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STANDARD SPECIFICATIONS AND CODE OF PRACTICE FOR WATER BOUND MACADAM

(Third Revision)

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STANDARD SPECIFICATIONS AND CODE OF PRACTICE FOR WATER BOUND MACADAM

1. INTRODUCTION

1.1 This standard was originally published in 1966. The first revision of the standard was approved by the Specifications and Standards Committee in their meeting held on the 29th & 30th September, 1972, by the Executive Committee in their meeting held at Gandhinagar on the 25th November, 1972 and by the Council in their 79th meeting held at Gandhinagar on the 25th November, 1972 for publication. Following the decision of the IRC Council at its meeting held on the 28th August, 1976, the tolerance of surface evenness were revised on the basis of IRC Special Publication 16 "Surface Evenness of Highway Pavements" and the second revision of standard was published in May, 1977 which was further amended in March, 1987.

The decision to review and revise the code of practice was taken during meeting of Flexible Pavement Committee on 10th February, 2001. The task was assigned to Dr. P.K. Jain and K. Sitaramanjaneyulu, Scientists of Central Road Research Institute. The draft of the revised code was presented and discussed in the meeting of Flexible Pavement Committee held on 17th May, 2002 and it was decided that the draft document may be modified in the light of the comments of the members and sent to Convenor, Flexible Pavement Committee for forwarding to Highways Specifications & Standards (HSS) Committee. Dr. P.K. Jain, and Shri K. Sitaramanjaneyulu modified the document and forwarded to Convenor, Flexible Pavement Committee. The draft standard was reviewed by the Flexible Pavement Committee (constituted in January, 2003) in its meeting held on 1st August, 2003 and authorized a Group consisting of Shri S.C. Sharma, Shri K.K. Singal and Dr. P.K. Jain to finalise the document incorporating the suggestions of the members and forward the same to HSS Committee. The draft standard was finalised by the Group in its meeting held on 7th May, 2004 and then sent for consideration of HSS Committee.

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The draft document finalised by the Flexible Pavement Committee was considered by the Highways Specifications and Standards Committee in its meeting held on 10th December, 2004 and approved with certain modifications.

The Council in its 173rd meeting held on 8th January, 2005 at Bangalore approved the document for publication subject to modification in light of the comments/suggestions given by the participants. The document was modified suitably by Shri S.C. Sharma, Convenor, Flexible Pavement Committee and printed by IRC as Third Revision of IRC:19.

1.2. Symbols and Abbreviations

1.2.1 For the purpose of this Standard, the following symbols for SI units and abbreviations shall apply.

1.2.1.1 Symbols for SI Units

kN	kilo-newton
m	metre
mm	millimetre

1.2.1.2 Abbreviations

BS	British Standards
IRC	Indian Roads Congress
IS	Indian Standard by Bureau of Indian Standards
LL	Liquid Limit
PI	Plasticity Index
WBM	Water Bound Macadam

1.3. References

1.3.1 The following IRC, IS and BS standards contain provisions, which, through reference in the text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision and parties to agreements based on this standard are encouraged to investigate the possibility of applying

the most recent editions of the standard indicated below :

No.	Title
IRC:SP:16-2004	Guidelines for Surface Evenness of Highway Pavements *(First Revision)*
IS 460:Part 1 : 1985	Specification for test sieves: Part 1 cloth test sieves *(Third Revision)*
IS 460:Part 2 : 1985	Specification for test sieves: Part 2 Perforated plate test sieves *(Third Revision)*
IS 460:Part 3 : 1985	Specification for test sieves: Part 3 Methods of examination of apertures of test sieves *(Third Revision)*
IS 2386:Part 1-1963	Method of Test for Aggregates for Concrete – Part 1: Particle Size and Shape *(Reaffirmed 2002 Amds. 3)*
IS 2386:Part 3-1963	Method of Test for Aggregates for Concrete – Part 3: Specific gravity, density, voids, absorption and bulking *(Reaffirmed 2002)*
IS 2386:Part 4-19	Method of Test for Aggregates for Concrete – Part 4: .....
IS 2430:1986	Methods for Sampling of Aggregates for Concrete (First Revision) *(Reaffirmed 2000)*
IS 5640:1970	Method of test for determining aggregate impact value of soft coarse aggregates *(Reaffirmed 1998 Amds.1)*
IS 14685-1999	.....
BS 1047:1983	Specification for air-cooled blast furnace slag aggregate for use in construction (Replaced by EN 12620)

2. SCOPE

This Standard covers the specification for construction of Water Bound Macadam as Sub-base, Base Course and Surfacing Course of a road pavement.

