
400

**SUB-BASES, BASES
(NON-BITUMINOUS) AND
SHOULDERS**

401 GRANULAR SUB-BASE**401.1 Scope**

This work shall consist of laying and compacting well-graded material on prepared subgrade in accordance with the requirements of these Specifications. The material shall be laid in one or more layers as sub-base or lower sub-base and upper sub-base (termed as sub-base hereinafter) as necessary according to lines, grades and cross-sections shown on the drawings or as directed by the Engineer.

401.2 Materials

401.2.1 The material to be used for the work shall be natural sand, crushed gravel, crushed stone, crushed slag, or combination thereof depending upon the grading required. Use of materials like brick metal, Kankar and crushed concrete shall be permitted in the lower sub-base. The material shall be free from organic or other deleterious constituents and shall conform to the gradings given in Table 400-1 and physical requirements given in Table 400-2. Gradings III and IV shall preferably be used in lower sub-base. Gradings V and VI shall be used as a sub-base-cum-drainage layer. The grading to be adopted for a project shall be as specified in the Contract. Where the sub-base is laid in two layers as upper sub-base and lower sub-base, the thickness of each layer shall not be less than 150 mm.

401.2.2 If the water absorption of the aggregates determined as per IS:2386 (Part 3) is greater than 2 percent, the aggregates shall be tested for Wet Aggregate Impact Value (AIV) (IS:5640). Soft aggregates like Kankar, brick ballast and laterite shall also be tested for Wet AIV (IS:5640).

Table 400-1 : Grading for Granular Sub-base Materials

IS Sieve Designation	Percent by Weight Passing the IS Sieve					
	Grading I	Grading II	Grading III	Grading IV	Grading V	Grading VI
75.0 mm	100	-	-	-	100	-
53.0 mm	80-100	100	100	100	80-100	100
26.5 mm	55 -90	70-100	55-75	50-80	55-90	75-100
9.50 mm	35-65	50-80	-	-	35-65	55-75
4.75 mm	25 - 55	40-65	10-30	15-35	25-50	30-55
2.36 mm	20- 40	30-50	-	-	10-20	10-25
0.85 mm	-	-	-	-	2-10	-
0.425 mm	10-15	10- 15	-	-	0-5	0-8
0.075 mm	<5	< 5	< 5	< 5	-	0-3

Table 400-2 : Physical Requirements for Materials for Granular Sub-base

Aggregate Impact Value (AIV)	IS:2386 (Part 4) or IS:5640	40 maximum
Liquid Limit	IS:2720 (Part 5)	Maximum 25
Plasticity Index	IS:2720 (Part 5)	Maximum 6
CBR at 98% dry density (at IS:2720-Part 8)	IS:2720 (Part 5)	Minimum 30 unless otherwise specified in the Contract

401.3 Construction Operations

401.3.1 Preparation of Sub-grade

Immediately prior to the laying of sub-base, the subgrade already finished to Clause 301 or 305 as applicable shall be prepared by removing all vegetation and other extraneous matter, lightly sprinkled with water, if necessary and rolled with two passes of 80–100 kN smooth wheeled roller.

401.3.2 Spreading and Compacting

The sub-base material of the grading specified in the Contract and water shall be mixed mechanically by a suitable mixer equipped with provision for controlled addition of water and mechanical mixing. So as to ensure homogenous and uniform mix. The required water content shall be determined in accordance with IS:2720 (Part 8). The mix shall be spread on the prepared subgrade with the help of a motor grader of adequate capacity, its blade having hydraulic controls suitable for initial adjustment and for maintaining the required slope and grade during the operation, or other means as approved by the Engineer.

Moisture content of the mix shall be checked in accordance with IS:2720 (Part 2) and suitably adjusted so that, at the time of compaction, it is from 1 to 2 percent below the optimum moisture content.

Immediately after spreading the mix, rolling shall be done by an approved roller. If the thickness of the compacted layer does not exceed 100 mm, a smooth wheeled roller of 80 to 100 kN weight may be used. For a compacted single layer upto 200 mm the compaction shall be done with the help of a vibratory roller of minimum 80 to 100 kN static weight capable of achieving the required compaction. Rolling shall commence at the lower edge and proceed towards the upper edge longitudinally for portions having unidirectional crossfall or on super-elevation. For carriageway having crossfall on both sides, rolling shall commence at the edges and progress towards the crown.

Each pass of the roller shall uniformly overlap not less than one-third of the track made in the preceding pass. During rolling, the grade and crossfall (camber) shall be checked and any high spots or depressions which become apparent, corrected by removing or adding fresh material. The speed of the roller shall not exceed 5 km per hour.

Rolling shall be continued till the density achieved is at least 98 percent of the maximum dry density for the material determined as per IS:2720 (Part 8). The surface of any layer of material on completion of compaction shall be well closed, free from movement under compaction equipment and from compaction planes, ridges, cracks or loose material. All loose, segregated or otherwise defective areas shall be made good to the full thickness of layer and re-compacted.

401.4 Surface Finish and Quality Control of Work

The surface finish of construction shall conform to the requirements of Clause 902. Control on the quality of materials and works shall be exercised by the Engineer in accordance with Section 900.

401.5 Arrangements for Traffic

During the period of construction, arrangements for the traffic shall be provided and maintained in accordance with Clause 112.

401.6 Measurements for Payment

Granular sub-base shall be measured as finished work in position in cubic metres.

The protection of edges of granular sub-base extended over the full formation as shown in the drawing shall be considered incidental to the work of providing granular sub-base and as such no extra payment shall be made for the same.

401.7 Rate

The Contract unit rate for granular sub-base shall be payment in full for carrying out the required operations including full compensation for:

- i) making arrangements for traffic to Clause 112 except for initial treatment to verges, shoulders and construction of diversions;
- ii) supplying all materials to be incorporated in the work including all royalties, fees, rents where applicable with all leads and lifts;
- iii) all labour, tools, equipment and incidentals to complete the work to the Specifications;
- iv) carrying out the work in part widths of road where directed; and
- v) carrying out the required tests for quality control.

