KERALA IRRIGATION INFRASTCTURE DEVELOPMENT CORPORATION

2 –days Workshop on

Quality Management in Construction and Testing of Materials

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Quality Management in Road Construction

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What is quality?

Quality is a measure of excellence or a state of being free from defects, deficiencies and significant variations.

Quality is brought about by strict and consistent commitment to certain standards, that will ensure the uniformity of a product, in order to satisfy specific customer or user requirements.

Quality Management System (QMS)

QMS - Definition....

QMS is a set of policies, processes and procedures required for planning and execution in an organisation.

QMS ensures that an organisation, product or services is consistent

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- **ISO: 9001-2008 is QMS tool developed by the International Organisation for Standardisation.**

Quality Management System (QMS)

4 components.....

Quality Planning

Quality Assurance

Quality Control

Quality Improvement

Quality Assurance & Quality control QA/QC

The terms "quality assurance" and "quality control" are often used interchangeably to refer to ways of ensuring the quality of a service or product.

The terms, however, have different meanings.

Quality Assurance (QA)

Quality Assurance

It refers to the planned and systematic activities implemented in a quality system so that quality requirements for a product or service will be fulfilled.

Examples of quality assurance activities:

Process checklists, project audits, methodology statements, standards development etc.

Quality Assurance activities are determined before the production work begins.

Quality Control (QC)

Quality Control refers to the evaluation techniques and activities used to fulfill the requirements for quality end product.

- **Quality Control can be termed as a process that is used to ensure a certain level of quality in a product or service.**

- **Quality Control activities are performed during & after the product is developed.**

Seven basic tools of quality?

- **Fishbone Diagrams**: To find out the root cause of the problem.
- **Histograms**: Plotting of the data.
- **Pareto Analysis**: data of problems occurrence are collected and prioritised.
- **Flowcharts**: Shows the events in each stage of the production process.
- **Check sheets**: The data collection of problems by counting or measuring.
- **Scatter Plots**: Plot of paired data (2 variables) for analysis.
- **Control Charts**: By plotting the data marking the upper & lower control limits.

Pre-requisites of Quality Control

- Construction drawings, specifications and detailed estimates.
- Sufficient trained staff with testing facilities for exercising proper QC.
- Periodical appraisal of the QC data. This will be helpful in guiding the construction process as well as effecting improvements in construction techniques.
- Updating the knowledge of the project team by on job training.


Steps to ensure quality in works

Get all the drawings/documents.
Keep a full set of drawings at site.

Materials Selection

The borrow area for embankment material shall be selected after careful sampling and testing

Requirements of soil for construction purposes

Plasticity Index (PI), Maximum Dry Density (MDD) & Optimum Moisture Content (OMC),

Natural moisture content (NMC),

CBR (Important for subgrade),

Deleterious content – Organic material,

Free Swelling Index – For road embankment.

Gradation/sand content *(If specified).*

IS: 2720

Frequency of testing of borrow material

Ref: Chapter 2-Earthwork: IRC Special Publication # 11

Sl. No.	Test	Code	Minimum desirable frequency
1	Gradation*/Sand content	IS: 2720 (Part 4)	1-2 tests per 8000 m^3
2	Plasticity Index (PI)	IS: 2720 (Part 5)	1-2 tests per 8000 m^3
3	Proctor test (Compaction)	IS: 2720 (Part 8)	1-2 tests per 8000 m^3
4	CBR (On a set of 3 specimens)	IS: 2720 (Part 16)	One test per 3000 m^3
5	Deleterious contents	IS: 2720 (Part 27)	As required.
6	Natural moisture content	IS: 2720 (Part 2)	One test per 250 m^3

Each size of aggregates shall be separately stacked with the size indicated

Frequency of testing of aggregates

Ref: Table 900-3 of MoRTH Specifications

Sl. No.	Test	Code	Minimum desirable frequency
1	Gradation	IS: 2386 (Part 1)	1 test per 200 m^3 (WMM) to 1000 m^3 (WBM).
2	Aggregate Impact Value/Los Angeles Abrasion Value	IS: 2386 (Part 4)	1 test per 1000 m^3
3	Flakiness & Elongation Indices	IS: 2386 (Part 1)	1 test per 500 m^3
4	Atterberg Limits	IS: 2720 (Part 5)	1 test per 200 m^3
5	Water absorption	IS: 2386 (Part 3)	One test per each source.
6	Stripping test	IS: 6241	One test per each source.


