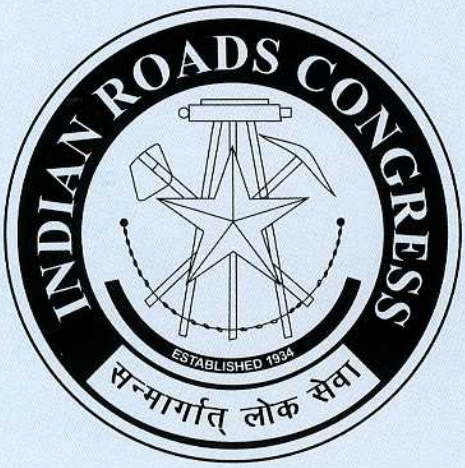
IRC:27-2009

SPECIFICATIONS
FOR
BITUMINOUS MACADAM
(FIRST REVISION)



INDIAN ROADS CONGRESS
2009

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Published by

INDIAN ROADS CONGRESS

Kama Koti Marg,
Sector 6, R.K. Puram,
New Delhi-110 022

2009

Price Rs.200/-
(Packing and Postage charges extra)

IRC:27-2009

First Published : November, 1967
Reprinted : March, 1977
Reprinted : August, 1989 (incorporate the seive sizes)
Reprinted : February, 2000
Reprinted : April, 2002
Reprinted : September, 2004
Reprinted : October, 2005
First Revision : June, 2009

Printed at India Offset Press, A-1, Mayapuri, New Delhi-110064
(500 copies)

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SPECIFICATION FOR BITUMINOUS MACADAM (FIRST REVISION)

1 INTRODUCTION

The Indian Roads Congress published the first specifications for Bituminous Macadam in the year 1967. The Flexible Pavement Committee (FPC) in its meeting held on 22nd April, 2006 decided to revise the specification to keep pace with the changes in the technology and improvements in the construction procedures as well as quality control expectations and authorized Shri R.K.Pandey to finalize the draft with technical input from Prof. P.S.Kandhal. The finalized draft was sent to all FPC members for comments. The FPC in its meeting on 9th September, 2006 discussed all comments in detail. The FPC in its meeting held on 5th May 2007 decided to publish the draft in Indian Highways to solicit comments from users at large.

Draft finalized by Prof. P. S. Kandhal was discussed by the Flexible Pavement Committee in its meeting held on 27th July, 2008 and authorized Convenor, Flexible Pavement Committee to modify the draft in the light of the discussions held and submit to the Highways Specifications and Standards (HSS) Committee. HSS Committee considered the draft in its fifth meeting held on 23rd November, 2008. Draft modified by the Convenor, HSS Committee was approved by the Executive Committee in its meeting held on 30th November, 2008, at New Delhi and by the Council in its meeting held on 13th December, 2008 at Kolkata subject to the incorporation of modifications keeping in view the comments of members and approval by the Convenor, Highways Specification and Standard Committee. The name of the Personnel of Flexible Pavement Committee (H-2) are given below:

Singh, Nirmal Jit	--	Convenor
Shukla, R.S.	--	Co-Convenor
Nirmal, S.K.	--	Member-Secretary

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Krishna, Prabhat	Director, HRS

2 SCOPE

2.1 This specification deals with the basic outline for the design, construction and controls needed while laying bituminous macadam course.

2.2 Bituminous Macadam (BM) shall consist of mineral aggregate and appropriate binder, mixed in a hot mix plant and laid with a mechanized paver. It is an open graded mixture suitable for base course. It is laid in a single course or in multiple layers on a previously prepared base. Thickness of the single layer shall be 50 mm to 100 mm.

2.3 Since the bituminous macadam is an open-graded mixture, there is a potential that it may trap water or moisture vapour within the pavement system. Therefore, adjacent layer should have proper drainage quality to prevent moisture-induced damage to the BM.

3 MATERIALS

3.1 Bitumen

3.1.1 The bitumen shall be viscosity graded paving bitumen complying with Indian Standard Specification for paving bitumen, IS:73. The grade of bitumen to be used would depend upon the climatic conditions and the traffic. Guidelines for selection of viscosity grade of paving grade bitumen are given in Tables 1 and 2.