402 LIME TREATED SOIL FOR IMPROVED SUB-GRADE/SUB-BASE**402.1 Scope**

This work shall consist of laying and compacting an improved sub-grade/lower sub-base of soil treated with lime on prepared sub-grade in accordance with the requirements of these Specifications and in conformity with the lines, grades and cross-sections shown on the drawings or as directed by the Engineer. Lime treatment is generally effective for soils which contain a relatively high percentage of clay and silty clay.

402.2 Materials**402.2.1 Soil**

Except when otherwise specified, the soil used for stabilization shall be the local clayey soil having a plasticity index greater than 8.

402.2.2 Lime

Lime for lime-soil stabilization work shall be commercial dry lime slaked at site or pre-slaked lime delivered to the site in suitable packing. Unless otherwise permitted by the Engineer, the lime shall have purity of not less than 70 percent by weight of Quick-lime (CaO) when tested in accordance with IS:1514. Lime shall be properly stored to avoid prolonged exposure to the atmosphere and consequent carbonation which would reduce its binding properties.

402.2.3 Quantity of Lime in Stabilized Mix

Quantity of lime to be added as percentage by weight of the dry soil shall be as specified in the Contract. The quantity of lime used shall be related to its calcium oxide content which shall be specified. Where the lime of different calcium oxide content is to be used, its quantity shall be suitably adjusted with the approval of the Engineer so that equivalent calcium oxide is incorporated in the work. The mix design shall be done to arrive at the appropriate quantity of lime to be added, having due regard to the purity of lime, the type of soil, the moisture-density relationship, and the design CBR/Unconfined Compressive Strength (UCS) value specified in the Contract. The laboratory CBR/UCS value shall be at least 1.5 times the minimum field value of CBR/UCS stipulated in the Contract.

402.2.4 Water

The water to be used for lime stabilisation shall be clean and free from injurious substances. Potable water shall be used.

402.3 Construction Operations**402.3.1 Weather Limitations**

Lime-soil stabilisation shall not be done when the air temperature in the shade is less than 10°C.

402.3.2 Degree of Pulverisation

For lime-soil stabilisation, the soil before addition of stabilizer, shall be pulverized using agricultural implements like disc harrows (only for low volume roads) and rotavators to the extent that it passes the requirements set out in Table 400-3 when tested in accordance with the method described in Appendix-3.

Table 400-3 : Soil Pulverisation Requirements for Lime Stabilisation

IS Sieve designation	Minimum percent by weight passing the IS Sieve
26.5 mm	100
5.6 mm	80

402.3.3 Equipment for Construction

Stabilised soil sub-bases shall be constructed by mix-in-place method of construction or as otherwise approved by the Engineer. Manual mixing shall be permitted only where the width of laying is not adequate for mechanical operations, as in small-sized jobs.

The equipment used for mix-in-place construction shall be a rotavator or similar approved equipment capable of pulverizing and mixing the soil with additive and water to specified degree to the full thickness of the layer being processed, and of achieving the desired degree of mixing and uniformity of the stabilized material. If so desired by the Engineer, trial runs with the equipment shall be carried out to establish its suitability for work.

The thickness of any layer to be stabilized shall be not less than 100 mm when compacted. The maximum thickness can be 200 mm, provided the plant used is accepted by the Engineer.

402.3.4 Mix-in-place Method of Construction

Before deploying the equipment, the soil after it is made free of undesirable vegetation or other deleterious matter shall be spread uniformly on the prepared subgrade in a quantity sufficient to achieve the desired compacted thickness of the stabilised layer. Where single-pass equipment is to be employed, the soil shall be lightly rolled as directed by the Engineer.

The equipment used shall either be of single-pass or multiple pass type. The mixers shall be equipped with an appropriate device for controlling the depth of processing and the mixing blades shall be maintained or reset periodically so that the correct depth of mixing is obtained at all times.

With single-pass equipment the forward speed of the machine shall be so selected in relation to the rotor speed that the required degree of mixing, pulverisation and depth of processing is obtained. In multiple-pass processing, the prepared sub-grade shall be pulverised to the required depth with successive passes of the equipment and the moisture content adjusted to be within prescribed limits mentioned hereinafter. The lime shall then be spread uniformly and mixing continued with successive passes until the required depth and uniformity of processing have been obtained.

The mixing equipment shall be so set that it cuts slightly into the edge of the adjoining lane processed previously so as to ensure that all the material forming a layer has been properly processed for the full width.

402.3.5 Construction with Manual Means

Where manual mixing is permitted, the soil from borrow areas shall first be freed of all vegetation and other deleterious mater and placed on the prepared subgrade. The soil shall then be pulverized by means of crow-bars, pick axes or other means approved by the Engineer.

Water in requisite quantities may be sprinkled on the soil for aiding pulverisation. On the pulverized soil, the lime in requisite quantities shall be spread uniformly and mixed thoroughly by working with spades or other similar implements till the whole mass is uniform. After adjusting the moisture content to be within the limits mentioned later, the mixed material shall be leveled up to the required thickness so that it is ready to be rolled.

402.3.6 Addition of Lime

Lime may be mixed with the prepared material either in slurry form or dry state at the option of the Contractor with the approval of the Engineer.

Dry lime shall be prevented from blowing by adding water to the lime or other suitable means selected by the Contractor, with the approval of the Engineer.

The tops of windrowed material may be flattened or slightly trenched to receive the lime.

The distance to which lime may be spread upon the prepared material ahead of the mixing operation shall be determined by the Engineer.

No traffic other than the mixing equipment shall be allowed to pass over the spread lime until after completion of mixing.

Mixing or remixing operations, regardless of equipment used, shall continue until the material is free of any white streaks or pockets of lime and the mixture is uniform.

Non-uniformity of colour reaction, when the treated material is tested with the standard phenolphthalein alcohol indicator, will be considered evidence of inadequate mixing.

402.3.7 Moisture Content for Compaction

The moisture content at compaction checked vide IS:2720 (Part 2) shall neither be less than the optimum moisture content corresponding to IS:2720 (Part 8) nor more than 2 percent above it.

