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No. NH-11042/1/87-NHIII/DI *Dated the 18th April, 1988*

To,

1. Chief Engineers of States Union Territories PWDs dealing with National Highways
2. Director General (Works)
3. Director General Border Roads

Subject : Quality Assurance System for road works on National Highways and other Centrally sponsored Highway Schemes

The importance of ensuring adequate and effective control over the quality of National Highway and other centrally sponsored works so that they strictly conform to the specification requirements needs no special emphasis. The Ministry has been stressing on the need for effective quality control from time to time, and the last detailed circular in this regard was of letter No. RW/NHIII/P/1/83 dated 19.4.84. An exclusive provision of 1% of the cost of work is allowed in all estimates of NH projects towards quality control. Besides, financial support has been extended to States for augmenting laboratory facilities and setting up mobile testing laboratories. The requisite control tests to be conducted, their frequency, acceptance criteria, manner of rectification of works not coming up to standards, etc are laid down in Chapter 900 of the Ministry's Specifications for Road and Bridge Works (Second Revision, 1988), and guidelines in this regard are also available in the IRC Special Publication No. 11, "Handbook of Quality Control for Construction of Roads and Runways".

2. Yet, impact of quality control on works has not been felt to the desired extent, and this could be attributed to lack of a uniform and effective implementation system which, inter-alia, includes the mandatory provisions in the Contract Documents, the capacity and capability of the contractor, intensity of supervision by the Engineer etc. For bridging the gap in this regard, the Ministry have taken action in several directions. Some of these are :

(i) A system of pre-qualification of contractors has been introduced for NH works subject to certain conditions to ensure that the competing contrctors have the requisite capacity, capability, equipment and technical skills to execute the works to the requirements of specifications stipulated in the Contract.

(ii) In the Second Revised Edition of the Ministry's Specifications for Road and Bridge Works, certain new clauses have been added to ensure quality work on the part of the Contractor, and usage of appropriate equipment and techniques on the work by him. Important among these is that the final responsibility for quality of the work till completion of the maintenance period and final take-over of the work will be on the contractor irrespective of the approval in stages of the work by the Engineer.

(iii) A draft Model Contract Document for item rate tenders has been prepared and circulated among all State Chief Engineers for their comments/suggestions, *vide* No. NH-11024/2/86-NHIII/DI dated 14.10.87. This document is at present under finalisation. Till such time the final document is available, the State PWDs are requested to incorporate such clauses in the tender documents as are relevant to assurance of quality for the works.

(iv) Quality assurance has to be in-built with supervision, measurement, payment and certification. It is, therefore necessary that the Engineer supervising the work should also be responsible for ensuring and certifying that the materials incorporated and the works executed are strictly in accordance with the specifications and to the required quality standards as stipulated in the Contract Documents and as stressed by the Ministry from time to time. For conducting the necessary tests and checks to satisfy himself about the quality, the Engineer should make use of the Quality Control Units and other laboratory facilities in the Department.

3. For implementation of the quality assurance system effectively on all NH and Centrally sponsored works, while the various provisions in the Ministry's Specifications (Second Revision, 1988) should be strictly adhered to, illustrations highlighting some of the important requirements are given in the Annexure for guidance. These guidelines, inter-alia, bring out the duties and responsibilities of the Contractor and the Engineer, the crucial control tests/checks to be conducted, and the specific conditions to be incorporated in the tender documents of the work towards this end.

4. It is requested that contents of this Circular be brought to the notice of all officers in your Department dealing with National Highways and other Centrally Sponsored Road Works. At the same time, the Ministry shall be glad to receive suggestions for improving and strengthening the Quality Assurance System on the road works.