3.1.2 Both the highest daily mean air temperature and the lowest daily mean air temperatures mentioned in Table 2 can be obtained for the weather station nearest to the project site from the Indian Meteorological Organization (IMO). The IMO has data on daily mean high temperature for all 365 days in a year for all weather stations based on historical records of the last 30-40 or more years. This daily mean high temperature on a specific day is the same as daily "normal" high temperature for that day as usually reported in some newspapers. The highest of the 365 daily

Table 1 Viscosity Graded (VG) Bitumen and their General Applications

Viscosity Grade (VG)	General Applications
VG-30 (50-60 penetration)	Use for paving in most of India in lieu of old 60/70 penetration grade
VG-20 (60-80 penetration)	Use in cold climatic, high altitude regions of North India
VG-10 (80-100 penetration)	Use in spraying applications and paving in very cold climatic region in lieu of old 80/100 penetration grade

Table 2 Selection Criteria for Viscosity-Graded (VG) Paving Bitumen Based on Climatic Conditions

Highest Daily Mean Air Temperature, °C

Lowest Daily Mean Air Temperature, °C	Less than 20°C	20 to 30°C	More than 30°C
More than −10°C	VG-10	VG-20	VG-30
-10°C or lower	VG-10	VG-10	VG-20

mean high air temperatures (which usually occurs on some day in May or June) is used in Table 2. Likewise, the lowest daily mean air temperature (which usually occurs on some day in January) can also be obtained from the IMO.

3.2 Coarse Aggregate

3.2.1 The coarse aggregate shall consist of crushed rock, crushed gravel or other hard material retained on 2.36 mm sieve. It shall be clean, hard, durable and cubical shape, free from dust and soft organic and other deleterious substances. The aggregate shall satisfy the physical requirements specified in Table 3.

3.2.2 Where crushed gravel is proposed for use as aggregate, not less than 90% by weight of the crushed material retained on 4.75 mm sieve shall have at least two fractured faces resulting from crushing operation.

Table 3 Physical Properties of Coarse Aggregate

Property	Test	Requirement	Test method
Cleanliness	Grain size analysis	Max. 5% passing 0.075 micron	IS: 2386 Part I
Particle shape	Flakiness & Elongation Index (combined)	Max. 40%	IS: 2386 Part I
Strength *	Los Angeles Abrasion Value	Max. 40%	IS: 2386 Part IV
	Aggregate Impact Value	Max. 30%	IS: 2386 Part IV
Durability	Soundness (Sodium or Magnesium), Sodium Sulphate	5 cycles Max. 12%	IS: 2386 Part V
	Magnesium Sulphate	Max. 18%	IS: 2386 Part V
Water absorption	Water absorption	Max. 2%	IS: 2386 Part III
Stripping	Coating and Stripping of Bitumen Aggregate	Min. Retained Coating 95%	IS: 6241
Water sensitivity	Retained Tensile strength**	Min 80%	ASHTO 283

Note:

* The coarse aggregate may satisfy either of the two strength tests.

** If the minimum retained tensile strength falls below 80%, use of anti-stripping agent is recommended to meet the minimum requirements.

3.3 Fine Aggregate

Fine aggregate shall consist of crushed or naturally occurring mineral material, or a combination of two, passing 2.36 mm sieve and retained on 75 micron sieve. It shall be clean, hard, durable, free from dust and soft organic and other deleterious substances. The amount of rounded, natural sand in the total fine aggregate shall be limited to 10 percent if the BM is used within 100 mm from the road surface and to 50 percent if the BM is used more than 100 mm below the road surface.

3.4 Aggregate Grading and Bitumen Content

3.4.1 The combined grading of the coarse aggregate and fine aggregate, when tested in accordance with IS 2386 Part 1, wet sieving method, shall conform to limits given in Table 4. The type and quantity of bitumen and appropriate thickness is also given in the Table 4.

3.4.2 The combined aggregate grading shall not vary from the lower limit on one sieve to the higher limit on the adjacent sieve to avoid gap grading. The aggregate may be proportioned and blended to produce a uniform mix complying with the requirements in Table 4.

Table 4 Aggregate Grading and Bitumen Content

Grading	1	2
Nominal maximum aggregate size*	40 mm	19 mm
Layer thickness	80–100 mm	50–75 mm
IS Sieve size (mm)	Cumulative % by weight of total aggregate passing	
45	100	
37.5	90–100	
26.5	75–100	100
19	–	90–100
13.2	35–61	56–88
4.75	13–22	16–36
2.36	4–19	4–19
0.3	2–10	2–10
0.075	0–8	0–8
Bitumen content **	3.3	3.4

* Nominal maximum aggregate size is the largest specified sieve size upon which any of the aggregate material is retained.

