900

Quality Control for Road Works

901. GENERAL

901.1. All materials to be used, all methods adopted and all works performed shall be strictly in accordance with the requirements of these Specifications. The Contractor shall set up a field laboratory at locations approved by the Engineer and equip the same with adequate equipment and personnel in order to carry out all required tests and Quality Control work as per Specifications and/or as directed by the Engineer. The internal layout of the laboratory shall be as per Clause 121 and/or as directed by the Engineer. The list of equipment and the facilities to be provided shall be got approved from the Engineer in advance.

901.2. The Contractor's laboratory should be manned by a qualified Materials Engineer/Civil Engineer assisted by experienced technicians, and the set-up should be got approved by the Engineer.

901.3. The Contractor shall carry out quality control tests on the materials and work to the frequency stipulated in subsequent paragraphs. In the absence of clear indications about method and or frequency of tests for any item, the instructions of the Engineer shall be followed.

901.4. For satisfying himself about the quality of the materials and work, quality control tests will also be conducted by the Engineer (by himself, by his Quality Control Units or by any other agencies deemed fit by him), generally to the frequency set forth hereinunder. Additional tests may also be conducted where, in the opinion of the Engineer, need for such tests exists.

901.5. The Contractor shall provide necessary co-operation and assistance in obtaining the samples for tests and carrying out the field tests as required by the Engineer from time to time. This may include provision of labour, attendants, assistance in packing and despatching and any other assistance considered necessary in connection with the tests.

901.6. For the work of embankment, subgrade and pavement, construction of subsequent layer of same or other material over the finished layer shall be done after obtaining permission from the Engineer. Similar permission from the Engineer shall be obtained in respect of all other items of works prior to proceeding with the next stage of construction.

901.7. The Contractor shall carry out modifications in the procedure of work, if found necessary, as directed by the Engineer during inspection. Works falling short of quality shall be rectified/redone by the Contractor at his own cost, and defective work shall also be removed from the site of works by the Contractor at his own cost.

901.8. The cost of laboratory building including services, essential supplies like water, electricity, sanitary services and their maintenance and cost of all equipment, tools, materials, labour and incidentals to perform tests and other operations of quality control according to the Specification requirements shall be deemed to be incidental to the work and no extra payment shall be made for the same. If, however, there is a separate item in the Bill of Quantities for setting up of a laboratory and installing testing equipment, such work shall be paid for separately.

901.9. For testing of samples of soils/soil mixes, granular materials, and mixes, bituminous materials and mixes, aggregates, cores etc., samples in the required quantity and form shall be supplied to the Engineer by the Contractor at his own cost.

901.10. For cement, bitumen, mild steel, and similar other materials where essential tests are to be carried out at the manufacturer's plants or at laboratories other than the site laboratory, the cost of samples, sampling, testing and furnishing of test certificates shall be borne by the Contractor. He shall also furnish the test certificates to the Engineer.

901.11. For testing of cement concrete at site during construction, arrangements for supply of samples, sampling, testing and supply of test results shall be made by the Contractor as per the frequency and number of tests specified in the Handbook of Quality Control for Construction of Roads and Runways (IRC : SP : 11) and relevant IS Codes or relevant clauses of these Specifications, the cost of which shall be borne by the Contractor.

901.12. The method of sampling and testing of materials shall be as required by the "Handbook of Quality Control for Construction of Roads and Runways" (IRC : SP : 11), and these MOST Specifications. Where they are contradicting, the provision in these Specifications shall be followed. Where they are silent, sound engineering practices shall be adopted. The sampling and testing procedure to be used shall be as approved by the Engineer and his decision shall be final and binding on the Contractor.

901.13. The materials for embankment construction shall be got approved from the Engineer. The responsibility for arranging and obtaining the land for borrowing or exploitation in any other way shall rest with the Contractor who shall ensure smooth and uninterrupted supply of materials in the required quantity during the construction period.

Similarly, the supply of aggregates for construction of road pavement shall be from quarries approved by the Engineer. Responsibility for arranging uniterrupted supply of materials from the source shall be that of the Contractor.

901.14. Defective Materials

All materials which the Engineer/his representative has determined as not conforming to the requirements of the Contract shall be rejected whether in place or not; they shall be removed immediately from the site as directed. Materials, which have been subsequently corrected, shall not be used in the work unless approval is accorded in writing by the Engineer. Upon failure of the Contractor to comply with any order of the Engineer/his representative, given under this Clause, the Engineer/his representative shall have authority to cause the removal of rejected material and to deduct the removal cost thereof from any payments due to the Contractor.

901.15. Imported Materials

At the time of submission of tenders, the Contractor shall furnish a list of materials/finished products manufactured, produced or fabricated outside India which he proposes to use in the work. The Contractor shall not be entitled to extension of time for acts or events occurring outside India and it shall be the Contractor's responsibility to make timely delivery to the job site of all such materials obtained from outside India.

The materials imported from outside India shall conform to the relevant Specifications of the Contract. In case where materials/ finished products are not covered by the Specifications in the Contract, the details of Specifications proposed to be followed and the testing procedure as well as laboratories/ establishments where tests are to be carried out shall be specifically brought out and agreed to in the Contract.

The Contractor shall furnish to the Engineer a certificate of compliance of the tests carried out. In addition, certified mill test reports clearly identified to the lot of materials shall be furnished at the Contractor's cost.

902. CONTROL OF ALIGNMENT, LEVEL AND SURFACE REGULARITY

902.1. General

All works performed shall conform to the lines, grades, cross sections and dimensions shown on the drawings or as directed by the Engineer, subject to the permitted tolerances described herein-after.