Ensure!
Good Quality Cement is used!

Cement

Generally OPC grade cement is used for construction purposes.
The grades of OPC available are...
33 Grade (IS: 269), 43 Grade (IS: 8112) & 53 Grade (IS: 12269).
Pozzolana Portland Cement PPC (IS: 1489-Part 1) is also used in construction.

Ensure that only good quality cement is used!

Cement shall be stored at site very carefully.

Loss of strength of stored cement

Strength loss is about 20% after 3 months & 30% after 6 months from the date of manufacture. From the manufacturing date, the age of the raw cement can be estimated.

Quality certificates for each batch of cement shall be obtained from the manufacturer or dealer and kept as record.

Effort should be made to test the cement before put into use, for major works.

For small works, where usage of cement is limited, testing of cement can be omitted.

Potable water is recommended by BIS for using in making of concrete.

IS: 456 give stipulations for water to be used for making concrete. Testing of water, for determining the chemical and other constituents in it, is done as per IS: 3025.

Recommended frequency for testing water

Sl. No.	Test	Code	Minimum desirable frequency
1	Suspended matter	IS: 3025 (Part 17)	1 test for each source - every three months.
2	Organic contents	IS: 3025 (Part 16)	-Do-
3	Inorganic contents	IS: 3025 (Part 19)	-Do-
4	Sulphates (As SO_2)	IS: 3025 (Part 24)	-Do-
5	Chlorides (As Cl)	IS: 3025 (Part 32)	-Do-
6	pH value	IS: 3025 (Part 11)	-Do-

Testing of reinforcement steel

Effort should be made to test the steel periodically and for each lot supplied.

Tensile strength and bending stress are the most important tests to be done.

Weight per metre length and cross sectional area are two tests which can be done even at site itself.

Bitumen

Viscosity graded bitumen conforming to IS: 73 is used in bituminous construction.

Bituminous materials are used for providing tack coat and priming of granular surfaces.

The tests to be done on bitumen are Ductility, Softening Point, Penetration & Viscosity.

Selection of bitumen

The type of VG bitumen to be selected is based on lowest and highest daily mean air temperature which can be obtained from the Indian Meteorological Organisation (IMO).

Lowest daily mean air temp in °C	***Highest daily mean air temperature in °C***		
	Less than 20°C	***20°C to 30°C***	***More than 30°C***
More than -10°C	**VG-10**	**VG-20**	**VG-30**
-10°C or lower	**VG-10**	**VG-10**	**VG-20**

Frequency of testing bitumen

Sl. No.	Test	Code	Minimum desirable frequency
1	Ductility	IS: 1208	1 test for each supply.
2	Softening point	IS: 1203	1 test for each supply.
3	Penetration	IS: 1203	1 test for each supply.
4	Viscosity	IS: 1206 Part-II	1 test for each supply.

QC in embankment construction

Clause 305 of MoRTH Specifications

Typical cross section of pavement layers....

Natural ground or fill

Preliminaries.....

Prepare earthwork schedules indicating the number of layers to filled at each cross-section.

Check the ground material – if it is good for fill or subgrade. Samples of in-situ material shall be taken and tested, well in advance.

Determine the MDD & OMC of the in-situ material in the laboratory - as per IS: 2720 (Part 8).

The MDD requirements of soil are given in table 300-1 of MoRTH Specifications.

Also check if any unsuitable material exists 500 mm below the subgrade.