ANNEXURE

QUALITY ASSURANCE SYSTEM FOR NATIONAL HIGHWAY ROAD WORKS

1. **Introduction**

1.1 The most important requirement of any Highway construction is that the materials incorporated and the works executed and maintained are strictly in accordance with the specification, drawings and other provisions of the Contract. Road construction is a long and spread-out activity and has to be carried out in many stages. It involves several operations such as collection of naturally occurring and manufactured materials to suit the specification, requirements, selection of suitable construction equipment, choice of construction procedures and methods capable of producing and completing the work to the stipulated quality standards and prescribed time schedule; and above all, strict control over the quality of the materials and work at all stages so that the final product has the quality, durability and capability of discharging its intended functions efficiently.

1.2 The ownership of all National Highways vests with the Roads Wing of the Ministry of Surface Transport but in accordance with the provisions of the National Highways Act, powers of supervision, quality assurance, measurement, payment and acceptance of works thereon have been delegated to State PWDs/Central Government Departments on agency basis. Thus, it is incumbent on the concerned agency through its organisational structure to have the work completed to the requisite quality standards and within the prescribed time schedule.

1.3 NH works are normally executed through contract. The Ministry have separately laid down the policy as regards pre-qualification of Contractors as spelt out from time to time in its policy circulars on the subject with a view to ensuring that the prospective Contractor has the necessary capacity, capability and technical competence to execute the works to the requirements. Further, as provided in the Ministry's Specifications for Road and Bridge Works (Second Revision) and in the Model Conditions Contract circulated among all State PWDs *vide* the Ministry's letter No. NH-11024/2/86-NHIII/DI dated 14.10.87 according to which, on its finalization, for all NH works to be executed, the Contractor is responsible for the quality of the entire construction works for which purpose he should have the necessary set-up and other facilities with him. At the same time, the Engineer who is to supervise and accept the work has the responsibility to satisfy himself that the quality of the materials incorporated and the work carried but conform to the Specification requirements. Thus, both the Engineer and Contractor have their own and interactive roles to play of achieving the final objectives.

1.4 Quality Assurance, does not mean only testing of materials or the final work, but includes complete control over the entire construction process encompassing choice of appropriate equipment, working methods and procedures, etc. By this way only it will be possible to achieve not only quality final product but also uniformity which is important for durability and long-term performance of the work.

1.5 Based on the above requirements, guidelines/instructions on some of the major aspects for ensuring effective control over quality of NH and other Centrally aided works are given in the succeeding paragraphs.

2. **Provisions in the Contract Documents**

2.1 The contractual obligations on the part of the Contractor to use quality materials and execute the works in accordance with the Specifications are laid down in the "Model Conditions of Contract" and the Ministry's Specifications (Second Revision) (both referred to in para 1.3 above). Salient features of these provisions are briefly brought out below. Till such time the above referred documents are brought into operation, it is suggested that the tender agreement should incorporate the following conditions :

(i) Clause 106 of Ministry's Specification (2nd revision)

This Clause stipulates certain conditions relating to choice and use of equipment which have relevance to production of quality work. These are :

(a) The Contractor shall be required to give a trial run of the equipment for establishing capability to achieve the laid down specifications and tolerances to the satisfation of the Engineer before commencement of the work.

(b) All equipment provided shall be of proven efficiency and shall be operated and maintained at all times in a manner acceptable to the Engineer.

(c) No equipment or personnel will be removed from the site without the permission of the Engineer.

(ii) Clause 901 of Ministry's Specification (2nd revision)

(a) The responsibility for the quality of the entire construction work is on the Contractor. For this purpose, he is required to have his own independent and adequate set-up.

(b) The Engineer, for satisfying himself about the quality of the materials and work will also have tests conducted by quality control units or by any other agency, generally to the frequency set out in the Specifications. For test to be done by the Engineeer, the Contractor is to render all necessary co-operation and assistance including the provision of labour, assistance in packing and despatching samples, etc.

(c) For the work of embankment, subgrade and pavement, construction of subsequent layer of the same or other material over the finished layer shall be done only after obtaining approval from the Engineer.

(d) The Contractor shall be responsible for rectifying/replacing any work falling short of quality requirements as directed by the Engineer.