2.1. Description

2.1.1 Water Bound Macadam (WBM) shall consist of clean, crushed coarse aggregates mechanically interlocked by rolling, and voids thereof filled with screening and binding material with the assistance of water, laid on a prepared subgrade, sub-base, base or existing pavement as the case may be. WBM may be used as a sub-base, base course or surfacing course depending upon category of road. In each case, it shall be constructed in accordance with the specifications given in this Code and in conformity with the lines, grades and cross-sections shown on the drawings or as directed.

2.1.2 The WBM shall not be laid on an existing bituminous top surface without scarifying or providing adequate measures for proper bond and drainage at the interface of existing bituminous surface and WBM layer.

2.1.3 WBM should not be laid directly over a silty or clayey subgrade. It is advisable to lay a suitable intervening granular layer.

3. MATERIALS

3.1. Coarse Aggregates - General Requirements

3.1.1 Coarse aggregates shall consist of clean crushed or broken stone, crushed slag, over burnt brick (Jhama) metal or naturally occurring aggregates such as kankar and laterite of requisite quality as stated hereinafter. Use of crushable type aggregates should generally be restricted to lower layers of the pavement. The aggregates shall conform to the physical requirements set forth in Table 1.

3.1.2. Crushed or broken stone : Crushed or broken stone shall be hard, durable and free from flat, elongated, soft and disintegrated particles, dirt or other deleterious materials.

3.1.3 Crushed slag : Crushed slag shall be manufactured from air-cooled blast furnace slag. It shall be angular in shape, reasonably uniform in quality and density, and generally free from soft, elongated and flat pieces, dirt or other deleterious material. Crushed slag shall not weigh less than 11.2 kN per m^3 and the glassy material in it shall not be in excess of 20 per cent. It should also comply with the following requirements.

(i) Chemical stability : To comply with requirement of *Appendix of BS : 1047*

(ii) Sulphur content *(IS 14685-1999)* : Maximum 2 per cent

(iii) Water absorption (IS 2386, Part 3) : Maximum 10 per cent

Table 1: Physical Requirements of Coarse Aggregates for WBM

Sl. No.	Type of Construction	Test +	Test Method	equirements
1.	Sub-base	Los Angeles Abrasion Value* or	IS 2386 (Part 4)	Max. 50%
		Aggregate Impact Value*	IS 2386 (Part 4) or IS 5640**	Max. 40%
2.	Base course with bituminous surfacing	Los Angeles Abrasion Value* or	IS 2386 (Part 4)	Max. 40%
		Aggregate Impact Value*	IS 2386 (Part 4) or IS 5640**	Max. 30%
		Flakiness Index***	IS 2386 (Part 1)	Max. 20%
3.	Surfacing course	Los Angeles Abrasion Value* or	IS 2386 (Part 4)	Max. 40%
		Aggregate Impact Value*	IS 2386 (Part 4) or IS 5640**	Max. 30%
		Flakiness Index***	IS 2386 (Part 1)	Max. 15%

Notes :

* Aggregates may satisfy the requirements of either the Los Angeles test or Aggregate Impact Value Test.

** Aggregates like brick metal, kankar, laterite, etc., which get softened in presence of water should invariably be tested for impact value under wet conditions in accordance with IS 5640.

*** The requirement of Flakiness Index shall be enforced only in the case of crushed/ broken stone and crushed slag.

\+ Samples for tests shall be representative of the materials to be used and collected in accordance with the procedure set forth in IS 2430.

3.1.4 Overburnt (Jhama) brick metal : Brick metal shall be made out of overburnt bricks or brick bats and be free from dust and other deleterious materials.

3.1.5 Kankar : Kankar shall be tough having a blue almost opalescent fracture. It shall not contain any clay in the cavities between nodules.

3.1.6 Laterite : Laterite shall be hard, compact, heavy and of dark colour. Light coloured sandy laterities, as also those containing ochreous clay shall not be used.