Compaction of original ground

Compact the original ground to the required density, after scarifying to 150 mm depth.

The compacted layer shall be tested by sand-replacement method as per IS: 2720 Part 28 to check the percentage compaction.

Density requirement are given in table 300-2 of MoRTH Specifications.

MoRTH specifications stipulate 95% density for fill & 97% for subgrade/shoulders.

Poor embankment foundations

Rock fill embankment is adopted where the existing foundation condition for forming the embankment is poor (**Clause 313 of MoRTH**).

Ground improvement using pre-fabricated vertical drain (PVD) which is adopted in weak soil conditions is given in **Clause 314.2 of MoRTH**.

Guidelines for strengthening weak foundations using rammed stone columns is given in **Clause 314.3 of MoRTH**.


Construction of rock fill embankment
Clause 313 of MoRTH Specifications
ayer of fine material
n top of rock fill.

Geosynthetics

Sometimes, geotextiles are required to be incorporated into the soil layers.

Types of geosynthetics/geofabrics, their properties and usage of can be obtained from Section 700 of MoRTH Specifications.

Geofabrics made of natural fibres such as coir or jute is called natural geotextile.

Trial section

A trial section of 50 m to 150 m length is recommended to be constructed before you start with the embankment forming.

This will help to check the adequacy & efficiency of the compacting equipment as well as the work force.

Non-bituminous bases and sub-bases

Section 400 of MoRTH Specifications

Non-bituminous pavement layers

- **Water Bound Macadam (WBM) - Clause 404 of MoRTH Specifications: Now a days, this is not preferred in highways or major road pavement layers.**

- **Granular Subbase (GSB) - Clause 401 of MoRTH Specifications: This is basically a drainage layer protecting the subgrade from moisture damages.**

Non-bituminous pavement layers

- **Wet Mix Macadam (WMM) - Clause 406 of MoRTH Specifications: WMM is preferred over WBM and constructed as per IRC: 109.**

- **Crusher Run Macadam (CRM) - Clause 407 of MoRTH Specifications.**

WMM & CRM

WMM is prepared in a mixing plant and paved using paver finisher.

CRM is directly brought to site from the crusher and spread using a grader.

The maximum compacted layer thickness allowed is 200 mm.

Dry lean concrete subbase

DLC subbase is provided in concrete pavement.

Clause 601 of MoRTH Specifications provides the guidelines in designating, making and placing zero slump DLC.

The aggregate grading requirement is given in table 600-1 of MoRTH Specifications.

The maximum size of aggregate is 26.5 mm and 75% to 95% shall pass 19 mm IS sieve.

The amount of fines is 10% maximum.

Bituminous bases and surface courses

Section 500 of MoRTH Specifications

Bituminous base courses……

The major pavement layer courses coming under bituminous base courses are…..

1. **Bituminous Macadam (BM) –**
   Clause 504 of MoRTH Specifications
   &
2. **Dense Bituminous Macadam (DBM) -**
   Clause 505 of MoRTH Specifications.

Details of all pavement layers are available in the MoRTH Specifications 5th revision (2013).

Bituminous surface courses.....

The surface courses include:

1. Open graded/close graded premixed surfacing – Clause 510 & 508.
2. Single or two coat surface dressing – Clause 509.
3. Seal coat over premixed surfacing – Clause 511.
4. Bituminous Concrete (BC) – Clause 507.
5. Stone Matrix Asphalt (SMA) – Clause 515.
6. Semi-dense Bituminous Concrete (SDBC) etc.

Prime coat

Priming & tacking are two essential procedures involved in the construction of pavement layers.

Prime coat (Clause 502) is done over granular surfaces to minimise seepage of water into subgrade.

Bitumen cutbacks MC30 or Emulsion SS1 are used for priming.

Primed carriageway portion of a subbase layer constructed with cement treated aggregate mix.
The shoulder construction in progress.

Tack coat

Tack coat helps to develop proper bond between the old and new layers.