902.2. Horizontal Alignment

Horizontal alignments shall be reckoned with respect to the centre line of the carriageway as shown on the drawings. The edges of the carriageway as constructed shall be correct within a tolerance of ± 10 mm therefrom. The

corresponding tolerance for edges of the roadway and lower layers of pavement shall be ± 25 mm.

902.3. Surface Levels

The levels of the subgrade and different pavement courses as constructed, shall not vary from those calculated with reference to the longitudinal and cross-profile of the road shown on the drawings or as directed by the Engineer beyond the tolerances mentioned in Table 900-1.

TABLE 900-1. TOLERANCES IN SURFACE LEVELS

1.	Subgrade	+ 20 mm - 25 mm
2.	Sub-base + 10 mm	
	(a) Flexible pavement	- 20 mm
	(b) Concrete pavement	+ 6 mm
	[Dry lean concrete or Rolled concrete]	- 10 mm
3.	Base-course for flexible pavement	
	(a) Bituminous course	+ 6 mm - 6mm
	(b) Other than bituminous	+ 10 mm
	(i) Machine laid	- 10 mm
		+ 15 mm
	(ii) Manually laid	- 15 mm
4.	Wearing course for flexible pavement	
	(a) Machine laid	+ 6 mm - 6 mm
	(b) Manually laid	+ 10 mm - 10 mm
5.	Cement concrete pavement	+ 5 mm - 6 mm *

* This may not exceed - 8 mm at 0 - 30 cm from the edges.

Provided, however, that the negative tolerance for wearing course shall not be permitted in conjunction with the positive tolerance for base course, if the thickness of the former is thereby reduced by more than 6 mm for flexible pavements and 5 mm for concrete pavements.

For checking compliance with the above requirement for subgrade, sub-base and base courses, measurements of the surface levels shall be taken on a grid of points placed at 6.25 m longitudinally and 3.5 m transversely. For any 10 consecutive measurements taken longitudinally or transversly, not more than one measurement shall be permitted to exceed the tolerance as above, this one measurement being not in excess of 5 mm above the

permitted tolerance.

For checking the compliance with the above requirement for bituminous wearing courses and concrete pavements, measurements of the surface levels shall be taken on a grid of points spaced at 6.25 m along the length and at 0.5 m from the edges and at the centre of the pavement. In any length of pavement, compliance shall be deemed to be met for the final road surface, only if the tolerance given above is satisfied for any point on the surface.

902.4. Surface Regularity of Pavement Courses

The longitudinal profile shall be checked with a 3 metre long straight edge/moving straight-edge as desired by the Engineer at the middle of each traffic lane along a line parallel to the centre line of the road.

The maximum permitted number of surface irregularities shall be as per Table 900-2.

TABLE 900-2. MAXIMUM PERMITTED NUMBER OF SURFACE IRREGULARITIES

	Surfaces of carriageways and paved shoulders				Surfaces of laybys, service areas and all bituminous base courses			
Irregularity	4 mm		7 mm		4 mm		7 mm	
Length(m)	300	75	300	75	300	75	300	75
National Highways/ Expressways*	20	9	2	1	40	18	4	2
Roads of lower category*	40	18	4	2	60	27	6	3

*Category of each section of road as described in the Contract.

The maximum allowable difference between the road surface and underside of a 3 m straight-edge when placed parallel with, or at right angles to the centre line of the road at points decided by the Engineer shall be:

for pavement surface (bituminous and cement concrete)	3 mm
for bituminous base courses	6 mm
for granular sub-base/ base courses	8 mm
for sub-bases under concrete pavements	10 mm

902.5. Rectification

Where the surface regularity of subgrade and the various pavement courses fall outside the specified tolerances, the Contractor shall be liable to rectify these in the manner described below and to the satisfacion of the Engineer.

(i) **Subgrade:** Where the surface is high, it shall be trimmed and suitably compacted. Where the same is low, the deficiency shall be corrected by scarifying the lower layer and adding fresh material and recompacting to the required density. The degree of compaction and the type of material to be used shall conform to the requirements of Clause 305.

(ii) **Granular Sub-base:** Same as at (i) above, except that the degree of compaction and the type of material to be used shall conform to the requirements of Clause 401.

(iii) **Lime/Cement Stabilized Soil Sub-base:** For lime/cement treated materials where the surface is high, the same shall be suitably trimmed while taking care that the material below is not disturbed due to this operation. However, where the surface is low, the same shall be corrected as described herein below.

For cement treated material, when the time elapsed between detection of irregularity and the time of mixing of the material is less than 2 hours, the surface shall be scarified to a depth of 50 mm supplemented with freshly mixed materials as necessary and recompacted to the relevant specification. When this time is more than 2 hours, the full depth of the layer shall be removed from the pavement and replaced with fresh material to Specification. This shall also apply to lime treated material except that the time criterion shall be 3 hours instead of 2 hours.

(iv) **Water Bound Macadam/Wet Mix Macadam Sub-base/Base:** Where the surface is high or low, the top 75 mm shall be scarified, reshaped with added material as necessary and recompacted to Clause 404. This shall also apply to wet mix macadam to Clause 406.

(v) **Bituminous Constructions:** For bituminous construction other than wearing course, where the surface is low, the deficiency shall be corrected by adding fresh material over a suitable tack coat if needed and recompacting to specifications. Where the surface is high, the full depth of the layer shall be removed and replaced with fresh material and compacted to specifications.

For wearing course, where the surface is high or low, the full depth of the layer shall be removed and replaced with fresh material and compacted to specifications. In all cases where the removal and replacement of a bituminous layer is involved, the area treated shall not be less than 5 m in length and not less than 3.5 m in width.