** Corresponds to specific gravity of the Aggregate being 2.7. In case aggregate have specific gravity more than 2.7, bitumen content can be reduced proportionately. Further, for regions where highest daily mean air temperature is 30°C or lower and lowest daily mean air temperature is –10°C or lower, the bitumen content may be increased by as much as 0.5 percent.

Tolerance of 0.3% by weight of mix is allowed to individual specimen taken up for quality control in accordance with Clause 5.

4 CONSTRUCTION

4.1 Preparation of Base

1. **Cleaning of the surface:** The surface shall be cleaned of all loose extraneous matter by means of mechanical broom, high-pressure air jet received from a compressor or any other approved equipment/method.

2. **Filling up of potholes and sealing of cracks:** Any potholes and/or cracks shall be repaired and sealed.

3. **Geosynthetics:** Depending upon the requirement, layer of geosynthetics shall be laid, if specified.

4. **Profile corrective course:** Depending upon site requirement, profile-corrective course for correcting the existing pavement profile shall be laid either as a separate layer or as a composite layer with varying thickness. Where the maximum thickness of the profile corrective course is less than 40 mm, the profile corrective course shall be laid as an integral part of the overlaying layer. In other cases, the profile corrective course shall be constructed as a separate layer. When it is laid as a separate layer, type of material for the use as the profile corrective course may differ.

5. **Prime Coat:** Prime Coat wherever required shall be as per IRC:16 "Standard Specification and Code of Practice for Prime and Tack Coat".

6. **Tack Coat:** Tack Coat shall be as per IRC:16 "Standard Specification and Code of Practice for Prime and Tack Coat".

4.2 Mixing

Bituminous macadam shall be prepared in a Hot Mix Plant (HMP) of adequate capacity and capable of yielding a mix of proper and uniform quality with thoroughly coated aggregate. Essential features for HMP are given in Annex A. The temperature range of bitumen and aggregate at the time of mixing for different grade and type of bitumen is given in Table 4. The difference in the temperature of aggregate and bitumen shall not exceed 15°C. In order to ensure uniform quality of mix the plant shall be calibrated from time to time.

4.3 Transportation

Bituminous material shall be transported in clean insulated covered vehicles. An asphalt release agent, such as, soap or limewater, which does not adversely affect the bituminous mix, may be applied to the interior of the vehicle to prevent sticking and to facilitate discharge of the material.

4.4 Laying

4.4.1 Weather and seasonal limitations: Bituminous macadam shall not be laid:

a) in presence of standing water on the surface,

b) when rain is imminent and during rains, fog or dust storm

c) when the base/binder course is damp,

d) when the air temperature on the surface on which it is to be laid is less than 10°C

e) When the wind speed at any temperature exceed the 40 km/h at 2 m height.

4.4.2 **Preparation of the base:** Base shall be prepared by carrying out all or some of the operations as per Clause 4.1, depending upon the site conditions.

4.4.3 **Spreading:** Except in areas where paver cannot have access, bituminous mixture shall be spread, leveled and tamped by self-propelled hydrostatic paver finisher preferably equipped with sensor. As soon as possible after arrival at site, the asphalt mix shall be supplied continuously to the paver and laid without delay. The rate of delivery of material to the paver shall be regulated to enable the paver to operate continuously. The travel rate of paver and the method of operation shall be adjusted to ensure even and uniform flow of bituminous material across the screed, free from dragging, tearing and segregation.

Restricted areas (such as confined space, footways, irregular shape and varying thickness, approaches to expansion joints etc.) where paver cannot be used, the material shall be spread, raked and leveled with suitable hand tool by trained staff.

When laying bituminous macadam near expansion joint, the machine laying shall be stopped about 300 mm short of joint. The remainder of the pavement up to the joint and the corresponding area beyond it shall be laid manually. The laying of bituminous macadam shall be completed before the mix temperature reaches the values specified in the Table 5.

Bituminous material, with temperature greater than 145°C shall not be laid or deposited on bridge deck, waterproofing system unless precautions against the heat damage have been taken.

Table 5 Mixing, Laying and Rolling Temperatures for Bituminous Macadam (Degree Celcius)

Bitumen Viscosity Grade	Bitumen Temperature	Aggregate Temperature	Mixed Material Temperature	Laying Temperature	*Rolling Temperature
VG-40	160-170	160-175	160-170	150 Min.	100 Min.
VG-30	150-165	150-170	150-165	140 Min.	90 Min.
VG-20	145-165	145-170	145-165	135 Min.	85 Min.
VG-10	140-160	140-165	140-160	130 Min.	80 Min.