Tack coat (Clause 503) is done over existing bituminous surfaces before a new layer is placed.

VG10 bitumen or Emulsion RS1 can be used for tack coat.

Where subzero temperature condition exists, cutback RC70 is recommended.


Tack coat applied on a base layer with emulsion

Application of prime coat & tack coat

The rate of application of primer is given under tables 500-3 & 500-4 of MoRTH Specifications.

[0.6 kg to 1.2 kg per m^2]

Rate of application of tack coat is given under table 500-5 of MoRTH Specifications.

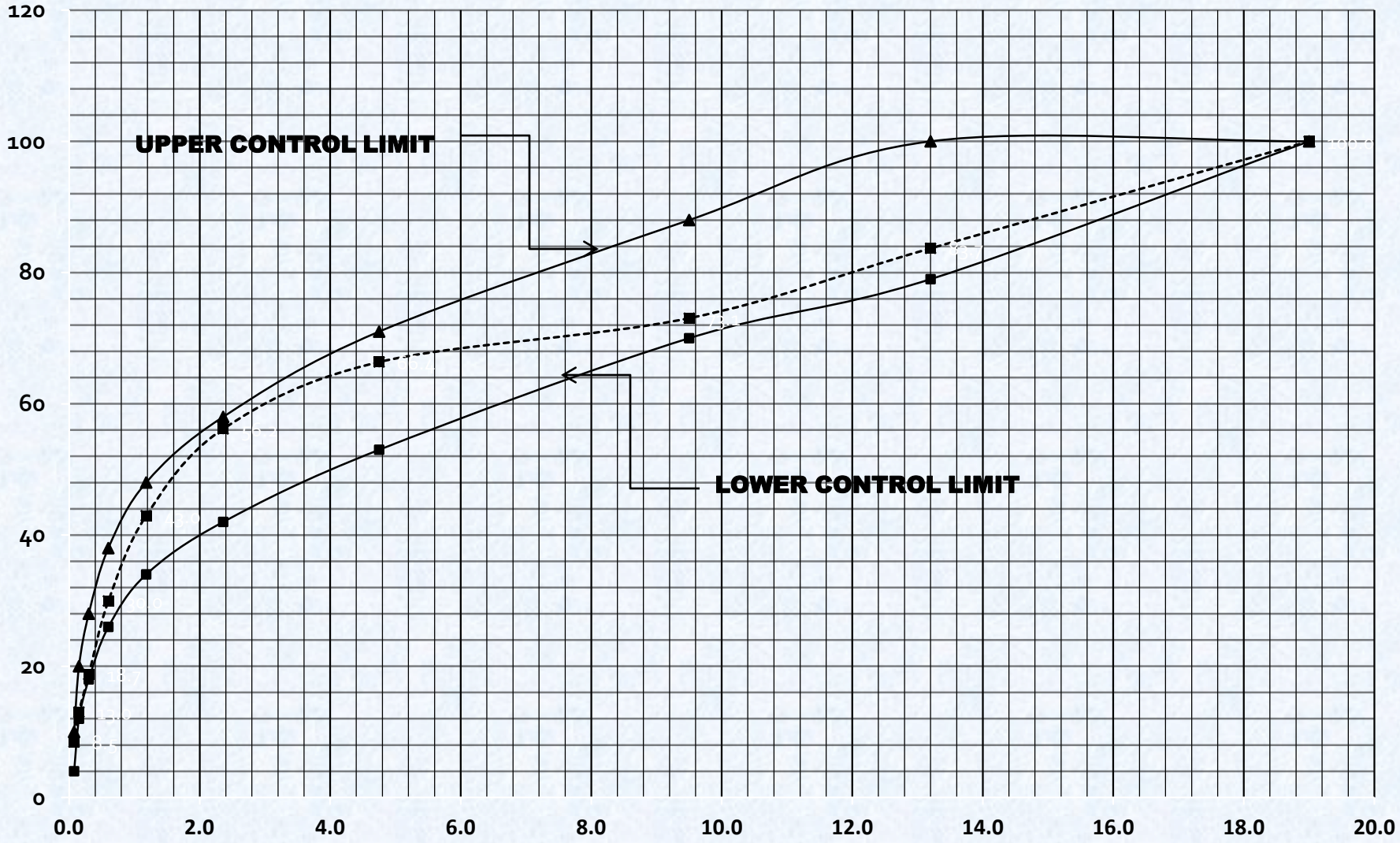
[0.2 kg to 0.35 kg per m^2]