(vi) **Dry Lean Concrete Sub-base/Rolled Cement Concrete:** The defective length of the course shall be removed to full depth and replaced with material conforming to Clauses 601 or 603, as applicable. The area treated shall be at least 3 m long, not less than 1 lane wide and extend to the full depth. Before relaying the course, the disturbed subgrade or layer below shall be corrected by levelling, watering and compacting.

(vii) **Cement concrete pavement:** The defective areas having surface irregularity exceeding 3 mm but not greater than 6 mm may be rectified by bump cutting or scrabbling or grinding using approved equipment. When required by the Engineer, areas which have been reduced in level by the above operation(s) shall be retextured

in an approved manner either by cutting grooves (5 mm deep) or roughening the surface by hacking the surface. If high areas in excess 6 mm or low areas in excess of 3 mm occur, exceeding the permitted numbers and if the Contractor cannot rectify, the slab shall be demolished and reconstructed at the Contractor's expense and in no case the area removed shall be less than the full width of the lane in which the irregularity occurs and full length of the slab.

If deemed necessary by the Engineer, any section of the slab which deviates from the specified levels and tolerances shall be demolished and reconstructed at the Contractor's expense.

903. QUALITY CONTROL TESTS DURING CONSTRUCTION

903.1. General

The materials supplied and the works carried out by the Contractor shall conform to the specifications prescribed in the preceding Clauses.

For ensuring the requisite quality of construction, the materials and works shall be subjected to quality control tests, as described hereinafter. The testing frequencies set forth are the desirable minimum and the Engineer shall have the full authority to carry out additional tests as frequently as he may deem necessary, to satisfy himself that the materials and works comply with the appropriate specifications. However, the number of tests recommended in Tables 900-3 and 900-4 may be reduced at the discretion of the Engineer if it is felt that consistency in the quality of materials can still be maintained with the reduced number of tests.

Test procedures for the various quality control tests are indicated in the respective Sections of these Specifications or for certain tests within this Section. Where no specific testing procedure is mentioned, the tests shall be carried out as per the prevalent accepted engineering practice to the directions of the Engineer.

903.2. Tests on Earthwork for Embankment, Subgrade Construction and Cut Formation

903.2.1. Borrow material : Grid the borrow area at 25 m c/c (or closer, if the variability is high) to full depth of proposed working. These pits should be logged and plotted for proper identification of suitable sources of material. The following tests on representative samples shall be carried out:

(a) **Sand Content [IS: 2720 (Part-4)]**: 2 tests per 3000 cubic metres of soil.

(b) **Plasticity Test [IS: 2720 (Part-5)]**: Each type to be tested, 2 tests per 3000 cub. metres of soil.

(c) **Density Test [IS:2720 (Part 8)]**: Each soil type to be tested, 2 tests per 3000 cubic metres of soil.

(d) **Deleterious Content Test [IS:2720 (Part-27)]**: As and when required by the Engineer.

(e) **Moisture Content Test [IS :2720 (Part-2)]:** One test for every 250 cubic metres of soil.

(f) **CBR Test on materials to be incorporated in the subgrade on soaked/unsoaked samples [IS : 2720 (Part-16)]:** One CBR test for every 3000 cu. m. atleast or closer as and when required by the Engineer.

903.2.2. Compaction Control : Control shall be exercised on each layer by taking at least one measurement of density for each 1000 square metres of compacted area, or closer as required to yield the minimum number of test results for evaluating a day's work on statistical basis. The determination of density shall be in accordance with IS: 2720 (Part-28). Test locations shall be chosen only through random sampling techniques. Control shall not be based on the result of any one test but on the mean value of a set of 5-10 density determinations. The number of tests in one set of measurements shall be 6 (if non-destructive tests are carried out, the number of tests shall be doubled) as long as it is felt that sufficient control over borrow material and the method of compaction is being exercised. If considerable variations are observed between individual density results, the minimum number of tests in one set of measurement shall be increased to 10. The acceptance criteria shall be subject to the condition that the mean density is not less than the specified density plus:

$$\left[1.65 - \frac{1.65}{(\text{No. of samples})^{0.5}}\right] \text{times the standard deviation.}$$

However, for earthwork in shoulders (earthen) and in the subgrade, at least one density measurement shall be taken for every 500 square metres for the compacted area provided further that the number of tests in each set of measurements shall be atleast 10. In other respects, the control shall be similar to that described earlier.

903.2.3. Cut formation : Tests for the density requirements of cut formation shall be carried out in accordance with Clause 903.2.2.

903.3. Tests on Sub-bases and Bases (excluding bitumen bound bases)

The tests and their frequencies for the different types of bases and sub-bases shall be as given in Table 900-3. The evaluation of density results and acceptance criteria for compaction control shall be on lines similar to those set out in Clause 903.2.2.

903.3.1. Acceptance criteria: The acceptance criteria for tests on the strength of cement/lime stabilised soil and distribution of stabiliser content shall be subject to the condition that the mean value is not less than the

specified value plus :

$$\left[1.65 - \frac{1.65}{(\text{No. of samples})^{0.5}}\right] \text{ times the standard deviation.}$$

TABLE 900-3. CONTROL TESTS AND THEIR MINIMUM FREQUENCY FOR SUB-BASES AND BASES (EXCLUDING BITUMEN BOUND BASES)