(iii) Clauses in the Conditions of Contract

(a) All materials and workmanship shall be of the respective type described in the Contract and in accordance with the Engiener's instructions and shall be subjected from time to time to such tests as the Engineer may direct at the place of manufacture or fabrication, or on the site. All samples shall be supplied by the Contractor.

(b) No work is to be covered up or put out of view without the approval of the Engineer for his examination and measurement.

(c) During the progress of the works, the Engineer shall have the power to order the removal from the site of any unsuitable material, substitution of proper and suitable material and the removal and proper re-erection notwithstanding any previous test or interim payment therefore, and of any work which in respect of materials or workmanship is not, in the opinion of the Engineer, in accordance with the contract.

3. Guidelines on Quality Control Operations

3.1 Contractor's facilities

According to the contract (see para 1.3 above), the Contractor is responsible for the quality of the entire construction work, and for this purpose he is required to have his own independent and adequate set-up. To meet this requirement :

(a) The contract shall set up his own laboratory at location (s) approved by the Engineer. The laboratory shall be equipped with modern and efficient equipment with sufficient standbyes suitable to carry out the tests prescribed for different materials and work according to the specifications. The list of equipment to be procured and the facilities to be provided shall be got approved by the Engineer. The equipment shall be maintained in a workable conditon to the satisfaction of the Engineer.

(b) Sampling and testing procedures shall be in accordance with the relevant standards of BIS (previously called ISI) or IRC. Frequency of testing shall be as laid down in the Ministry's Specifications for Roads and Bridge Work (2nd revision). In the absence of relevant Indian Standards, sampling and testing procedures shall be as approved by the Engineer.

(c) The laboratory should be manned by a qualified materials. Engineer assisted by Materials Inspectors/ Technicians, and the set-up should he got approved by the Engineer.

(d) The Contractor should prepare printed proforma for recording readings and results of each type of test, after getting the formats of the performance approved from the Engineer. He should keep a daily record of all the tests conducted by him. Two copies of the test results should be submitted to the Engineer for his examination and approval, of which one copy will be returned to the Contractor for being kept at site of work.

(e) The Materials Engineer of the Contractor should keep close liaison with the Quality Control Unit of the Engineer and keep the latter informed of the sampling and testing programme so that the Engineer's representative could be present during this activity, if considered necessary.

3.3. Engineer's Facilities

For satisfying himself about the quality of the materials and work, and for independent testing, the Engineer should have with him a Quality Control Unit with necessary laboratory facilities. This unit which may be headed by an Officer of the rank of AE/AEE should report directly to the Engineer.

3.4 Action on the part of the Engineer

(a) After award of the contract when the Engineer is moved in for supervision, his first job will be to examine the various provisions in the contract for the types of materials to be incorporated and the works to be constructed including the manner of their execution.

(b) The methodology for construction and the construction techniques should be discussed with the Contractor and the suitability of the procedure and the equipment to achieve the Specification should be carefully examined.

(c) While the construction techniques selected by the Contractor may achieve the desired specifications, selection of equipment for such techniques should also be examined in detail by the Engineer with regard to capability of achieving the desired results.

(d) The Engineer should call for information on the sources of supply for various materials proposed to be used by the Contractor, including test results/test certificates for examination. For naturally occurring materials like soil, stone aggregate moorum etc., he should inspect the site of the source/quarry and examine the manner of extraction to ensure that only materials conforming to the Specifications would be extracted and delivered to the site of work. Materials from only such sources as are approved by the Engineer should be allowed to be delivered to the site of works.

(e) For all items involving blending of more than one material, the Engineer should call for the job mix formula (JME) proposed to be used by the Contractor, and examine the same for suitability. For important items such as bituminous mixes, and for others if considered necessary, the Engineer should independently check the JMF through testing by his Quality Control Unit or at another laboratory. The Contractor should be permitted to use only the JMF approved by the Engineer.