Use pressure sprayer for applying prime/tack coat.

The rate of spread of binder can be verified by tray test.

Steps to ensure quality in bituminous layer construction

1. Grading curve of the aggregates combined shall be carefully prepared.



2. Bituminous mix design

Get the bituminous mix design from a competent authority using the materials intended to be used for the work.

The Job Mix Formula (JMF) shall be approved by the Engineer.

3. Plant & machineries shall be installed properly and thoroughly checked for its accuracy & efficiency to produce the required mix.

4. Follow the manufacturing and rolling temperatures for bituminous mixes given below:

Bitumen grade	Bitumen temp °C	Aggregate temp °C	Mix temp °C	Laying temp °C	*Rolling temp °C
VG40	160-170	160-175	160-170	150 Min	100 Min
VG30	150-165	150-170	150-165	140 Min	90 Min
VG20	145-165	145-170	145-165	135 Min	85 Min
VG10	140-160	140-165	140-160	130 Min	80 Min

****Rolling should be completed before the layer temperature falls below these minimum values.***

5. Mixing temperature

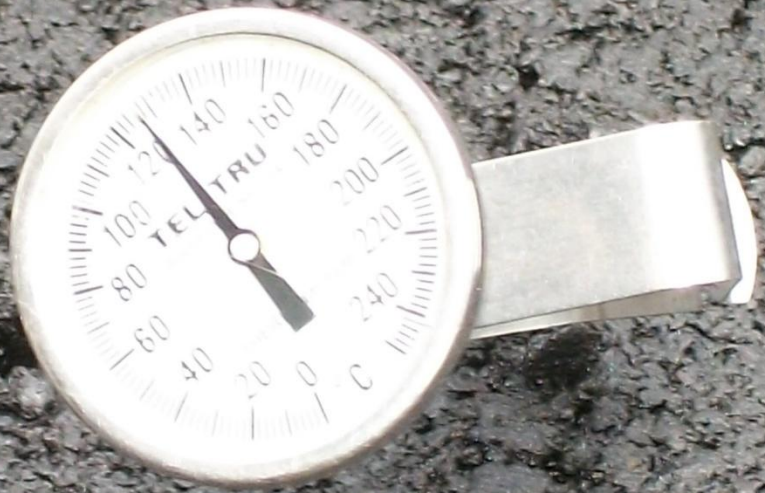
Avoid over heating of the mix!

Durability of bituminous layer is related to oxidation of the bitumen in the mix.

The mix shall not be heated to the maximum, if the haulage is short.

The difference in temperature between aggregate and binder shall not exceed 14°C.

6. Check the temperature of the mix in the truck on arrival and during paving operations, regularly.



7. Paving

Thoroughly clean the surface to be paved with power broom/jet air.

Use sensor paver to carry out the paving.

Take field samples of the paved mix & prepare Marshall test specimens for determining the density, binder content, air voids etc in the laboratory.