Sl. No.	Type of Construction		Test	Frequency (min.)
1	Granular	(i)	Gradation	One test per 200 m^3
		(ii)	Atterberg limits	One test per 200 m^3
		(iii)	Moisture content prior to compaction	One test per 250m^2
		(iv)	Density of compacted layer	One test per 500 m^2
		(v)	Deleterious constituents	As required
		(vi)	C.B.R.	As required
2.	Lime/Cement Stabilised Soil Sub-base	(i)	Quality of lime/ cement	One test for each consignment subject to a minimum of one test per 5 tonnes
		(ii)	Lime/Cement content	Regularly, through procedural checks
		(iii)	Degree of pulverisation	Periodically as considered necessary
		(iv)	CBR or Unconfined Compressive Strength test on a set of 3 specimens	As required
		(v)	Moisture content prior to compaction	One test per 250 sq. m.
		(vi)	Density of compacted layer	One test per 500 m^2
		(vii)	Deleterious constituents	As required
3.	Water Bound Macadam	(i)	Aggregate Impact Value	One test per 200 m^3 of aggregate
		(ii)	Grading	One test per 100 m^3
		(iii)	Flakiness Index and Elongation Index	One test per 200 m^3 of aggregate
		(iv)	Atterberg limits of binding material	One test per 25 m^3 of binding material

S.No.	Type of Construction		Test	Frequency (min.)
		(v)	Atterberg limits of portion of aggregate passing 425 micron sieve	One test per 100 cubic metre of aggregate
4.	Wet Mix Macadam	(i)	Aggregate Impact Value	One test per 200 m^3 of aggregate
		(ii)	Grading	One test per 100 m^3 of aggregate
		(iii)	Flakiness and Elongation Index	One test per 200 m^3 of aggregate
		(iv)	Atterberg limits of portion of aggregate passing 425 micron sieve	One test per 100 m^3 of aggregate
		(v)	Density of compacted layer.	One test per 500 m^2

903.4. Tests on Bituminous Construction

903.4.1. Tests and frequency : The tests and their minimum frequencies for the different types of bituminous works shall be as given in Table 900-4. The Engineer may direct additional testing as required.

903.4.2. Acceptance criteria : The acceptance criteria for tests on density and Marshall stability shall be subject to the condition that the mean value is not less than the specified value plus :

$$\left[1.65 - \frac{1.65}{(\text{No. of samples})^{0.5}}\right] \text{times the standard deviation}$$

TABLE 900-4. CONTROL TESTS FOR BITUMINOUS WORKS, AND THEIR MINIMUM FREQUENCY

Sl. No.	Type of Construction	Test		Frequency (min.)
1.	Prime Coat/Tack Coat/ Fog Spray	(i)	Quality of binder	Number of samples per lot and tests as per IS:73, IS:217 and IS:8887 as applicable.
		(ii)	Binder temperature for application	At regular close intervals
		(iii)	Rate of spread of Binder	One test per 500m^2 and not less than two tests per day.
2.	Seal Coat/Surface Dressing	(i)	Quality of Binder	Same as mentioned under Serial No. 1
		(ii)	Aggregate Impact Value/Los Angeles Abrasion Value	One test per 50 m^3 of aggregate
		(iii)	Flakiness Index and Elongation Index	-do-

	(iv)	Stripping value of aggregates (Immersion Tray Test)	Initially one set of 3 representative specimens for each source of supply. Subsequently when warranted by changes in the quality of aggregates
	(v)	Water absorption of aggregates	-do-
	(vi)	Water sensitivity of mix	Initially one set of 3 representative specimens for each source of supply. Subsequently when warranted by changes in the quality of aggregates (if required)
	(vii)	Grading of aggregates	One test per 25 m^3 of aggregate
	(viii)	Soundness (Magnesium and Sodium Sulphate)	Initially, one determination by each method for each source of supply, then as warranted by change in the quality of the aggregates.
	(ix)	Polished stone value	As required
	(x)	Temperature of binder at application	At regular close intervals
	(xi)	Rate of spread of materials	One test per 500 m^2 of work, and, not less than two tests per day
	(xii)	Percentage of fractured faces	When gravel is used, one test per 50m^3 of aggregate
3. Open-graded Premix Surfacing/ Close-graded Premix Surfacing	(i)	Quality of binder	Same as mentioned under Serial No. 1
	(ii)	Aggregate Impact Value/Los Angeles Abrasion Value	Same as mentioned under Serial No.2
	(iii)	Flakiness Index and Elongation Index	-do-
	(iv)	Stripping value	Same as mentioned under Serial No.2
	(v)	Water absorption of aggregates	Same as mentioned under Serial No.2
	(vi)	Water sensitivity of mix	Same as mentioned under Serial No. 2
	(vii)	Grading of aggregates	Same as mentioned under Serial No.2
	(viii)	Soundness (Magnesium and Sodium Sulphate)	Same as mentioned under Serial No.2
	(ix)	Polished stone value	As required
	(x)	Temperature of binder at application	At regular close intervals
	(xi)	Binder content	One test per 500m^3 and not less than two tests per day

		(xii)	Rate of spread of mixed material	Regular control through checks of layer thickness
		(xiii)	Percentage of fractured faces	Same as mentioned under Serial No.2
4.	Bituminous Macadam	(i)	Quality of binder	Same as mentioned under Serial No. 1
		(ii)	Aggregate Impact Value/Los Angeles Abrasion Value	Same as mentioned under Serial No.2
		(iii)	Flakiness Index and Elongation Index	Same as mentioned under Serial No.2
		(iv)	Stripping Value	Same as mentioned under Serial No.2
		(v)	Water sensitivity of mix	-do-
		(vi)	Grading of aggregates	Two tests per day per plant both on the individual constituents and mixed aggregates from the dryer
		(vii)	Water absorption of aggregates	Same as in Serial No. 2
		(viii)	Soundness (Magnesium and Sodium Sulphate)	Same as mentioned under Serial No.2
		(ix)	Percentage of fractured faces	Same as mentioned under Serial No.2
		(x)	Binder content and aggregate grading	Periodic, subject to minimum of two tests per day per plant
		(xi)	Control of temperature of binder and aggregate for mixing and of the mix at the time of laying and rolling	At regular close intervals
		(xii)	Rate of spread of mixed material	Regular control through checks of layer thickness
		(xiii)	Density of compacted layer	One test per 250m^2 of area
5.	Bituminous Penetration Macadam/Built-up Spray-Grout	(i)	Quality of binder	Same as mentioned under Serial No. 1
		(ii)	Aggregate Impact Value/Los Angeles Abrasion Value	One test per 200 m^3 of aggregate
		(iii)	Flakiness Index and Elongation Index	-do-