(f) The Engineer should be in constant liaison with the Contractor or his site representative and have periodical meetings for monitoring of progress, achievement of quality work including further improvement required and

related matters, and should keep a record of the proceedings of such meetings. All discussion points of the meeting and the decision taken should be sent to the Regional Officer of Ministry of Surface Transport (Roads Wing) for information.

(g) The Engineer should evolve and lay down, in consonance with the work programme submitted by the Contractor, the programme for day-to-day checking and testing of completed works for approval to proceed ahead as well as to commence a continuation phase, in stagewise constructions. A *Stage Passing Register*, i.e. a Register in which approval of the Engineer for starting the next stage of construction is recorded and signed by the Engineer, should be maintained at site of work. The Contractor should be permitted to start on the next stage of construction only after the approval of the Engineer in writing.

(h) Set-out data for horizontal and vertical curves should be got worked out by the Contractor, and the calculations should be examined by the Engineer for approval before field operation starts. Similarly, elevations at superelevated sections and vertical curves should be got worked out by the Contractor at 10 m or less intervals for the approval of Engineer. It may be pointed out that the Contract Drawings show the final road levels, and the levels at the top of subgrade, sub-base, base and binder course should be got worked out from the thickness of the various pavement courses for control of levels at each stage. No tolerance should be permitted in the calculations. Crossfalls for the various pavement layers and subgrade should also be clearly indicated.

(i) The Engineer should keep the Ministry of Surface Transport (Roads Wing) in picture on all salient developments, changes, achievement of requisite quality of the works etc. He should have a regular contact with the Roads Wing, and if necessary, seek advice in sorting out difficulties encountered and in approving any deviation. Any deviation from the provisions of the Contract can be made by him only with the written approval of the MOST (Roads Wing).

3.5 Day-to-day Quality Control Operations

The day-to-day controls to be exercised by the Contractor and the Engineer are enumerated in the below paragraphs.

3.5.1 Alignment and level control

(a) The Contractor should locate the centre-line of the road from the pegs, pillars or reference points fixed during the location survey and from the information furnished in the Contract drawings. Any discrepancy between the reference points on the ground and those on the drawings should immediately be brought to the notice of the Engineer for reconciliation.

(b) Based on the approved centre-line, the Contractor should set up batter pegs (to delineate the limits of embankment/cutting) and clearing stakes (to delineate limits of clearing and grubbing) and have these got checked and approved by the Engineer.

(c) The Contractor should check the reduced levels of bench marks set up along the alignment. Any discrepancy in the reduced levels of those at site and as indicated in the drawings should immediately be brought to the notice of the Engineer for reconciliation. The Contractor should re-establish those bench marks which are found missing at site, and should establish additional bench marks, as needed, for ensuring effective level control.

(d) The Contractor shall be responsible for the true and proper setting out of the works in relation to original survey points, lines and levels of reference given by the Engineer in writing. If at any time during the progress of the works, any error shall appear or arise in the position, levels, dimensions or alignment of any part of the works, the Contractor on being required to do so by the Engineer, shall, at his own cost, rectify the error to the satisfaction of the Engineer, unless such error is based on incorrect data supplied in writing by the Engineer.

(e) The Contractor shall carefully protect and preserve all bench marks, reference pillars and pegs used in setting out the works, till final take over by the Engineer.

3.5.2. Natural ground for embankment construction/cut formation and their compaction

(a) Atterberg Limits, in-situ dry density and CBR of the material at ground/cut formation level, should be determined and got approved by the Engineer. Any unsuitable material shall be removed and replaced by better material as ordered by the Engineer.

(b) The Engineer's Quantity Control Unit (s) shall have independent test checks on the quality and compaction of the natural ground/cut formation

3.5.3. Embankment Construction

(a) All borrow areas shall be got approved by the Engineer based on results of tests for Atterberg Limits, Proctor/ modified proctor density, CBR and soil classification.