402.3.8 Rolling

Immediately after spreading, grading and levelling of the mixed material, compaction shall be carried out with approved equipment preceded by a few passes of lighter rollers if necessary. Rolling shall commence at edges and progress towards the centre, except at super elevated portions or for carriageway with unidirectional cross-fall where it shall commence at the inner edge and progress towards the outer edge. During rolling, the surface shall be frequently checked for grade and crossfall (camber) and any irregularities corrected by loosening the material and removing/adding fresh material. Compaction shall continue until the density achieved is at least 98 percent of the maximum dry density for the material determined in accordance with IS:2720 (Part 8).

Care shall be taken to see that the compaction of lime stabilised material is completed within three hours of its mixing or such shorter period as may be found necessary in dry weather.

During rolling it shall be ensured that roller does not bear directly on hardened or partially hardened treated material previously laid other than what may be necessary for achieving the specified compaction at the joint. The final surface shall be well closed, free from movement under compaction planes, ridges, cracks or loose material. All loose or segregated or otherwise defective areas shall be made good to the full thickness of the layer and recompacted.

402.3.9 Curing

The sub-base course shall be suitably cured for a minimum period of 7 days after which subsequent pavement courses shall be laid to prevent the surface from drying out and becoming friable. No traffic of any kind shall ply over the completed sub-base unless permitted by the Engineer.

402.4 Surface Finish and Quality Control of Work

The surface finish of construction shall conform to the requirements of Clause 902.

Control on the quality of materials and works shall be exercised by the Engineer in accordance with Section 900.

402.5 Strength

When lime is used for improving the subgrade, the soil-lime mix shall be tested for its CBR value. When lime stabilized soil is used in a sub-base, it shall be tested for unconfined compressive strength (UCS) at 7 days. In case of variation from the design CBR/UCS, in situ value being lower, the pavement design shall be reviewed based on the actual CBR/UCS values. The extra pavement thickness needed on account of lower CBR/UCS value shall be constructed by the Contractor at his own cost.

402.6 Arrangements for Traffic

During the period of construction, arrangements for traffic shall be provided and maintained in accordance with Clause 112.

402.7 Measurements for Payment

Stabilised soil sub-graded sub-base shall be measured as finished work in position in cubic metres.

402.8 Rate

The Contract unit rate for lime stabilised soil sub-graded/ sub-base shall be payment in full for carrying out the required operations including full compensation for all components listed in Clause 401.7 (i) to (v).

403 CEMENT TREATED SOIL AND CEMENT-FLYASH TREATED SUB-BASE/BASE**403.1 Scope**

This work shall consist of laying and compacting a sub-base/base course of soil treated with cement or cement-flyash on prepared subgrade/sub-base, in accordance with the requirements of these

Specifications and in conformity with the lines, grades and cross-sections shown on the drawings or as directed by the Engineer.

403.2 Materials**403.2.1 Material to be Treated**

The material used for cement or cement-flyash treatment shall be soil including sand and gravel, laterite, kankar, brick aggregate, crushed rock or slag or any combination of these. For use in a sub-base course, the material shall have a grading shown in Table 400-4. It shall have a uniformity coefficient not less than 5, capable of producing a well-closed surface finish. For use in a base course, the material shall be sufficiently well graded to ensure a well-closed surface finish and have a grading within the range given in Table 400-4. If the material passing 425 micron sieve is plastic, it shall have a liquid limit not greater than 45 percent and a plasticity index not greater than 20 percent determined in accordance with IS:2720 (Part 5). The physical requirements for the material to be treated with cement for use in a base course shall be same as for Grading I Granular Sub-base, Clause 401.2.2.

403.2.2 Cement

Cement for stabilization shall either be ordinary Portland Cement, Portland Slag Cement or Portland Pozzolana Cement and shall comply with the requirements of IS:269, 455 or 1489 respectively.

Table 400-4 : Grading Limits of Material for Stabilisation with Cement

IS sieve size	Percentage by mass passing Sub-Base/Base within the range
53.00 mm	100
37.5 mm	95 – 100
19.0 mm	45 – 100
9.5 mm	35 – 100
4.75 mm	25 – 100
600 micron	8 – 65
300 micron	5 – 40
75 micron	0 – 10

403.2.3 Lime

If needed for pre-treatment of highly clayey soils, Clause 402.2.2 shall apply.

403.2.4 Flyash

Flyash may be from anthracitic coal or lignitic coal. Flyash to be used for cement-flyash treatment shall conform to the requirement given in Tables 400-5 and 400-6.

Table 400-5 : Chemical Requirements for Fly Ash as Pozzolana

Sl. No.	Characteristics	Requirements for Fly Ash		Method of Test
		Anthracitic Flyash	Lignitic Flyash	
1)	$\text{SiO}_2 + \text{Al}_2\text{O}_3 + \text{Fe}_2\text{O}_3$ in percent by mass, Min	70	50	IS:1727
2)	SiO_2 in percent by mass, Min	35	25	IS:1727
3)	MgO in percent by mass, Max	25	5.0	IS:1727
4)	SO_3 in percent by mass, Max	2.75	3.5	IS:1727
5)	Available alkalies as $\text{Na}_2\text{O}/\text{K}_2\text{O}$ in percent by mass, Max,	1.5	1.5	IS:4032
6)	Total chlorides in percent by mass, Max	0.05	0.05	IS:1727
7)	Loss on ignition in percent by mass, Max	5.0	5.0	IS:1727

Table 400-6 : Physical Requirement for Fly Ash as a Pozzolona

Sl. No.	Characteristics	Requirement
1)	Fineness-specific surface in m^2/Kg by Blaine's permeability test, Min	250
2)	Particles retained on 45 micron IS sieve, Max	40
3)	Lime reactivity in N/mm^2 , Min	3.5
4)	Soundness by autoclave test expansion of specimen in percent, Max	0.8
5)	Soundness by Lechatelier method-expansion in mm, Max	10

Pond ash or bottom ash, which do not meet the requirements of Tables 400-5 and 400-6 can also be used for cement-flyash treatment. However, in all cases of cement stabilised fly-ash/ bottom ash/ pond ash, mix should develop adequate strength.