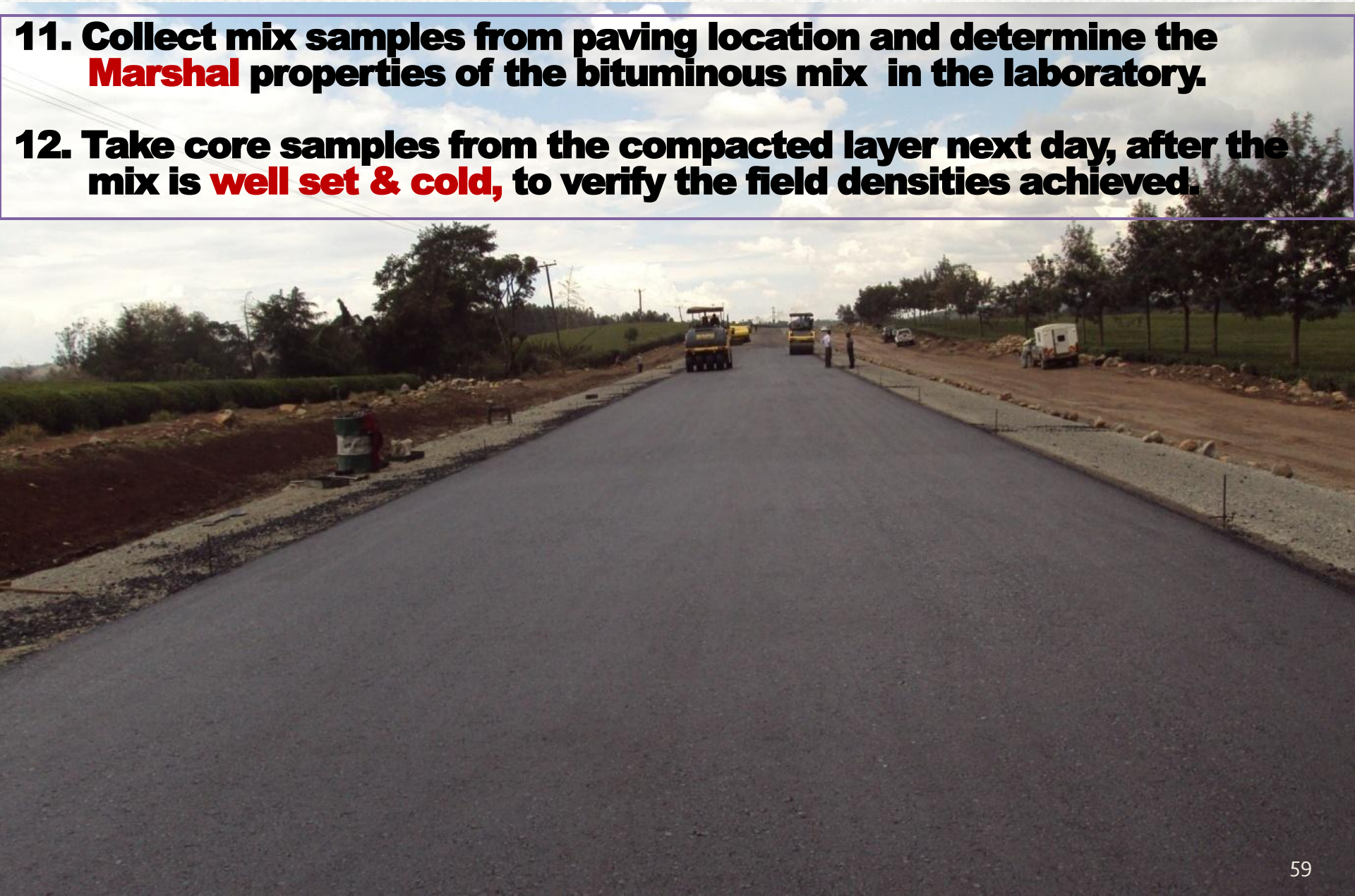
8. Provide adequate compaction arrangements.

9. Check the layer thickness during paving

10. Compact the layer to 92%-94% of maximum density.

11. Collect mix samples from paving location and determine the Marshal properties of the bituminous mix in the laboratory.

12. Take core samples from the compacted layer next day, after the mix is well set & cold, to verify the field densities achieved.



END OF PRESENTATION..
on
Quality management in road construction

Thank you all.....