(b) Layer thickness and in-situ density shall be checked and not approved by the Engineer before proceeding to the next layer.

3.5.4. Subgrade

(a) Specific borrow areas having soil satisfying the requirements of specifications and specified strength criteria shall be identified for use in subgrade and got approved by the Engineer based on tests on borrow material for Proctor/ modified proctor density and CBR.

(b) In-situ density and CBR of the constructed subgrade shall be checked and got approved by the Engineer before proceeding on with the next pavement layer.

(c) The soil used in actual construction of subgrade shall be remoulded at density referred in sub-para (b) above at placement moisture content and checked for 4 days soaked and unsoaked CBR. A set of 3 specimens shall be collected from each 3000 m^2 area of the subgrade (i.e. top 0.5m of embankment) for CBR test.

(d) In case of any appreciable variation of inbuilt subgrade characteristics from the designed ones, the pavement design shall be reviewed to match the inbuilt characteristics of the subgrade.

3.5.5 **Sub-base**

(a) The source of supply of material shall be inspected, tested and got approved by the Engineer before any material is delivered to site of work (s).

(b) Job-mix formula falling within the specified limits where applicable, shall be got approved by the Engineer based on test results thereof.

(c) Samples of materials from the laid sub-base shall be tested for gradation, proctor density, PI and CBR.

(d) Field compaction shall be checked and got approved by the Engineer before proceeding with the work on the next pavement layer.

(e) In case of any appreciable variation of inbuilt sub-base characteristics from the designed ones, the pavement design shall be reviewed to match the inbuilt characteristics of the sub-base.

3.5.6 **Granular Base Course**

(a) For graded type of granular material, the job mix formula falling within the specified grading limits should be got approved by the Engineer.

(b) Testing of aggregate brought to site of works for gradation and AIV should be done.

(c) Testing of filler material for WBM for gradation LL and PI shall be done.

(d) Field compaction — Control should be exercised for density and by other sensory checks such as observation of movement of layer under compaction plant, sinking/crushing of a piece of aggregate placed before a moving roller complete removal of roller marks, etc.

3.5.7 **Shoulders**

(a) Checking for the quality of shoulder materials including gradation shall be done.

(b) Field compaction shall be checked at site on the compacted layer.

(c) Checking for the crossfall built shall be done.

3.5.8 **Bituminous Construction — General**

(a) Manufacturer's test certificate for quality of bitumen will be acceptable to the Engineer. However, where the quality is in doubt, the Engineer may call for tests to be conducted by the Contractor for verification.

(b) The base on which bituminous courses are to be laid must be dry and free of dust and other deleterious matter.

(c) Mineral aggregates to be used should be checked for their specification requirements and got approved by the Engineer.

3.5.9 **Bituminous Sprayed Work**

(a) Temperature of binder in the boiler and rate of spray at site shall be checked. Spraying shall be uniform and shall be carried out with the help of either self propelled or towed bitumen pressure sprayer with self heating arrangement and spraying nozzles arrangement.

(b) Rate and uniformity of spread of chippings should be checked and controlled.

(c) Adequate embedment of the chippings by rolling shall be ensured.

3.5.10 **Hot Mixed and Hot-laid Bituminous Constructions**

(a) Job mix formula (JMF) satisfying specification requirements should be worked out based on laboratory tests and got approved by the Engineer.

The Engineer will have independent tests made before approving the JMF.

(b) The plant should be checked for capability to produce mix conforming to the JMF. If necessary, trial stretches should be laid and checked approximately.

(c) Control should be exercised on temperature of binder in the boiler, aggregate in the dryer and mix at the time of laying and rolling.

(d) Tests for stability flow, unit weight etc. of mix collected from the discharge point of the plant, extraction test for binder content and aggregate gradation should be performed to check on the quality of mix discharged from the plant.

(e) Thickness and density of the compacted mix should be checked by taking core samples.

3.5.11 **Culverts and other Appurtenances**

(a) Lines, levels and quality of the foundation should be checked.