*Rolling must be completed before the mat cools to these minimum temperatures

4.5 Compaction

4.5.1 Compaction shall commence as soon as possible after laying and shall be completed before the temperature falls below the range specified in Table 4. Rolling of the longitudinal joints shall be done immediately behind the paving operation. After this, the rolling shall commence at the edge and progress towards the center longitudinally except at sections with unidirectional camber, where it shall progress from lower edge to upper edge parallel to centerline of the pavement.

4.5.2 All deficiencies in the surface after laying shall be made good by the attendant behind the paver, before initial rolling is commenced. The initial or breakdown rolling shall be done with an 8 to 10 tonnes dead weight or vibratory steel wheel roller. The intermediate rolling shall be done with 8 to 10 tonnes dead weight or vibratory roller with an amplitude 0.3 mm to 0.8 mm and frequency between 30 to 50 hz. or with a pneumatic roller of 12 to 15 tonnes, with a tire pressure of at least 0.56 MPa. The finished rolling shall be done with 6 to 8 tonnes smooth wheel roller. Rolling shall continue until at least 98% of the lab density obtained in the Marshall mould made using approved gradation and bitumen content is achieved. The number of roller passes should be established on a control strip prior to starting the main work. The mixtures with a maximum aggregate size up to 25 mm shall be compacted in a 100 mm (4 inches) Marshall mould with 50 blows on each side. The mixtures with a maximum aggregate size of more than 25 mm shall be compacted in a 150 mm (6 inches) Marshall mould with 75 blows on each side in accordance with the Asphalt Institute MS-2 (Sixth Edition). For smaller works where no density is specified rolling shall continue until there is no further movement under roller.

4.5.3 The bitumen macadam shall be rolled in the longitudinal direction with the roller as close to the paver as possible. The overlap on successive passes should be at least one-third of the width of the rear roll or in the case of pneumatic wheeled rollers, at least the nominal width of 300 mm. The roller should move at a speed of no more than 5 km /hour. The roller shall not be permitted to stand on pavement, which has not been fully compacted. All precautions shall be taken to prevent dropping of oil, grease, petrol or other foreign material on the pavement. The wheel of the rollers shall be kept moist with the water or spray system provided with the machine to prevent the mixture from adhering to the wheels. Minimum moisture to prevent adhesion between wheels and mixture shall be used and surplus water shall not be allowed to stand on the partially completed pavement.

4.6 Joints

Where joints are made in bitumen macadam, the material shall be fully compacted and the joint made flush in one of the following ways:

a) All joints shall be cut vertical to the full thickness of the previously laid mix. All loosened material shall be discarded and the vertical face be coated with any viscosity grade bitumen, or cold applied emulsified bitumen. While spreading the material along the joint the material spread shall overlap 25 mm to 50 mm on the previously laid mix beyond the vertical face of the joint. The thickness of the loose overlap material should be approximately a quarter more than the final compacted thickness. The overlapped mix should be dragged back to the hot lane so that the roller can press the small excess into the hot side of the joint to obtain a high joint density.

b) By using two or more pavers in echelon, where this is practicable and in sufficient proximity for adjacent width to be fully compacted by continuous rolling.

In multi-layer construction the longitudinal joint in one layer shall offset the joint in the underneath layer by about 150 mm.

For transverse joints method a) above can apply. Transverse joints in the successive and adjoining layers should have a minimum offset of 2 m.

4.7 Arrangement for Traffic

It shall be ensured that the bituminous macadam surface is covered with the next pavement course within a maximum of 48 hours until which no traffic shall be applied. In case of delay, the course may be covered with the seal coat in accordance with the appropriate IRC Standard prior to opening to traffic.

5 CONTROLS

5.1 Surface Finish

5.1.1 The levels of the bituminous macadam shall not vary from those calculated with reference to longitudinal and cross profile of the roads as per the Contract beyond 6 mm.

5.1.2 For checking the compliance with the above requirement measurements of the surface level shall be taken on a grid of points spaced 6.25 m along the length and 0.5 m from the edges and at the centre of the pavement. The compliance shall be deemed to have been met for the final road surface only if the tolerance given above is satisfied for any point on the surface.