3.2 Coarse Aggregates-Size and Grading Requirement

3.2.1 The coarse aggregates shall conform to one of the grading given in Table 2. Grading 1 shall be used only for sub-base courses, with a compacted layer thickness of 100 mm.

3.2.2 The size of aggregates to be used would depend on the type of aggregates available and compacted thickness of the layer.

3.2.3 The crushable type aggregates like brick metal, kankar and laterite shall also generally satisfy the grading requirements of Table 2. Relaxation in grading may be permitted for such materials with the permission of the Engineer.

3.3 Screenings

3.3.1 Screenings to fill voids in the coarse aggregates shall generally be of the same material as the coarse aggregates. However, from economic considerations, predominantly non-plastic material such as kankar, moorum or gravel (other than river-borne rounded aggregate) may also be used for this purpose provided that the liquid limit and plasticity index of such material are below 20 and 6 respectively and the fraction passing 75 micron sieve does not exceed 10 per cent.

3.3.2 As far as possible, screenings shall conform to the grading shown in Table 3. Screenings of type A shall be used in conjunction with coarse aggregates of grading 1, and of type B with coarse aggregates of grading 3. With coarse

Table 2 : Size and Grading Requirement of Coarse Aggregate for WBM

Grading No.	Size Range and compacted thickness for layer	Sieve Designation (IS 460)	Per cent by Weight Passing the Sieve
1	90 mm to 45 mm (100 mm)	125 mm	100
		90 mm	90-100
		63 mm	25-60
		45 mm	0-15
		22.4 mm	0-5
2	63 mm to 45 mm (75 mm)	90 mm	100
		63 mm	90-100
		53 mm	25-75
		45 mm	0-15
		22.4 mm	0-5
3	53 mm to 22.4 mm (75 mm)	63 mm	100
		53 mm	90-100
		45 mm	65-90
		22.4 mm	0-10
		11.2 mm	0-5

Table 3 : Grading Requirements of Screenings for WBM

Grading Classification	Size of Screenings (IS 460)	Sieve Designation Passing the Sieve	Percent by Weight
A	13.2 mm	13.2 mm 11.2 mm 5.6 mm 180 micron	100 95-100 15-35 0-10
B	11.2 mm	11.2 mm 5.6 mm 180 micron	100 90-100 15-35

aggregates of grading 2, either type A or type B screenings may be used. For crushable screenings like moorum and gravel, the grading given in Table 3 shall not be binding.

3.3.3 The use of screenings may be dispensed with when crushable type soft aggregates such as brick metal, kankar, laterite, etc., are used as coarse aggregates, as these are likely to get crushed to a certain extent during rolling.

3.4 Binding Material

3.4.1 Binding material to be used for WBM as filler shall consist of a fine grained material passing 100 per cent through 425 micron sieve and possessing PI value of 4-8 when the WBM is used as a surfacing course, and less than 6 when the WBM is adopted as a sub-base/base course with bituminous surfacing. If limestone formations are available nearby, limestone dust or kankar nodules may be used as binding material.

3.4.2 Application of binding material may not be necessary, where the screenings consist of crushable type material like moorum or gravel. However, for WBM used as a surfacing course, where the PI of crushable type screenings is less than 4, application of a small quantity of binding material having PI of 4-6 would be required at the top. The quantity of screenings could be reduced correspondingly.

3.5 Quantities of Material

3.5.1 Approximate quantities of coarse aggregates and screenings required for 100 mm compacted thickness of WBM sub-base course are given in Table 4. Likewise, quantities of materials for WBM sub-base/base or surfacing

Table 4 : Approximate Quantities of Coarse Aggregates and Screenings Required for 100 mm compacted thickness of WBM Sub-base Course per 10 m²

Coarse Aggregates			Screenings			
Classification	Size Range (mm)	Loose Quantity (m^3)	Stone Screenings: Grading classification and size	Stone Screenings: Loose quantity (m^3)	Crushable Type Such as Moorum or Gravel: Properties and size	Crushable Type Such as Moorum or Gravel: Loose quantity (m^3)
1	2	3	4	5	6	7
Grading 1	90 to 45	1.21 to 1.43	Type A 13.2 mm	0.27 to 0.30	LL<20, PI<6 Per cent passing 75 micron <10	0.30 to 0.32