(b) In case of pipe culverts

(i) The quality of the pipes should be checked. For BIS (formerly ISI) marked pipes, manufacturer's certificate is acceptable. For others, the Contractor shall demonstrate the strength capability of pipes through tests either at the place of manufacture or at site of works.

(ii) The quality of materials used for pipe bedding should be checked. Invert level, smoothness of the pipeline and proper sealing of joints should be checked prior to backfilling.

(c) In case of cement concrete works

(i) Besides manufacturer's test certificate for quality of cement, at least one set of physical and chemical tests should be conducted for each source of supply for verification. Where the quality is in doubt, or where the cement had been stored for long periods or in improper condition, the Engineer shall call for testing the cement at more frequent intervals.

(ii) Job mix formula worked out based on trials carried out in the Contractor's laboratory should be got approved by the Engineer.

(iii) The mineral aggregates should be tested for their properties. Water to be used for mixing should be tested for chemical impurities.

(iv) Checking for stability and sturdiness of formwork.

(v) Ensuring that the crucial equipment like mixers and vibrators are in working order before start of work.

(vi) Control on water-cement ratio.

(vii) Control on workability and time elapsed between mixing and placing of concrete.

(viii) Control on compaction and finishing.

(ix) Tests on cube samples at 7 and 28 days.

(x) Check on provisions for adequate curing.

(d) In case of masonry work, control should be exercised on the quality on the material (e.g. stone, brick, sand, cement etc.) as also on mortar proportions.

(e) For RCC work, quality of steel in each batch may be approved on the basis of test certificate. The reinforcement layout should be checked for conformity with approved drawings and bar bending schedules. All laps should be checked for conformity with the specification. The reinforcement should be free of oil and loose rust/scale, and should be properly tied with binding wire. The size and spacing of the bars as also the cover should be checked for correctness.

3.5.12 **Pavement Courses — General Controls**

(a) The base on which the pavement layer is to be placed should be checked for levels and regularity, and should be in a condition to receive the pavement layer.

(b) Each layer should be checked for thickness, levels, crossfall (camber), regularity and strength before next layer is permitted to be laid.

4. Check list of Points About Quality Assurance of Road Works

A broad based check-list in light of what has been stated above has been drawn as a guide to the Engineer or his representative. Based on site requirements it can be modified and/or made more exhaustive by the Engineer.

4.1 Contractor's Facilities

4.1.1 Has the Contractor set up his laboratory testing-facilities at approved location? Have the type and condition of the testing equipment been inspected and approved by the Engineer.

4.1.2 Is the laboratory manned by qualified Materials Engineer?

4.1.3 Have printed proformae for recording the results of different tests been prepared?

4.1.4 Are the equipment and construction methodology of the Contractor approved by the Engineer?

4.2 Engineer's Facilities

4.2.1 Have Quality Control Units with necessary testing facilities been lined up for the work?

4.3 Pre-construction Actions

4.3.1 Have the methodology/techniques of construction proposed to be adopted by the Contractor been examined for suitability to achieve specification requirements?

4.3.2 Are the construction plants/equipment proposed to be used by the Contractor capable of achieving the desired results? Is there need for laying trial stretches for checking the capability of the plants/equipment?

4.3.3 Have the sources of supply of various construction materials been obtained from the Contractor? Have these sources been inspected/materials therefrom tested for checking their suitability?

4.3.4 Has a programme for day-to-day testing/checking of materials/work been worked out in consonance with the work programme of the Contractor?

4.4 Alignment and Level Control

4.4.1 Have the reduced levels of Bench Marks been checked? Have the needed additional Bench Marks been established?

4.4.2 Has the centre-line been correctly set out and referenced as per the Drawings and duly checked? Have the construction pegs such as batter pegs, clearing stakes, etc been fixed?