5.1.3 In case where surface levels fall outside the specified tolerance, the Contractor shall be liable to rectify these by replacing the full depth of layer. In all cases of replacement the area treated shall not be less than 5 m in length and not less than 3.5 m in width.

5.2 Surface Evenness

5.2.1 The measurement and checking of surface evenness shall be done by a 3 m straight edge in accordance with the procedure in IRC:SP:16.

5.2.2 The maximum permissible surface unevenness using longitudinal profile 3 m straight edge shall be 6 mm. The maximum permissible unevenness using transverse profile camber shall be 4 mm.

5.2.3 The maximum permissible frequency of surface unevenness in 300 m length in longitudinal profile shall be as per Table 6.

Table 6 Maximum Permissible Frequency of Unevenness

Maximum Number of Surface unevenness

Type of layer	Unevenness, mm	NH/SH	MDR and Lower Category
Bituminous Macadam	4–6	20	40

5.2.4 Where the surface unevenness falls outside the tolerance, the Contractor shall be liable to rectify these in the manner described below:

When surface is low the deficiency shall be corrected by adding fresh material after applying tack coat if needed and re-compacting to specification. When the surface is high, the full depth of the layer shall be removed and replaced with fresh material and compacted to the specification.

5.3 Quality Control During Construction

The material supplied and the work shall conform to the specifications prescribed in the preceding Clauses. To ensure the quality the material and the work shall be subjected to tests described hereunder. The tests and minimum frequency for each test is indicated in the Table 7.

Table 7 Control Tests for Bituminous Macadam Work and Their Minimum Frequency

S.No	Test	Frequency
1.	Quality of bituminous binder	As per number of samples and tests per lot specified in IS: 73
2.	Aggregate impact value/ Los Angles Abrasion value	One test per 350 m^3 of aggregate for each source and whenever there is change in the quality of aggregate
3.	Flakiness & Elongation Index	One test per 350 m^3 of aggregate for each source and whenever there is change in the quality of aggregate
4.	Soundness test (Sodium or Magnesium Sulphate test)	1 test for each source and whenever there is change in the quality of aggregate
5.	Water absorption of aggregate	1 test for each source and whenever there is change in the quality of aggregate
6.	Percent of fractured faces	When crushed gravel is used as aggregate one test per 350 m^3 of aggregate
7.	Mix grading	One set for individual constituent and mixed aggregate from dryer for each 400 tonnes of mix subject to minimum of two tests per day per plant
8.	Stripping (IS:6241)	1 test for each mix design and whenever there is change in the source or quality of coarse aggregate
9.	Water sensitivity	1 test for each mix design and whenever there is change in the source or quality of coarse aggregate
10.	Temperature of binder in boiler, aggregate in dryer and mix at the time of laying and compaction	At regular interval
11.	Binder content	One set for each 400 tonnes of mix subject to minimum of two tests per day per plant
12.	Rate of spread of mix material	At regular interval
13.	Density of compacted layer	One test per 700 m^2 area

5.4 Acceptance Criteria

The acceptance criteria for test on density (N=3) shall be subjected to the condition that the mean value of N samples is not less than the specified value plus [1.65 – 1.65/(No. of samples)$^{0.5}$] x standard deviation.

ANNEX A
(*Clause* 4.2)

Features of Hot Mix Plants & Pavers for Bituminous Construction:

Hot mix plant shall be of suitable capacity preferably of batch mix type. Total system for crushing of stone aggregates and feeding of aggregate fractions in required proportions to achieve the desired mix, must be capable of meeting the overall specification requirements under stringent quality control. The plant shall have the following essential features:

A General

a) The plant shall have a coordinated set of essential units capable of producing uniform mix as per the job mix formula.

b) Cold aggregate feed system with minimum 4 bins having belt conveyor arrangement for initial proportioning of aggregates from each bin in the required quantities. In order to have free flow of fines from the bin, bin should be fitted with vibrator to intermittently shake it.

c) Belt conveyers below each bin should have variable speed drive motors. There should be electronic load sensor on the main conveyer for measuring the flow of aggregates.

d) Dryer unit with burner capable of heating the aggregate to the required temperature without any visible unburnt fuel or carbon residue on the aggregate and reducing the moisture content of the aggregate to the specified minimum.

e) The plant shall be fitted with suitable type of thermometric instruments at appropriate places so as to indicate or record/register the temperature of heated aggregate, bitumen and mix.

f) Bitumen supply unit capable of heating, measuring/metering and spraying of bitumen at specific temperature with automatic synchronization of bitumen and aggregate feed in the required proportion.