403.2.5 Quantity of Cement in Cement-Soil Stabilised Mix

The quantity of cement to be added as percent by weight of the dry soil shall be specified in the Contract. Also if lime is used as pretreatment for highly clayey soils, the quantity as percent by weight of dry soil shall be specified in the Contract. The mix design shall be done on the basis of 7 day unconfined compressive strength (UCS) and/or durability test under 12 cycles of wet-dry conditions. The laboratory strength values shall be at least 1.5 times the minimum field UCS value stipulated in the Contract.

403.2.6 Quantity of Cement in Cement/Fly Ash Treated Sub-base/Base

The quantity of cement shall be more than 2 percent by weight of cement/ fly-ash mix. The mix design shall be done to achieve a strength of 1.75 MPa when tested on cylindrical specimens compacted to the density at optimum moisture content, tested in accordance with IS:2720 (Part 8 as specified in the contract) after 7 days moist curing. The design mix shall indicate the proportions of cement and fly ash and the quantity of water to be mixed.

403.2.7 Water

The water to be used for cement stabilization shall be clean and free from injurious substances. Potable water shall be used.

403.3 Construction Operations**403.3.1 Weather Limitations**

Stabilisation shall not be done when the air temperature in the shade is less than 10°C.

403.3.2 Degree of Pulverisation

For stabilisation, the soil before addition of cement shall be pulverised, where necessary, to the extent that it passes the requirements as set out in Table 400-7 when tested in accordance with the method described in Appendix-3.

Table 400-7 : Soil Pulverisation Requirements for Cement Stabilisation

IS sieve Designation	Minimum percent by weight passing the IS sieve
26.5 mm	100
5.6 mm	80

403.3.3 Clauses 402.3.3 to 402.3.5 shall apply as regards spreading and mixing the stabilizer except that cement or lime plus cement as the case may be, shall be used as the stabilizing material in place of lime.

403.3.4 Moisture Content for Compaction

The moisture content at compaction checked vide IS:2720 (Part 2) shall not be less than the optimum moisture content corresponding to IS:2720 (Part 8) nor more than 2 percent above it.

403.3.5 Rolling

Clause 402.3.8 shall apply except that care shall be taken to see that the compaction of cement stabilised material is completed within two hours of its mixing or such shorter period as may be found necessary in dry weather.

403.3.6 Curing

The sub-base/base course shall be suitably cured for 7 days. Subsequent pavement course shall be laid soon after to prevent the surface from drying out and becoming friable. No traffic of any kind shall ply over the completed sub-base unless permitted by the Engineer.

403.4 Surface Finish

The surface finish of construction shall conform to the requirements of Clause 902.

403.5 Strength and Quality Control

Control on the quality of materials and works shall be exercised by the Engineer in accordance with Section 900.

Cement treated soil sub-base/base and cement/fly ash treated sub-base/base shall be tested for the unconfined compressive strength (UCS) value at 7 days, actually obtained in-situ. In case of variation from the design UCS, in-situ value being on lower side, prior to proceeding with laying of base/surface course on it, the pavement design shall be reviewed for actual UCS value. The extra pavement thickness needed on account of lower UCS shall be constructed by the Contractor at his own cost.

403.6 Arrangements for Traffic

During the period of construction, arrangements for traffic shall be provided and maintained in accordance with Clause 112.

403.7 Measurements for Payment

Stabilised soil sub-base/base shall be measured as finished work in position in cubic metres.

403.8 Rate

The Contract unit rate for cement treated soil sub-base/base with pretreatment with lime if required and cement/fly ash treated sub-base/base shall be payment in full for carrying out

required operations including full compensation for all components listed in Clause 401.7 (i) to (v).

404 WATER BOUND MACADAM SUB-BASE/BASE

404.1 Scope

This work shall consist of clean crushed aggregates mechanically interlocked by rolling and bonding together with screening, binding material where necessary and water laid on a properly prepared subgrade/sub-base/base or existing pavement, as the case may be and finished in accordance with the requirements of these Specifications and in close conformity with the lines, grades, cross-sections and thickness as per approved plans or as directed by the Engineer.

404.2 Materials

404.2.1 Coarse Aggregates

Coarse aggregates shall be either crushed or broken stone, crushed slag, overburnt (Jhama) brick aggregates or any other naturally occurring aggregates such as kankar and laterite of suitable quality. Materials other than crushed or broken stone and crushed slag shall be used in sub-base courses only. If crushed gravel /shingle is used, not less than 90 percent by weight of the gravel/shingle pieces retained on 4.75 mm sieve shall have at least two fractured faces. The aggregates shall conform to the physical requirements set forth in **Table 400-8**. The type and size range of the aggregate shall be specified in the Contract or shall be as specified by the Engineer. If the water absorption value of the coarse aggregate is greater than 2 percent, the soundness test shall be carried out on the material delivered to site as per IS:2386 (Part 5).

Table 400-8 : Physical Requirements of Coarse Aggregates for Water Bound Macadam for Sub-base/Base Courses

S.No.	Test	Test Method	Requirements
1) ***	Los Angeles Abrasion value	IS: 2386(Part 4)	40 percent (Max)
	or Aggregate Impact value	IS: 2386 (Part-4) or IS:5640*	30 percent (Max)
2)	Combined Flakiness and Elongation Indices (Total) **	IS:2386 (Part-1)	35 percent (Max)

* Aggregates which get softened in presence of water shall be tested for Impact value under wet conditions in accordance with IS:5640.

- ** The requirement of flakiness index and elongation index shall be enforced only in the case of crushed broken stone and crushed slag.
- *** In case water bound macadam is used for sub-base, the requirements in respect of Los Angeles Value and Aggregate Impact Value shall be relaxed to 50 percent and 40 percent maximum respectively.

404.2.2 Crushed or Broken Stone

The crushed or broken stone shall be hard, durable and free from excess flat, elongated, soft and disintegrated particles, dirt and other deleterious material.