Table 5 : Approximate Quantities of Coarse Aggregates and Screenings Required for 75 mm compacted thickness of WBM Sub-base/Base Course/Surfacing Course per 10 m²

Coarse Aggregates			Screenings				
Classification	Size Range (mm)	Loose Quantity (m^3)	Stone Screenings			Crushable Type Such as Moorum or Gravel	
			Grading classification and size	Loose quantity or		Properties and size (m^3)	Loose quantity (m^3)
				WBM sub-base/ base course (m^3)	WBM surfacing course* (m^3)		
1	2	3	4	5	6	7	8
Grading 2	63 to 45	0.91 to 1.07	Type A, 13.2mm	0.12 to 0.15	0.10 to 0.12	LL<20, PI<6 Percent passing 75 micron <10	0.22 to 0.24
Grading 2	63 to 45	—do—	Type B, 11.2mm	0.20 to 0.22	0.16 to 0.18	—do—	—do—
Grading 3	53 to 22.4	—do—	—do—	0.18 to 0.21	0.14 to 0.17	—do—	—do—

*Quantities in Col. 6 are 80 per cent of those in Col. 5 as larger quantity of binding material will need to be used where the WBM is to act as a surfacing course (see Clause 3.5.2.).

course for a compacted thickness of 75 mm are given in Table 5.

3.5.2 The quantity of binding material where it is to be used (see Clause 3.4.), will depend on the type of screenings and function of WBM. Generally, the quantity required for 75 mm compacted thickness will be 0.06-0.09 m^3/10 m^2 in the case of WBM sub-base/base course and 0.10-0.15 m^3/10 m^2 when the WBM is to function as a surfacing course. For 100 mm thickness, the quantity needed will be 0.08-0.10 m^3/10 m^2 for sub-base course.

3.5.3 The above mentioned quantities should be taken as a guide only, for estimation of quantities for construction, etc.

4 CONSTRUCTION PROCEDURE

4.1 Preparation of Foundation for Receiving WBM Layer

4.1.1 The subgrade, sub-base or base to receive the WBM course shall be prepared to the required grade and camber and cleaned of all dust, dirt and other extraneous matter. Any ruts or soft yielding places that have appeared due to improper drainage, service under traffic or other reasons shall be corrected and rolled until firm.

4.1.2 Where the WBM is to be laid on an existing un-surfaced road, the surface shall be scarified and re-shaped to the required grade and camber as necessary. Weak places shall be strengthened, corrugations removed and depressions and potholes made good with suitable material before spreading the coarse aggregates for WBM.

4.1.3 As far as possible, laying of WBM course over an existing bituminous surface should be avoided since it will cause problems of proper bond and internal drainage of the pavement at the interface of two courses. It is desirable to completely remove the existing thin surfacing of bituminous layer, where WBM is proposed to be laid over it. Where the intensity of rain is low and interface drainage facility is efficient, WBM can be laid over existing thin bituminous surfacing by

cutting 50 mm x 50 mm (minimum) furrows at 1 metre intervals at 45 degrees to the centre line of the carriageway before proceeding with the laying of WBM.

The direction and depth of furrows shall be such that they provide adequate bondage and also serve to drain water to the existing granular base course beneath the existing bituminous surface.

4.1.4 In all cases, the foundation shall be kept well drained during the construction operations.

4.2 Provision of Lateral Confinement of Aggregates

For construction of WBM, arrangement should be made for the lateral confinement of aggregates. This shall be done by building adjoining shoulders alongwith WBM layers. The practice of constructing WBM in a trench section excavated in the finished formation must be completely avoided.

4.3 Spreading of Coarse Aggregates

4.3.1 The coarse aggregates shall be spread uniformly and evenly upon the prepared base in required quantities from stockpiles along the side of the road or directly from vehicles. In no case shall these be dumped in heaps directly on the area where these are to be laid nor shall their hauling over a partly completed base be permitted. The aggregates shall be spread to proper profile by using templates placed across the road about 6 m apart. Where possible, approved mechanical devices shall be used to spread the aggregates uniformly so as to minimize the need for their manipulation by hand.