		(iv) Stripping value	Same as mentioned under Serial No. 2
		(v) Water absorption of aggregates	Same as Serial No. 2
		(vi) Water sensitivity of mix	Same as Serial No. 2
		(vii) Aggregate grading	One test per 100 m^3 of aggregate
		(viii) Soundness (Magnesium and Sodium Sulphate)	Same as mentioned under Serial No.2
		(ix) Percentage of fractured faces	Same as mentioned under Serial No.2
		(x) Temperature of binder at application	At regular close intervals
		(xi) Rate of spread of binder	Same as mentioned under Serial No.2
6.	Dense Bituminous Macadam/Semi Dense Bituminous Concrete/ Bituminous Concrete	(i) Quality of binder	Same as mentioned under Serial No. 1
		(ii) Aggregate Impact Value/Los Angeles Abrasion Value	Same as mentioned under Serial No.2
		(iii) Flakiness Index and Elongation Index	-do-
		(iv) Stripping Value	Same as mentioned under Serial No.2
		(v) Soundness (Magnesium and Sodium Sulphate)	Same as mentioned under Serial No.2
		(vi) Water absorption of aggregates	As in Serial No. 2
		(vii) Sand equivalent test	As required
		(viii) Plasiticity Index	As required
		(ix) Polished stone value	As required, for Semi Dense Bituminous Concrete/ Bituminous Concrete
		(x) Percentage of fractured faces	Same as mentioned under Serial No.2
		(xi) Mix grading	One set of tests on individual constituents and mixed aggregate from the dryer for each 400 tonnes of mix subject to a minimum of two tests per plant per day

		(xii) Stability of Mix	For each 400 tonnes of mix produced, a set of 3 Marshall specimens to be prepared and tested for stability, flow value, density and void content subject to a minimum of two sets being tested per plant per day
		(xiii) Water sensitivity of mix (Retained Tensile Strength)	Same as mentioned under Serial No.2
		(xiv) Swell test on the mix	As required for the Bituminous Concrete
		(xv) Control of temperature of binder in boiler, aggregate in the dryer and mix at the time of laying and rolling	At regular close intervals
		(xvi) Control of binder content and grading of the mix	One test for each 400 tonnes of mix subject to a minimum of two tests per day per plant
		(xvii) Rate of spread of mixed material	Regular control through checks on the weight of mixed material and layer thickness
		(xviii) Density of compacted layer	One test per 250 m^2 area
7.	Mastic Asphalt	(i) Quality of binder	Same as mentioned under Serial No. 1
		(ii) Aggregate Impact Value/Los Angeles Abrasion Value	Same as mentioned under Serial No.2
		(iii) Flakiness Index and Elongation Index	-do-
		(iv) Stripping Value	-do-
		(v) Water sensitivity of mix	-do-
		(vi) Grading of aggregates	Two tests per day per plant both on the individual constituents and mixed aggregates from the dryer
		(vii) Water absorption of aggregates	Same as in Serial No. 2

		(viii)	Soundness (Magnesium and Sodium Sulphate)	Same as mentioned under Serial No.2
		(ix)	Percentage of fractured faces	Same as mentioned under Serial No.2
		(x)	Binder content and aggregate grading	Periodic, subject to minimum of two tests per day per plant
		(xi)	Control of temperature of binder and aggregate for mixing and of the mix at the time of laying and rolling	At regular close intervals
		(xii)	Rate of spread of mixed material	Regular control through checks of layer thickness
		(xiii)	Hardness number	One test for each 400 tonnes of mix subject to a minimum of two tests per day
8.	Slurry seal	(i)	Quality of binder	Same as mentioned under Serial No. 1.
		(ii)	Film stripping test	Initially one set of 3 representative specimens for each source of supply, then as warranted by changes in the quality of aggregates
9.	Recycled material	(i)	Binder content and aggregate grading	Minimum of one test per 25 m^3 of recycled material
		(ii)	Recovered binder penetration	Minimum of one test per 50m^3 of recycled material
		(iii)	Mix stability (Remix/ Repave)	For each 400 tonnes of mix recycled, a set of 3 Marshall specimens to be prepared and tested for stability, flow, density and void content, subject to a minimum of two sets of tests per day
10.	Cold Mix	(i)	Quality of binder	Same as mentioned under Serial No. 1
		(ii)	Aggregate Impact Value/Los Angeles Abrasion Value	Same as mentioned under Serial No.2
		(iii)	Flakiness Index and Elongation Index	-do-
		(iv)	Stripping Value	-do-
		(v)	Water sensitivity of mix	-do-