404.2.3 Crushed Slag

Crushed slag shall be made from air-cooled blast furnace slag. It shall be of angular shape, reasonably uniform in quality and density and generally free from thin, elongated and soft pieces, dirt or other deleterious materials. The weight of crushed slag shall not be less than 11.2 kN per m³ and the percentage of glossy material shall not be more than 20. It should also comply with the following requirements:

- i) Chemical stability : To comply with requirements of appendix of ES:1047
- ii) Sulphur content : Maximum 2 percent
- iii) Water absorption : Maximum 10 percent

404.2.4 Overburnt (Jhama) Brick Aggregates

Jhama brick aggregates shall be made from overburnt bricks or brick bats and be free from dust and other objectionable and deleterious materials. This shall be used only for road stretch when traffic is low.

404.2.5 Grading Requirement of Coarse Aggregates

The coarse aggregates shall conform to one of the Gradings given in Table 400-9 as specified.

404.2.6 Screenings

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

Table 400-9 : Grading Requirements of Coarse Aggregates

Grading No.	Size Range	IS Sieve Designation	Percent by weight Passing
1)	63 mm to 45 mm	75 mm	100
		63 mm	90 – 100
		53 mm	25 – 75
		45 mm	0 – 15
		22.4 mm	0 – 5
2)	53 mm to 22.4 mm	63 mm	100
		53 mm	95 – 100
		45 mm	65 – 90
		22.4 mm	0 – 10
		11.2 mm	0 – 5

Note : The compacted thickness for a layer shall be 75 mm.

Screenings shall conform to the grading set forth in Table 400-10. The quantity of screenings required for various grades of stone aggregates are given in Table 400-11. The Table also gives the quantities of materials (loose) required for 10 m² for sub-base/base compacted thickness of 75 mm.

The use of screenings shall be omitted in the case of soft aggregates such as brick metal, kankar, laterites, etc. as they are likely to get crushed to a certain extent under rollers.

404.2.7 Binding Material

Binding material to be used for water bound macadam as a filler material meant for preventing ravelling shall comprise of a suitable material approved by the Engineer having a Plasticity Index (PI) value of less than 6 as determined in accordance with IS:2720 (Part-5).

The quantity of binding material where it is to be used, will depend on the type of screenings. Generally, the quantity required for 75 mm compacted thickness of water bound macadam will be 0.06–0.09 m³ per 10 m².

Table 400-10 : Grading For Screenings

Grading Classification	Size of Screenings	IS Sieve Designation	Percent by Weight Passing the Sieve
A	13.2 mm	13.2 mm	100
		11.2 mm	95 – 100
		5.6 mm	15 - 35
		180 micron	0 – 10
B	11.2 mm	11.2 mm	100
		9.5 mm	80 – 100
		5.6 mm	50 – 70
		180 micron	5 – 25

Table 400-11 : Approximate Quantities of Coarse Aggregates and Screenings Required for 75 mm Compacted Thickness of Water Bound Macadam (WBM) Sub-Base/Base Course for 10 m² Area

Classification	Size Range	Compacted Thickness	Loose Qty.	Screenings			
				Stone Screening		Crushable Type Such as Moorum or Gravel	
				Grading Classification & Size	For WBM Sub-base/ Base Course (Loose Quantity)	Grading Classification & Size	Loose Qty.
Grading 1	63 mm to 45 mm	75 mm	0.91 to 1.07 m ³	Type A 13.2 mm	0.12 to 0.15 m ³	Not uniform	0.22 to 0.24 m ³
-do-	-do-	-do-	-do-	Type B 11.2 mm	0.20 to 0.22 m ³	-do-	-do-
Grading 2	53 mm to 22.4 mm	75 mm	-do-	-do-	0.18 to 0.21 m ³	-do-	-do-

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

Application of binding materials may not be necessary when the screenings used are of crushable type such as moorum or gravel.

404.3 Construction Operations

404.3.1 Preparation of Base

The surface of the sub-grade/sub-base/base to receive the water bound macadam course shall be prepared to the specified grade and camber and cleaned of dust, dirt and other extraneous material. Any ruts or soft yielding places shall be corrected in an approved manner and rolled until firm surface is obtained.

Where the WBM is to be laid on an existing metalled road, damaged area including depressions and potholes shall be repaired and made good with the suitable material. The existing surface shall be scarified and re-shaped to the required grade and camber before spreading the coarse aggregate for WBM.

As far as possible, laying water bound macadam course over existing bituminous layer may be avoided since it will cause problems of internal drainage of the pavement at the interface of two courses. It is desirable to completely pick out the existing thin bituminous wearing course where water bound macadam is proposed to be laid over it.

404.3.2 Inverted Choke/Sub-surface Drainage Layer

If water bound macadam is to be laid directly over the sub-grade, without any other intervening pavement course, a 25 mm course of screenings (Grading B) or coarse sand shall be spread on the prepared sub-grade before application of the aggregates is taken up. In case of a fine sand or silty or clayey sub-grade, it is advisable to lay 100 mm insulating layer of screening or coarse sand on top of fine grained soil, the gradation of which will depend upon whether it is intended to act as a drainage layer as well. As a preferred alternative to inverted choke, appropriate geosynthetics performing functions of separation and drainage may be used over the prepared sub-grade as directed by the Engineer. Section 700 shall be applicable for use of geosynthetics.

404.3.3 Lateral Confinement of Aggregates

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

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 sub-grade level except where widening specifications envisages laying of a stabilised sub-base using in-situ operations in which case the same should be removed only up to the sub-base level.

404.3.4 Spreading Coarse Aggregates

The coarse aggregates shall be spread uniformly and evenly upon the prepared sub-grade/ sub-base in the required quantities from the stockpiles to proper profile by using templates placed across the road about 6 m apart, in such quantities that the thickness of each compacted layer is not more than 75 mm. 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. Wherever possible, approved mechanical devices such as aggregate spreader shall be used to spread the aggregates uniformly so as to minimize the need for manual rectification afterwards.

No segregation of coarse aggregates shall be allowed and the coarse aggregates, as spread shall be of uniform gradation with no pockets of fine material.

The surface of the aggregates spread shall be carefully checked with templates and all high or low spots remedied by removing or adding aggregates as may be required. The surface shall be checked frequently with a straight edge while spreading and rolling so as to ensure a finished surface as per approved drawings.