4.3.2 The WBM Course shall be constructed in layers such that thickness of each compacted layer is not more than 100 mm for grading 1 (Table 2). The compacted thickness of layer shall be 75 mm for grading 2 and grading 3. Each layer shall be tested by depth blocks. No segregation of large or fine particles shall be allowed. The coarse aggregates as spread shall be of uniform gradation with no pockets of fine material.

4.3.3 The coarse aggregates shall normally not be spread in lengths exceeding three days average work ahead of the rolling and bonding of the preceding section.

4.4 Rolling

4.4.1 After the laying of coarse aggregates, these shall be compacted to full width by rolling with either three wheel-power roller of 80 to 100 kN capacity or an equivalent vibratory roller.

4.4.2 The rolling shall begin from edges with roller running forward and backward until the edges have been firmly compacted. The roller shall then progress gradually from edges to the centre, parallel to the centre line of the road and overlapping uniformly each preceding rear wheel track by one half width and shall continue until the entire area of the course has been rolled by the rear wheel. Rolling shall continue until the road metal is thoroughly keyed and the creeping of stone ahead of the roller is no longer visible. Slight sprinkling of water may be done, if required.

4.4.3 On super elevated portions of the road, rolling shall commence from the lower edge and progress gradually towards the upper edge of the pavement.

4.4.4 Rolling shall not be done when the subgrade is soft or yielding or when it causes a wave-like motion in the base course or subgrade. If irregularities develop during rolling, which exceed 12 mm when tested with a 3 m straight edge, the surface shall be loosened and aggregates added or removed as required before rolling again so as to achieve all uniform surface conforming to the desired cross section and grade. The surface shall also be checked transversely by template for camber, and any irregularities corrected in the manner described above. In no case shall the use of screenings to make up depressions be permitted.

4.4.5 Material, which gets crushed excessively during compaction or become segregated shall be removed and replaced with suitable aggregates.

4.5 Application of Screenings

4.5.1 After coarse aggregates have been rolled as per Clause 4.4, screenings to fill interstices shall be applied gradually over the surface. Dry rolling shall be done when the screenings are being spread so that the jarring effect of roller causes them to settle into the voids of the coarse aggregate. The screenings shall not be dumped in piles but applied uniformly in successive thin layers either by the spreading motion of hand shovels, mechanical spreaders, or directly from trucks. Trucks plying over the base course to spread screenings shall be equipped with pneumatic tyres and operated such as not to disturb the coarse aggregates.

4.5.2 The screenings shall be applied at a slow rate in three or more applications as necessary. This shall be accompanied by rolling and brooming. Either mechanical brooms/hand brooms or both may be used. In no case shall the screenings be applied so fast and thick as to form cakes or ridges on the surface making the filling of voids difficult or preventing the direct bearing of roller on the coarse aggregates. The spreading, rolling and brooming of screenings shall be taken up on sections, which can be completed within one day's operation. Damp and wet screenings shall not be used in any circumstances.

4.6 Sprinkling of Water and Grouting

4.6.1 After application of screenings, the surface shall be copiously sprinkled with water, swept and rolled. Hand brooms shall be used to sweep the wet screenings into the voids, and to distribute them evenly. The sprinkling, sweeping and rolling operations shall be continued and additional screenings applied, where necessary until the coarse aggregates are bonded and firmly set and a grout of screenings and water forms ahead of the wheels of the roller. Care shall be taken that the base or subgrade does not get damaged due to addition of excessive quantities of water during the construction.

4.6.2 In case of lime treated soil sub-base, construction of WBM on top of it can cause excessive water to flow down to the lime treated sub-base before it has picked up enough strength (is still "green") and thus cause damage to the sub-base layer. The laying of WBM layer in such cases shall be done after the sub-base attains adequate strength, as directed by the Engineer.

4.7 Application of Binding Material

4.7.1 After the application of screenings as per Clauses 4.5 and 4.6, binding material where it is required to be used (see Clause 3.4), shall be applied at an uniform and slow rate in two or more successive thin layers. After each application of binding material, the surface shall be copiously sprinkled with water and the resulting slurry swept in with hand brooms/mechanical brooms or both so as to fill the voids properly. This shall be followed by rolling with 80-100 kN roller during which water shall be applied to the wheels to wash down the binding material that may get stuck to them. The spreading of binding material, sprinkling of water, sweeping with brooms and rolling shall continue until the slurry of binding material and water forms a wave ahead of the wheels of moving roller.