	(vi)	Grading of aggregates	Two tests per day per plant both on the individual constituents and mixed aggregates from the dryer
	(vii)	Percentage minimum coating	Two tests per day per plant
	(viii)	Water absorption of aggregates	Same as in Serial No. 2
	(ix)	Soundness (Magnesium and Sodium Sulphate)	Same as mentioned under Serial No.2
	(x)	Percentage of fractured faces	When gravel is used, one test per 50m^3 of aggregate
	(xi)	Binder content and aggregate grading	Periodic, subject to minimum of two tests per day per plant
	(xii)	Mix stability	For each 400 tonnes of mix produced, one set of 3 Marshall specimens to be prepared and tested for stability, flow, density and void content, subject to a minimum of two sets of tests per plant per day
11. Sand Asphalt Base Course	(i)	Quality of binder	Same as mentioned under Serial No. 1
	(ii)	Los Angeles Abrasion Value	Same as mentioned under Serial No.2
	(iii)	Sand equivalent test	As required
	(iv)	Plasiticity Index	As required
	(v)	Mix grading	One set of tests on individual constituents and mixed aggregate from the dryer for each 400 tonnes of mix subject to a minimum of two tests per plant per day
	(vi)	Stability of Mix	For each 400 tonnes of mix produced, a set of 3 Marshall specimens to be prepared and tested for stability, flow value, density and void content subject to a minimum of two sets being tested per plant per day

	(vii)	Control of temperature of binder in boiler, aggregate in the dryer and mix at the time of laying and rolling	At regular close intervals
	(viii)	Control of binder content and grading of the mix	One test for each 400 tonnes of mix subject to a minimum of two tests per day per plant
	(ix)	Rate of spread of mixed material	Regular control and through checks on the weight of mixed material and layer thickness
	(x)	Density of compacted layer	One test per 250 m^2 area
12. Modified Binder	(i)	Softening Point	Initially on submission thereafter daily if site blended, weekly if pre-blended
	(ii)	Penetration at 25°C and 4°C	-do-
	(iii)	Elastic Recovery	-do-
	(iv)	Ductility	-do-
	(v)	Flash Point	-do-
	(vi)	Fraass Breaking	Initially on submission
	(vii)	Viscosity at 150°C	-do-
	(viii)	Thin film oven test, penetration, softening point, elastic recovery of residue, loss on heating	-do-
13. Geotextiles	(i)	The requirements of Clause 704.3.1 of the Ministry's Specification for Road and Bridge Works (third revision) shall apply	

903.5. Quality Control Tests for Concrete Road Construction

903.5.1. Dry lean concrete sub-base :

903.5.1.1. Sampling and testing of cubes: Samples of dry lean concrete for making cubes shall be taken from the uncompacted material from different locations immediately before compaction at the rate of 3 samples for each 1000 sq. m. or part thereof laid each day. The sampling of mix shall be done from the paving site.

Test cubes of 150 mm size shall be made immediately from each mix sample.

Cubes shall be made in accordance with the methods described in IS:516 except that the cubes shall be compacted by means of a vibratory hammer with the moulds placed on a level and rigid base. The vibrating hammer shall be electric or pneumatic type fitted with a square or rectangular foot having an area of between 7500 to 14000 sq.mm. The compaction shall be uniformly applied for 60 ± 5 seconds with a downward force of between 300 N and 400 N on to each of the three layers of the lean concrete material placed into the mould. The surface of each compacted layer shall be scarified before the next layer is added to give key for the next layer. The final layer shall be finished flush with the top of the cube mould.

The dry lean concrete cubes shall be cured in accordance with IS:516.

903.5.1.2. In-situ density: The dry density of the laid material shall be determined from three density holes at locations equally spaced along a diagonal that bisects each 2000 square metre or part thereof laid each day and shall comply with the requirements as per Clause 601.5.5.1. This rate of testing may be increased at the discretion of the Engineer in case of doubt or to determine the extent of defective area in the event of non-compliance. Density holes at random may be made to check the density at edges.

903.5.1.3. Thickness: The average thickness of the subbase layer as computed by the level data of sub-base and subgrade or lower sub-base shall be as per the thickness specified in the contract drawings. The thickness at any single location shall not be 10 mm less than the specified thickness. Such areas shall be corrected as stated in Clause 601.5.5.5. Areas which cannot be repaired should be replaced over full width. The extent of deficient area should be decided based on cores.

903.5.1.4. Frequency of quality control tests: The frequency of quality control tests for levels, alignment and materials shall be as in Table 900-6.

903.5.2. Pavement concrete

903.5.2.1. Sampling and testing of beam and cube specimens: At least two beam and two cube specimens, one each for 7 day and 28 day strength testing shall be cast for ever 150 cu.m (or part thereof) of concrete placed during construction. On each day's work, not less than three pairs of beams and cubes shall be made for each type of mix from the concrete delivered to the paving plant. Each pair shall be from a different delivery of concrete and tested at a place to be designated by the Engineer in accordance with the testing procedure as outlined in Clause 602.3.3. Groups of four consecutive results from single specimens tested at 28 days shall be used for assessing the strength for compliance with the strength requirements. The specimens shall be transported in an approved manner to prevent sudden impact causing fractures or damage to the specimen. The flexural strength test results shall prevail over compressive strength tests for compliance.

A quality control chart indicating the strength values of individual specimens shall be maintained for continuous quality assurance. Where the requirements are not met with, or where the quality of the concrete or its compaction is suspect, the actual strength of the concrete in the slab shall be ascertained by carrying out tests on cores cut from the hardened concrete at such locations. The cores shall be cut at the rate of 2 cores for every 150 cu. m. of concrete. The results of crushing strength tests on these cores shall not be less than 0.8 times the corresponding crushing strength of cubes, where the height to diameter ratio of the core is two. Where height to diameter ratio is varied, then the necessary corrections shall be made in calculating the crushing strength of cubes in the following manner.

The crushing strengths of cylinders with height to diameter ratios between 1 and 2 may be corrected to correspond to a standard cylinder of height to diameter ratio of 2 by multiplying with the correction factor obtained from the following equation:

$$f = 0.11\,n + 0.78$$

where f = correction factor and

n = height to diameter ratio

The corrected test results shall be analysed for conformity with the specification requirements for cube samples. Where the core tests are satisfactory, they shall have precedence for assessing concrete quality over the results of moulded specimens. The diameter of cores shall not be less than 150 mm.