The coarse aggregates shall not normally be spread more than 3 days in advance of the subsequent construction operations.

404.3.5 Rolling

Immediately following the spreading of the coarse aggregates, rolling shall be started with three wheeled power rollers of 80 to 100 kN capacity or tandem or vibratory rollers of 80 to 100 kN static weight. The type of roller to be used shall be approved by the Engineer based on trial run.

Except on superelevated portions and carriageway with unidirectional cross-fall, where the rolling shall proceed from inner edge to the outer, rolling shall begin from the edges gradually progressing towards the center. First the edge/edges shall be compacted with roller running forward and backward. The roller shall then move inward parallel to the center line of the road, in successive passes uniformly overlapping preceding tracks by at least one-half width.

Rolling shall be carried out on courses where coarse aggregates of crushed/ broken stone are used, till the road metal is partially compacted. This will be followed by application of screenings and binding material where required in Clauses 404.3.6 and 404.3.7.

However, where screenings are not to be applied as in the case of aggregates like brick metal, laterite and Kankar for sub-base construction, the compaction shall be continued until the aggregates are thoroughly keyed. Rolling shall be continued and light sprinkling of water shall be done till the surface is well compacted.. Rolling shall not be done when the sub-

grade is soft or yielding or when it causes a wave-like motion in the sub-grade or sub-base course.

The rolled surface shall be checked transversely with templates and longitudinally with 3 m straight edge. Any irregularities, exceeding 12 mm, shall be corrected by loosening the surface, adding or removing necessary amount of aggregates and re-rolling until the entire surface conforms to the desired camber and grade. In no case shall the use of screenings be permitted to make up depressions.

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

404.3.6 Application of Screenings

After the coarse aggregates have been rolled to Clause 404.3.5, screenings to completely fill the interstices shall be applied gradually over the surface. These shall not be damp or wet at the time of application. Dry rolling shall be done while the screenings are being spread so that vibrations of the roller cause them to settle into the voids of the coarse aggregates. The screenings shall not be dumped in piles but be spread uniformly in successive thin layers either by the spreading motions of hand shovels or by mechanical spreaders, or directly from tipper with suitable grit spreading arrangement. Tipper operating for spreading the screenings shall be equipped with pneumatic tyres and operated so as not to disturb the coarse aggregates.

The screenings shall be applied at a slow and uniform rate (in three or more applications) so as to ensure filling of all voids. This shall be accompanied by dry rolling and brooming with mechanical brooms, hand brooms or both. In no case shall the screenings be applied so fast and thick as to form cakes or ridges on the surface in such a manner as would prevent filling of voids or prevent the direct bearing of the roller on the coarse aggregates. These operations shall continue until no more screenings can be forced into voids of the coarse aggregates. The spreading, rolling, and brooming of screenings shall be carried out in only such lengths of the road which could be completed within one day's operation.

404.3.7 Sprinkling of Water and Grouting

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 voids and to distribute them evenly. The sprinkling, sweeping and rolling operation shall be continued, with additional screenings applied as necessary until the coarse aggregates have been thoroughly keyed, well-bonded and firmly set in its full depth and a grout has been formed of screenings. Care shall be taken to see that the sub-base or sub-grade does not get damaged due to the addition of excessive quantities of water during construction.

In case of lime treated soil sub-base, construction of water bound macadam on top of it shall be taken up after curing as per Clause 402.3.9 and as directed by the Engineer.

Application of binding material : After the application of screenings in accordance with Clauses 404.3.6 and 404.3.7, the binding material where it is required to be used (Clause 404.2.7) shall be applied successively in two or more thin layers at a slow and uniform rate. After each application, the surface shall be copiously sprinkled with water, the resulting slurry swept in with hand brooms, or mechanical brooms to fill the voids properly, and rolled during which water shall be applied to the wheels of the rollers if necessary to wash down the binding material sticking to them. These operations shall continue until the resulting slurry after filling of voids, forms a wave ahead of the wheels of the moving roller.

404.3.8 Setting and Drying

After the final compaction of water bound macadam course, the pavement shall be allowed to dry overnight. Next morning hungry spots shall be filled with screenings or binding material as directed, lightly sprinkled with water if necessary and rolled. No traffic shall be allowed on the road until the macadam has set. The Engineer shall have the discretion to stop hauling traffic from using the completed water bound macadam course, if in his opinion it would cause excessive damage to the surface.

The compacted water bound macadam course shall be allowed to completely dry and set before the next pavement course is laid over it.

404.4 Surface Finish and Quality Control of Work

404.4.1 The surface finish of construction shall conform to the requirements of Clause 902.

404.4.2 Control on the quality of materials and works shall be exercised by the Engineer in accordance with Section 900.

404.4.3 The water bound macadam work shall not be carried out when the atmospheric temperature is less than 10°C in the shade.

404.4.4 Reconstruction of Defective Macadam

The finished surface of water bound macadam shall conform to the tolerances of surface regularity as prescribed in Clause 902. However, where the surface irregularity of the course exceeds the tolerances or where the course is otherwise defective due to sub-grade soil mixing with the aggregates, the course 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 re-compacted. The area treated shall not be less than 10 sq.m. In no case shall depressions be filled up with screenings or binding material.

404.5 Arrangements for Traffic

During the period of construction, the arrangements for traffic shall be done as per Clause 112.

404.6 Measurements for Payment

Water bound macadam shall be measured as finished work in position in cubic metres.

404.7 Rate

The Contract unit rate for water bound macadam sub-base/base course shall be payable in full for carrying out the required operations including full compensation for all components listed in Clause 401.7 (i) to (v), including arrangement of water used in the work as approved by the Engineer.

405 CRUSHED CEMENT CONCRETE SUB-BASE**405.1 Scope**

This work shall consist of breaking and crushing the damaged cement concrete slabs and re-compacting the same as sub-base/base course in one or more layers. The work shall be performed on such widths and lengths as may be specified, in accordance with the requirements of these Specifications and in conformity with the lines, grades and cross-sections shown on the drawings or as otherwise directed by the Engineer.