4.4.3 Have the set-out data for curves been checked?

4.5 **Embankment and Subgrade Construction**

4.5.1 Are the borrow areas approved? Do the properties of the soil conform to specifications?

4.5.2 Are the needed equipment in place and in working condition? Is there need for laying trial stretches for checking the effectiveness of the equipment?

4.5.3 Has the natural ground been properly rolled? Is there need for removing unsuitable materials?

4.5.4 Is control on moisture content, layer thickness, size of clouds, etc. exercised?

4.5.5 Has soil meeting the specification requirements for subgrade been identified and reserved for use?

4.5.6 Is each compacted layer of embankment checked for density and approved prior to permitting the next layer?

4.5.7 Is stage passing register maintained and necessary certificate recorded thereon?

4.5.8 Has the compacted subgrade layer been tested for its CBR to see whether any change in pavement design is required on account of any variation between the insite CBR and the design CBR of the subgrade?

4.5.9 Has the subgrade been checked for its suitability just prior to the placement of the pavement layer?

4.6 **Granular Sub-base/Base/Shoulders**

4.6.1 Are the material sources approved?

4.6.2 Has the Job Mix Formula (for specifications using graded type of aggregates) been worked out and got approved?

4.6.3 Have the aggregates brought to site been tested for AIV, gradation, PI, etc?

4.6.4 Are the equipment used as per the specification?

4.6.5 Have the compaction, line, level, camber, regularity, and thickness of the compacted layer been checked, recorded and certified?

4.6.6 Has the subbase/base been checked for its suitability just prior to placement of the next pavement layer?

4.7 **Bituminous Works-General**

4.7.1 Has the quality of bitumen been checked?

4.7.2 Is the surface on which bituminous materials are to be laid dry and free of dust and loose particles?

4.7.3 Have the mineral aggregates been tested for their properties?

4.7.4. Have the needed plant/equipment been brought to site in working order prior to start of work?

4.8 **Bituminous Sprayed Works**

4.8.1 Is bitumen pressure distributor used?

4.8.2 Is the temperature and rate of spread of binder controlled?

4.8.3 Has adequate embedment of chippings by rolling (in case of surface dressing type of works) been ensured?

4.9 **Hot-mixed and hot-laid Bituminous Constructions**

4.9.1 Has the JMF been checked and approved?

4.9.2 Has the hot-mix plant been inspected and trial run done to ensure that the final mix conforms to specification?

4.9.3 Is the temperature of bitumen and aggregates in the plant, mix discharged from the plant and of the mix at the time of laying checked and controlled?

4.9.4 Is the mix discharged from the plant checked for stability, flow, etc. as also for composition after extraction test?

4.9.5 Are the laying and compaction equipment functioning properly?

4.9.6 Is control exercised on compacted density, layer thickness, surface regularity, etc?

4.10 **Culverts and other Appurtenances**

4.10.1 Has the quality of RCC pipe been checked?

4.10.2 Has the foundation been excavated to correct lines and levels?

4.10.3 Has the foundation been inspected to ensure that there are no unsuitable materials?

4.10.4 Has the quality of cement been checked? Is it ensured that it is not in a deteriorated condition due to storage etc?

4.10.5 Has the JMF for concrete been checked?

4.10.6 Are controls such as water-cement ratio, workability etc. exercised? Is the quality of water to be used checked?

4.10.7 Are necessary Cube samples cast for testing ?

4.10.8 Has the formwork been checked for strength, and the reinforcements for spacing, lap, etc. ?

4.10.9 Are equipment for compaction in position and in working order ?

4.10.10 Have necessary provisions been made for adequate curving ?

4.11 General

4.11.1 Are the results of all tests recorded got approved from the Engineer and kept at site for inspection ?

4.11.2 Is the stage passing Register, (i.e. a Register in which approval of the Engineer for starting the next stage of construction is recorded and signed by the Engineer) maintained at site of work ?

4.11.3 Is the Contractor being permitted to start on the next stage of work after the approval of the Engineer in writing ?