4.8 Setting and Drying

4.8.1 After final compaction of the course, the layer shall be allowed to dry overnight. Next morning, hungry spots shall be filled with screenings or binding material, lightly sprinkled with water if necessary, and rolled. No traffic shall be allowed till the macadam sets.

4.8.2 In the case of WBM base course to be provided with bituminous surfacing, the latter shall be laid only after the WBM course is completely dry and before allowing any traffic on it.

5. SURFACE EVENNESS OF WBM COURSE

5.1 The surface unevenness of completed WBM course in longitudinal and transverse directions shall be within the limits specified in Table 6.

5.2 The longitudinal profile shall be checked with a 3-metre long straight edge at the middle of

Table 6 : Permissible Surface Unevenness for WBM Courses

Sl. No.	Size Range of Coarse Aggregates	Longitudinal Profile measured with a 3-Metre Straight Edge			Transverse Profile
		Max. permissible Surface unevenness	Maximum number of undulations permitted in any 300-metre length, exceeding		Max. permissible variation from specified profile under camber template
		mm	12 mm	10 mm	mm
1.	90-45 mm	15	30	—	12
2.	63-45 mm or 53-22.4 mm	12	—	30	8

each traffic lane along a line parallel to the centre line of the road. The transverse profile shall be checked with a series of three camber templates at intervals of 10 m. For detailed guidance in this respect, reference may be made to IRC:SP:16-2004 "Guidelines for Surface Evenness of Highway Pavements (First Revision)".

6. RECTIFICATION OF DEFECTIVE CONSTRUCTION

Where the surface irregularity of the WBM courses exceeds the tolerances given in Table 6 or where the course is otherwise defective due to sub-grade soil mixing with the aggregates, the layer to its full thickness shall be scarified over the affected area, reshaped with added material, or removed and replaced with fresh material as applicable, and recompacted in accordance with Clause 4. The area treated in the aforesaid manner shall not be less than 10 m^2. In no case shall depressions be filled up with screenings or binding material.

7. CONSTRUCTION OF WBM OVER NARROW WIDTHS

Where the WBM course is to be constructed in narrow widths for widening of an existing pavement, the existing shoulders should be excavated to their full depth and width up to the subgrade level except where the widening specifications envisage laying of a stabilised-soil sub-base using in-situ operations in which case the same should be removed only up to the sub-base level. The construction of WBM shall be carried out as per the procedure prescribed in Clause 4.

8. MAINTENANCE OF WBM WEARING COURSES

8.1 The successful performance of WBM as a surfacing course depends to a large extent on timely maintenance. Maintenance measures for this can be considered under three heads: periodic patching of potholes along with removal of ruts and depressions, blinding of the surface, and surface renewals.

8.1.1 Patching of pot-holes along with removal of ruts and depressions : Potholes, ruts and other depressions should be drained of water and cut to regular shape with vertical sides. All the loose and disintegrated material shall be removed and the exposed surfaces swept clean. The holes/depressions shall then be filled with salvaged coarse aggregates mixed with sufficient quantity of fresh aggregates and recompacted as normal WBM to operations described in Clause 4 so that the patched area merges with the adjoining surface. Where the area so treated is small, hand rammers may be used for compaction instead of rollers.

8.1.2 Blinding of surface : Blinding of the surface shall be resorted to periodically as soon as the blinding material applied earlier has been eroded away due to a traffic or weather action

and the surface has started showing signs of ravelling. Blinding operations shall consist of application of binding material in thin layers and grouting in accordance with the procedure given in Clause 4.7.

8.1.3 Surface Renewal : WBM wearing course shall be renewed when the surface is worn out, is corrugated and badly ravelled or has a profusion of potholes and depressions which can not be treated economically with patching or blinding operations.

For renewal, the existing surface shall be scarified to a depth of 50-75 mm and the resulting material removed to berms for screening to salvage the usable coarse aggregates. The exposed pavement shall be scarified again at high spots so as to ensure proper grade and camber. The salvaged coarse aggregates mixed with sufficient quantity of fresh aggregates (usually between one half to one third of the quantity of salvaged aggregates) shall then be used to construct a new WBM course in accordance with Clause 4.

The official amendments to this code 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