405.2 Materials**405.2.1 Coarse Aggregates**

Coarse aggregates for this work shall be broken cement concrete slabs crushed to a size not exceeding 75 mm and as far as possible, conforming to one of the gradings given in **Table 400-9**.

405.3 Construction Operations**405.3.1 General**

Crushed cement concrete sub-base course may be constructed in one or two layers, depending upon the thickness of the concrete slabs dismantled and crushed. The thickness of each layer shall not exceed 75 mm compacted thickness.

405.3.2 Preparation of Surface

The surface of the subgrade shall be prepared in accordance with Clause 404.3.1.

405.3.3 Spreading of Aggregates

The sub-base material of grading specified in the Contract shall be spread on the prepared subgrade with the help of a motor grader of adequate capacity, its blade having hydraulic controls suitable for initial adjustment and for maintaining the required slope and grade during the operation, or other means as approved by the Engineer.

405.3.4 Rolling

Immediately following the spreading of the coarse aggregates, rolling shall be started with three wheeled power rollers of 80 to 100 kN capacity or tandem or vibratory rollers of 80 to 100 kN static weight. The type of roller to be used shall be approved by the Engineer based on trial run.

Except on superelevated portions and carriageway with unidirectional cross-fall where the rolling shall proceed from inner edge to the outer, rolling shall begin from the edges gradually progressing towards the center. First the edge/edges shall be compacted with roller running forward and backward. The roller shall then move inward parallel to the center line of the road, in successive passes uniformly overlapping preceding tracks by at least one-half width.

Rolling shall be continued and light sprinkling of water shall be done till the surface is well compacted.

The rolled surface shall be checked transversely with templates and longitudinally with 3 m straight edge. Any irregularities, exceeding 12 mm, shall be corrected by loosening the surface, adding or removing necessary amount of aggregates and re-rolling until the entire surface conforms to the desired camber and grade.

405.4 Surface Finish and Quality Control of Work

The surface finish and control on the quality of materials and works shall be exercised by the Engineer in accordance with Section 900.

405.5 Arrangements for Traffic

During the period of construction, arrangement for traffic shall be done as per Clause 112.

405.6 Measurements for Payment

Breaking the existing cement concrete pavement slabs, crushing and recompact the slab material as sub-base course shall be measured as a single item in terms of the volume of sub-base laid in position in cubic metres.

405.7 Rate

The Contract unit rate for crushed cement concrete sub-base course shall be payment in full for carrying out the required operations including full compensation for:

- i) making arrangements for traffic to Clause 112 except for initial treatment to verges/shoulders and construction of diversions;
- ii) breaking the cement concrete slabs, crushing, sieving and recompact the slab material as sub-base course;
- iii) all labour, tools, equipment and incidentals to complete the work to the Specifications;
- iv) carrying out the work in part widths of road where directed; and
- v) carrying out the required tests for quality control.

406 WET MIX MACADAM SUB-BASE/BASE**406.1 Scope**

This work shall consist of laying and compacting clean, crushed, graded aggregate and granular material, premixed with water, to a dense mass on a prepared sub-grade/sub-base/base or existing pavement as the case may be in accordance with the requirements of these Specifications. The material shall be laid in one or more layers as necessary to lines, grades and cross-sections shown on the approved drawings or as directed by the Engineer.

The thickness of a single compacted Wet Mix Macadam layer shall not be less than 75 mm. When vibrating or other approved types of compacting equipment are used, the compacted depth of a single layer of the sub-base course may be upto 200 mm with the approval of the Engineer.

406.2 Materials**406.2.1 Aggregates****406.2.1.1 Physical Requirements**

Coarse aggregates shall be crushed stone. If crushed gravel/shingle is used, not less than

90 percent by weight of the gravel/shingle pieces retained on 4.75 mm sieve shall have at least two fractured faces. The aggregates shall conform to the physical requirements set forth in Table 400-12.

If the water absorption value of the coarse aggregate is greater than 2 percent, the soundness test shall be carried out on the material delivered to site as per IS:2386 (Part-5).

Table 400-12 : Physical Requirements of Coarse Aggregates for Wet Mix Macadam for Sub-base/Base Courses

S. No.	Test	Test Method	Requirements
1)	Los Angeles Abrasion value	IS:2386 (Part-4)	40 percent (Max.)
	or Aggregate Impact value	IS:2386 (Part-4) or IS:5640	30 percent (Max.)
2)	Combined Flakiness and Elongation indices (Total)	IS:2386 (Part-1)	35 percent (Max.)*

* To determine this combined proportion, the flaky stone from a representative sample should first be separated out. Flakiness index is weight of flaky stone metal divided by weight of stone sample. Only the elongated particles be separated out from the remaining (non-flaky) stone metal. Elongation index is weight of elongated particles divided by total non-flaky particles. The values of flakiness index and elongation index so found are added up.

406.2.1.2 Grading Requirements

The aggregates shall conform to the grading given in Table 400-13.

Table 400-13 : Grading Requirements of Aggregates for Wet Mix Macadam

IS Sieve Designation	Percent by weight passing the IS Sieve
53.00 mm	100
45.00 mm	95–100
26.50 mm	–
22.40 mm	60–80
11.20 mm	40–60
4.75 mm	25–40
2.36 mm	15–30
600.00 micron	8–22
75.00 micron	0–5

Material finer than 425 micron shall have Plasticity Index (PI) not exceeding 6.

The final gradation approved within these limits shall be graded from coarse to fine and shall not vary from the low limit on one sieve to the high limit on the adjacent sieve or vice versa.

406.3 Construction Operations

406.3.1 Preparation of Base

Clause 404.3.1 shall apply.

406.3.2 Provision of Lateral Confinement of Aggregates

While constructing wet mix macadam, arrangement shall be made for the lateral confinement of wet mix. This shall be done by laying materials in adjoining shoulders along with that of wet mix macadam layer and following the sequence of operations described in Clause 404.3.3.