If, however, the tests on cores also confirm that the concrete is not satisfying the strength requirements, then the concrete corresponding to

the area from which the cores were cut should be replaced, i.e., atleast over an area extending between two transverse joints where the defects could be isolated or over larger areas, if necessary, as assessed by additional cores and their test results. The equivalent flexural strength at 28 days shall be estimated in accordance with Clause 602.3.3.2.

In order to ensure that the specified minimum strength at 28 days is attained in 99 per cent of all test beams, the mix shall be proportioned to give an average strength at 28 days exceeding the specified strength by 2.33 times the standard deviation calculated first from the flexural strengths of test beams made from the trial mix and subsequently from the accumulating result of flexural strengths of job control test beams.

The standard deviation shall be re-calculated from the test results obtained after any change in the source or quality of materials and the mix shall be adjusted as necessary to comply with the requirements.

An individual 28 day test strength below the specified strength shall not be evidence for condemnation of the concrete concerned if the average 28 day strength of this beam plus the preceding 5 and succeeding 4 beams exceeds the specified strength by 2.33 times the standard deviation and provided that there is no other evidence that the concrete mix concerned is substandard.

Beams shall be made each day in pairs at intervals, each pair being from a different batch of concrete. At the start of the work, and until such time as the Engineer may order a reduction in the number of beams required, at least six pairs of beams and cubes shall be made each day, one of each pair for testing at 28 days for determination of the minimum permissible flexural strength and the other for testing at an early age for the Engineer to assess the quality of the mix. When the first thirty number of 28-day results are available, and for so long as the Engineer is satisfied with the quality of the mix, he may reduce the number of beams and cubes required.

During the course of construction, when the source of any material is to be changed, or if there is any variation in the quality of the materials furnished, additional tests and necessary adjustments in the mix shall be made as required to obtain the specified strength.

The flexural strengths obtained on beams tested before 28 days shall be used in conjunction with a correlation between them and the 28 day flexural strengths to detect any deterioration in the quality of the concrete being produced. Any such deterioration shall be remedied without awaiting the 28 day strengths but the earlier strengths shall not constitute sole evidence

of non-compliance of the concrete from which they were taken.

Concrete shall not comply with the Specification when more than one test beam in a batch has a 28 day strength less than the specified strength and the average 28 day flexural strength of the batch of beams is less than the specified strength plus 2.33 times the standard deviation of the batch.

Should the concrete fail to pass the Specification for strength as described above, the Contractor may, all at his own expense, elect to cut cores from the suspect concrete as the Engineer shall direct. From the relation between cube strength and flexural strength, the core strength shall be converted to flexural strength.

The equivalent flexural strength at 28 days shall be the estimated insitu strength multiplied by 100 and divided by the age-strength relation obtained from Table 900-5.

Any concrete that fails to meet the strength specification shall be removed and replaced at Contractor's expense.

TABLE 900-5. AGE - STRENGTH RELATION OF CONCRETE (RELATED TO 100 PER CENT AT 28 DAYS)

DAYS	0	2	4	6	8
0		41.0	60.0	71.0	77.5
10	81.5	85.0	87.5	90.0	92.0
20	94.0	96.0	97.5	98.5	100.0
30	101.0	102.0	103.5	104.5	105.5
40	106.5	107.0	108.0	109.5	110.0
50	110.5	111.0	112.0	112.5	113.0
60	114.0	114.5	115.0	115.5	116.0
70	116.5	117.0	117.5	118.0	118.5
80	119.0	119.5	119.5	120.0	120.5
90	121.0	121.5	122.0	122.0	122.5
100	123.5	123.5	123.5	124.0	124.5
110	125.0	125.0	125.5	125.5	126.0
120	126.0	126.5	127.0	127.0	127.5
130	127.5	128.0	128.5	128.5	129.0
140	129.0	129.5	129.5	130.0	130.0
150	130.5	130.5	131.0	131.0	131.5
160	131.5	131.5	132.0	132.0	132.5
170	132.5	132.5	133.0	133.0	133.5
180	133.5	134.0	134.0	134.5	134.5
190	135.0	135.0	135.0	135.5	135.5
200	135.5	135.5	136.0	136.0	136.5

210	136.5	136.5	137.0	137.0	137.0
220	137.0	137.5	137.5	137.5	138.0
230	138.0	138.5	138.5	138.5	138.5
240	139.0	139.0	139.0	139.5	139.5
250	139.5	140.0	140.0	140.0	140.0
260	140.5	140.5	140.5	140.5	141.0
270	141.0	141.0	141.5	141.5	141.5
280	142.0	142.0	142.0	142.0	142.0
290	142.5	142.5	142.5	142.5	142.5
300	143.0	143.0	143.0	143.0	143.5
310	143.5	143.5	144.0	144.0	144.0
320	144.0	144.5	144.5	144.5	144.5
330	144.5	145.0	145.0	145.0	145.0
340	145.0	145.5	145.5	145.5	145.5
350	146.0	146.0	146.0	146.0	146.0
360	146.0	146.0	146.5	146.5	146.5

903.5.2.2. In-situ density : The density of the compacted concrete shall be such that the total air voids are not more than 3 per cent. The air voids shall be derived from the difference between the theoretical maximum dry density of the concrete calculated from the specific gravities of the constituents of the concrete mix and the average value of three direct density measurements made on cores at least 150 mm diameter. Three cores shall be taken from trial lengths and in first two km length of the pavement, while the slab is being constructed during normal working. The proportions of the mix and the vibratory effort imparted i.e the frequency and magnitude of vibration shall be adjusted to achieve the maximum density.