g) A filler system suitable to receive bagged or bulk supply of filler material and its incorporation to the mix in the correct quantity wherever required.

h) A suitable built-in dust control system for the dryer to contain/recycle permissible fines into the mix. It should be capable of preventing the exhaust of fine dust into atmosphere for environmental control wherever so specified by the Engineer.

i) The plant should have centralized control panel/cabin capable of presetting, controlling/ synchronizing all operations stating from feeding of cold aggregates to the discharge of

ANNEX A
(Clause 4.2)

Features of Hot Mix Plants & Pavers for Bituminous Construction:

Hot mix plant shall be of suitable capacity preferably of batch mix type. Total system for crushing of stone aggregates and feeding of aggregate fractions in required proportions to achieve the desired mix, must be capable of meeting the overall specification requirements under stringent quality control. The plant shall have the following essential features:

A General

a) The plant shall have a coordinated set of essential units capable of producing uniform mix as per the job mix formula.

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c) Belt conveyers below each bin should have variable speed drive motors. There should be electronic load sensor on the main conveyer for measuring the flow of aggregates.

d) Dryer unit with burner capable of heating the aggregate to the required temperature without any visible unburnt fuel or carbon residue on the aggregate and reducing the moisture content of the aggregate to the specified minimum.

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h) A suitable built-in dust control system for the dryer to contain/recycle permissible fines into the mix. It should be capable of preventing the exhaust of fine dust into atmosphere for environmental control wherever so specified by the Engineer.

i) The plant should have centralized control panel/cabin capable of presetting, controlling/ synchronizing all operations stating from feeding of cold aggregates to the discharge of

the hot mix to ensure proper quality of mix. It should have indicators for any malfunctioning in the operation.

j) Every hot mix plant should be equipped with siren or horn so that the operator may use the same before starting the plant every time in the interest of safety of staff.

B For Batch Type Plant

i) Gradation control unit having minimum four decks vibratory screens for accurate sizing of hot aggregate and storing them in separate bins. This unit should be fully covered to reduce the maintenance cost and for better environmental condition.

ii) Proper arrangement for accurate weighing of each size of hot aggregate from the control panel before mixing.

iii) Paddle mixer unit shall be capable of producing a homogeneous mix with uniform coating of all particles of the mineral aggregate with binder.

C For Continuous Type Plant

i) Gradation control unit having vibratory screens for accurate sizing of hot aggregate and storing them in separate bins. This unit should be fully covered to reduce the maintenance cost and for better environmental condition.

ii) There should be appropriate arrangement for regulating and volumetric condition of the flow of hot aggregate from each bin to achieve the required proportioning.

iii) Paddle mixer unit shall be capable of producing a homogeneous mix with uniform coating of all particles of the mineral aggregate with binder.

D For Drum Mix Plant

i) It is a prerequisite that only properly screened and graded materials are fed to the bins. If required, a vibratory screening unit shall be installed at the plant site to ensure the same. A primary 4-deck vibratory screening unit shall be installed before the multiple bin cold feed system for screening the aggregates and grading the same.

ii) Belt conveyers below each bin should have variable speed drive motors. There should be electronic load sensor on the main conveyer for measuring the flow of aggregate.

iii) There should be arrangement to measure moisture content of the aggregate(s) so that moisture correction may be applied for working out requirements of binder and filler.

E Paver Finisher

The paver finisher shall have the following essential features:

a) Loading hoppers and suitable distributing mechanism.

b) All drives having hydrostatic drive/control.

c) The machine shall have a hydraulically extendable screed for appropriate with requirement.

d) The screed shall have tamping and vibrating arrangement for initial compaction to the layer as it is spread without rutting or otherwise marring the surface. It shall have adjustable amplitude and variable frequency.

e) The paver shall be equipped with necessary control mechanism so as to ensure that the finished surface is free from surface blemishes.

f) The paver shall be fitted with an electronic sensing device for automatic levelling and profile control within the specified tolerances.

g) The screed shall have an internal heating arrangement.

h) The paver shall be capable of laying either 2.5 to 4.0 m width or 4.0 to 7.0 m width as stipulated in the Contract.

i) The paver shall be so designed as to eliminate skidding/slippage of the tyres during operations.

(The Official amendments to this document would be published by the IRC in its periodical, 'Indian Highways' which shall be considered as effective and as part of the code/guidelines/manual, etc. from the date specified therein)