406.3.3 Preparation of Mix

Wet Mix Macadam shall be prepared in an approved mixing plant of suitable capacity having provision for controlled addition of water and forced/ positive mixing arrangement like pugmill or pan type mixer of concrete batching plant. The plant shall have following features:

- i) For feeding aggregates– three/ four bin feeders with variable speed motor
- ii) Vibrating screen for removal of oversize aggregates
- iii) Conveyor Belt
- iv) Controlled system for addition of water
- v) Forced/positive mixing arrangement like pug-mill or pan type mixer
- vi) Centralized control panel for sequential operation of various devices and precise process control
- vii) Safety devices

Optimum moisture for mixing shall be determined in accordance with IS:2720 (Part-8) after replacing the aggregate fraction retained on 22.4 mm sieve with material of 4.75 mm to 22.4 mm size. While adding water, due allowance should be made for evaporation losses. However, at the time of compaction, water in the wet mix should not vary from the optimum value by more than agreed limits. The mixed material should be uniformly wet and no segregation should be permitted.

406.3.4 Spreading of Mix

Immediately after mixing, the aggregates shall be spread uniformly and evenly upon the prepared sub-grade/sub-base/base in required quantities. 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 stretch be permitted.

The mix may be spread by a paver finisher. The paver finisher shall be self-propelled of adequate capacity with following features:

- i) Loading hoppers and suitable distribution system, so as to provide a smooth uninterrupted material flow for different layer thicknesses from the tipper to the screed.
- ii) Hydraulically operated telescopic screed for paving width upto to 8.5 m and fixed screed beyond this. The screed shall have tamping and vibrating arrangement for initial compaction of the layer.
- iii) Automatic levelling control system with electronic sensing device to maintain mat thickness and cross slope of mat during laying procedure.

In exceptional cases where it is not possible for the paver to be utilized, mechanical means like motor grader may be used with the prior approval of the Engineer. The motor grader shall be capable of spreading the material uniformly all over the surface.

The surface of the aggregate shall be carefully checked with templates and all high or low spots remedied by removing or adding aggregate as may be required. The layer may be tested by depth blocks during construction. No segregation of larger and fine particles should be allowed. The aggregates as spread should be of uniform gradation with no pockets of fine materials.

The Engineer may permit manual mixing and /or laying of wet mix macadam where small quantity of wet mix macadam is to be executed. Manual mixing/laying in inaccessible/ remote locations and in situations where use of machinery is not feasible can also be permitted. Where manual mixing/laying is intended to be used, the same shall be done with the approval of the Engineer.

406.3.5 Compaction

After the mix has been laid to the required thickness, grade and crossfall/camber the same shall be uniformly compacted to the full depth with suitable roller. If the thickness of single compacted layer does not exceed 100 mm, a smooth wheel roller of 80 to 100kN weight may be used. For a compacted single layer upto 200 mm, the compaction shall be done with the help of vibratory roller of minimum static weight of 80 to 100 kN with an arrangement

for adjusting the frequency and amplitude. An appropriate frequency and amplitude may be selected. The speed of the roller shall not exceed 5 km/h.

In portions having unidirectional cross fall/superelevation, rolling shall commence from the lower edge and progress gradually towards the upper edge. Thereafter, roller should progress parallel to the center line of the road, uniformly over-lapping each preceding track by at least one-third width until the entire surface has been rolled. Alternate trips of the roller shall be terminated in stops at least 1 m away from any preceding stop.

In portions in camber, rolling should begin at the edge with the roller running forward and backward until the edges have been firmly compacted. The roller shall then progress gradually towards the center parallel to the center line of the road uniformly overlapping each of the preceding track by at least one-third width until the entire surface has been rolled.

Any displacement occurring as a result of reversing of the direction of a roller or from any other cause shall be corrected at once as specified and/or removed and made good.

Along forms, kerbs, walls or other places not accessible to the roller, the mixture shall be thoroughly compacted with mechanical tampers or a plate compactor. Skin patching of an area without scarifying the surface to permit proper bonding of the added material shall not be permitted.

Rolling should not be done when the sub-grade is soft or yielding or when it causes a wave-like motion in the sub-base/base course or sub-grade. If irregularities develop during rolling which exceed 12 mm when tested with a 3 m straight edge, the surface should be loosened and premixed material added or removed as required before rolling again so as to achieve a uniform surface conforming to the desired grade and crossfall. In no case shall the use of unmixed material be permitted to make up the depressions.

Rolling shall be continued till the density achieved is at least 98 percent of the maximum dry density for the material as determined by the method outlined in IS:2720 (Part-8).

After completion, the surface of any finished layer shall be well-closed, free from movement under compaction equipment or any compaction planes, ridges, cracks and loose material. All loose, segregated or otherwise defective areas shall be made good to the full thickness of the layer and recompact.

406.3.6 Setting and Drying

After final compaction of wet mix macadam course, the road shall be allowed to dry for 24 hours.

406.4 Opening to Traffic

No vehicular traffic shall be allowed on the finished wet mix macadam surface. Construction equipment may be allowed with the approval of the Engineer.

406.5 Surface Finish and Quality Control of Work**406.5.1 Surface Evenness**

The surface finish of construction shall conform to the requirements of Clause 902.

406.5.2 Quality Control

Control on the quality of materials and works shall be exercised by the Engineer in accordance with Section 900.

406.6 Rectification of Surface Irregularity

Where the surface irregularity of the wet mix macadam course exceeds the permissible tolerances or where the course is otherwise defective due to sub-grade soil getting mixed with the aggregates, the full thickness of the layer shall be scarified over the affected area, re-shaped with added premixed material or removed and replaced with fresh premixed material as applicable and recompact in accordance with Clause 406.3. The area treated in the aforesaid manner shall not be less than 5 m long and 2 m wide. In no case shall depressions be filled up with unmixed and ungraded material or fines.

406.7 Arrangement for Traffic

During the period of construction, arrangements for traffic shall be done as per Clause 112.

406.8 Measurements for Payment

Wet mix macadam shall be measured as finished work in position in cubic metres.

406.9 Rate

The Contract unit rate for wet mix macadam shall be payment in full for carrying out the required operations including full compensation for all components listed in Clause 401.7.

407 CRUSHER-RUN MACADAM BASE**407.1 Scope**

This work shall consist of furnishing, placing and compacting crushed stone aggregate