All cores taken for density measurement in the trial section shall also be checked for thickness. The same cores shall be made use of for determining in-situ strength. In case of doubt, additional cores may be ordered by the Engineer and taken at locations decided by him to check the density of concrete slab or the position of dowel/tie bars without any compensation being paid for the same.

In calculating the density, allowance shall be made for any steel in cores.

Cores removed from the main carriageway shall be reinstated with compacted concrete with mix proportions of 1 part of portland cement : 2 parts of fine aggregate : 2 parts of 10 mm nominal size single sized coarse aggregate by weight. Before filling the fine mix, the sides shall be hacked and cleaned with water. Thereafter cement-sand slurry shall be applied to the sides just prior to filling the concrete mix.

903.5.2.3. Thickness : Thickness shall be controlled by taking levels as indicated in Clause 902.3. Thickness of the slab at any point checked as mentioned above shall be within a tolerance of -5 mm to + 25 mm of the specified thickness as per Drawing. Thickness deficiency more than 5 mm may be accepted and paid for at a reduced rate given in Clause 602.15.2. In no case, however, thickness deficiency shall be more than 25 mm.

903.5.2.4. Summary of control tests : Table 900-6 gives a summary of frequency of testing of pavement quality concrete.

TABLE 900-6 . FREQUENCY OF QUALITY CONTROL TESTS FOR PAVING QUALITY CONCRETE

1.	**Levels, alignment and texture**			
	(i) Level tolerance			Clause 902.3
	(ii) Width of pavement and position of paving edges			Clause 902.2
	(iii) Pavement thickness			Clauses 902.3 and 903.5.2.3
	(iv) Alignment of joints, widths, depths of dowel grooves			To be checked @ one Joint per 400 m length or a day's work whichever is more.
	(v) Surface regularity both transversely and longitudinally			Once a day or one day's work, without disturbing the curing operation.
	(vi) Alignment of dowel bars and their accuracy/tie bars			To be checked in trial length as per Clause 602.10 5.2 and once on every 2 km.
	(vii) Texture depth			Clause 602.9.8
2.	**Quality of Materials and Concrete**			
	Control tests for materials and concrete shall be as under:			
1.	Cement	Physical and chemical tests	IS : 269 IS : 455 IS : 1489 IS : 8112 IS : 12269	Once for each source of supply and occasionally when called for in case of long/improper storage. Besides, the Contractor also will submit daily test data on cement released by the Manufacturer.
2.	Coarse and Fine aggregates	(i) Gradation	IS: 2386 (Pt. 1)	One test for every day's work of each fraction of coarse aggregate and fine aggregate, initially; may be relaxed later at the discretion of the Engineer.
		(ii) Deleterious constituents	IS: 2386 (Pt. 2)	-do-

		(iii) Water absorption	IS:2386 (Pt. 3)	Regularly as required subject to a minimum of one test a day for coarse aggregate & two tests a day for fine aggregate. This data shall be used for correcting the water demand of the mix on daily basis.
3.	Coarse Aggregate	(i) Los Angeles Abrasion value or Aggregate Impact test	IS:2386 (Pt. 4)	Once for each source of supply and subsequently on monthly basis.
		(ii) Soundness	IS:2386 (Pt.5)	Before approving the aggregates and every month subsequently
		(iii) Alkali aggregate reactivity	IS:2386 (Pt. 7)	-do-
4.	Water	Chemical Tests	IS:456	Once for approval of source of supply, subsequently only in case of doubt.
5.	Concrete	(i) Strength of concrete	IS:516	2 cubes and 2 beams per 150 m^3 or part thereof (one for 7day and other for 28 day strength) or minimum 6 cubes and 6 beams per day's work whichever is more.
		(ii) Core strength on hardened concrete	IS:516	As per the requirement of the Engineer; only in case of doubt.
		(iii) Workability of fresh concrete-Slump Test	IS:1199	One test per each dumper load at both Batching plant site and paving site initially when work starts. Subsequently sampling may be done from alternate dumper.
		(iv) Thickness determination		From the level data of concrete pavement surface and sub-base at grid points of 5/ 6.25 m x 3.5 m
		(v) Thickness measurement for trial length		3 cores per trial length.
		(vi) Verification of level of string line in the case of slip form paving and steel forms in the case of fixed form paving		String line or steel forms shall be checked for level at an interval of 5.0 m or 6.25 m. The level tolerance allowed shall be ± 2mm. These shall be got approved 1-2 hours before the commencement of the concreting activity.

903.5.3. Rolled Concrete Base

903.5.3.1. Sampling and testing of beams and cubes : Clause 903.5.2.1 shall apply

903.5.3.2. Thickness : Thickness shall be controlled by taking levels as indicated in Clause 903.5.1.3.

903.5.3.3. In-situ density : The dry density of the laid material shall be determined from three density holes at locations equally spaced along a diagonal that bisects each 2000 square metre or part thereof laid each day and shall comply with the requirements as per Clause 601.5.5.1. This rate of testing may be increased at the discretion of the Engineer in case of doubt or to determine the extent of defective area in the event of non compliance. Density holes at random may be made to check the density at edges.

903.5.3.4. Summary of control tests : Table 900-6 gives the summary of tests for levels, alignment and materials.

903.5.4. Summary of rate of sampling and testing:

(i) Strength : 3 beams and 3 cubes for each 100 sq. m. or part thereof laid each day.

(ii) Density : 3 density holes for each 2000 sq.m. or part thereof laid each day.

(iii) Cores : Only when Engineer instructs. They shall not be cut on regular basis.

A relation between flexural strength and compressive strength may be developed by regression analysis using the available data. This may be updated from time to time.