

# CONSTRUCTION AND QUALITY CONTROL OF FLEXIBLE AND RIGID PAVEMENTS

## QA & QC Measures in Low Volume Roads

National Rural Infrastructure  
Development Agency



Ministry of Rural Development

National Institute of  
Technology



Warangal, Hyderabad

# Lecture-1

## QA & QC Measures in Low Volume Roads

# Flow of Presentation

- Quality
- Quality Assurance and Quality Control
- Quality Assurance System
- Quality Management in PMGSY

Quality

# Importance of Quality

- Economic growth of a country is mainly dependent on Good Infrastructure development
- Good Infrastructure development depends on Quality of Construction and Quality of Maintenance
- Quality Control is an important requirement for creating durable National Assets

# Quality of a Road

- **Serviceability:**
  - Good Geometrics, No cracking or rutting, Good riding Quality, Satisfactory performance, No undulations and uneven settlements
- **Safety:**
  - Able to carry design axle loads, Not effected by floods, No settlements of high embankments, Optimum geometrics for design speed, Skid resistant surface, Proper drainage, Proper road marking and signages
- **Durability:**
  - Ability to withstand stresses due to repetitive loading, No abnormal deterioration during design period
- **Economy:**
  - *Cost of construction should be minimum*, Appropriate design, Cost effective methodology, Use of readily/locally available materials, Use of most suitable machinery & equipment
- **Environmental Consideration:**
  - No adverse effect on existing eco system, Construction methods should be eco-friendly, Control of dust and noise pollution

# Quality Definition (1/3)

- The meaning of Quality is Degree of Excellence
- Quality is also known as meeting Customers Expectations
- Quality is fitness for use
  - Fitness of product or service for meeting or exceeding its intended use as required by the customer
- Quality is defined as the totality of Features and Characteristics of a product
- Quality also includes concepts of zero defects.
- Traditional thinking of Quality is Conformance to Specifications - The modern trend is to focus customer satisfaction and conformance to requirements (Philip Crosby)

# Quality Definition (2/3)

- As per ISO 8402 Quality can be described as: “the totality of features and characteristics of a product or service that bear on its ability to satisfy stated or implied needs”
- American society of quality defines: “Degree to which a set of inherent characteristics fulfill requirements”



# Quality Definition (3/3)

- According to Philip Crosby, Quality is free and quality improvements arise from
  - Waste reduction
  - Eliminating rework
  - Eliminating non-value added activities
- Therefore, Quality should not cost the organization more

# Quality Assurance vs Quality Control

# Types of Quality Control

## 1. Process Control

- In built control during construction process which is must and applied effectively
- Requires tests at regular intervals during the construction

## 2. End Result Control

- In the End Result type, the field / QC Engineer carryout tests on finished work at regular intervals to evaluate whether it meets the specification requirements or not
- Test at regular intervals on finished end product

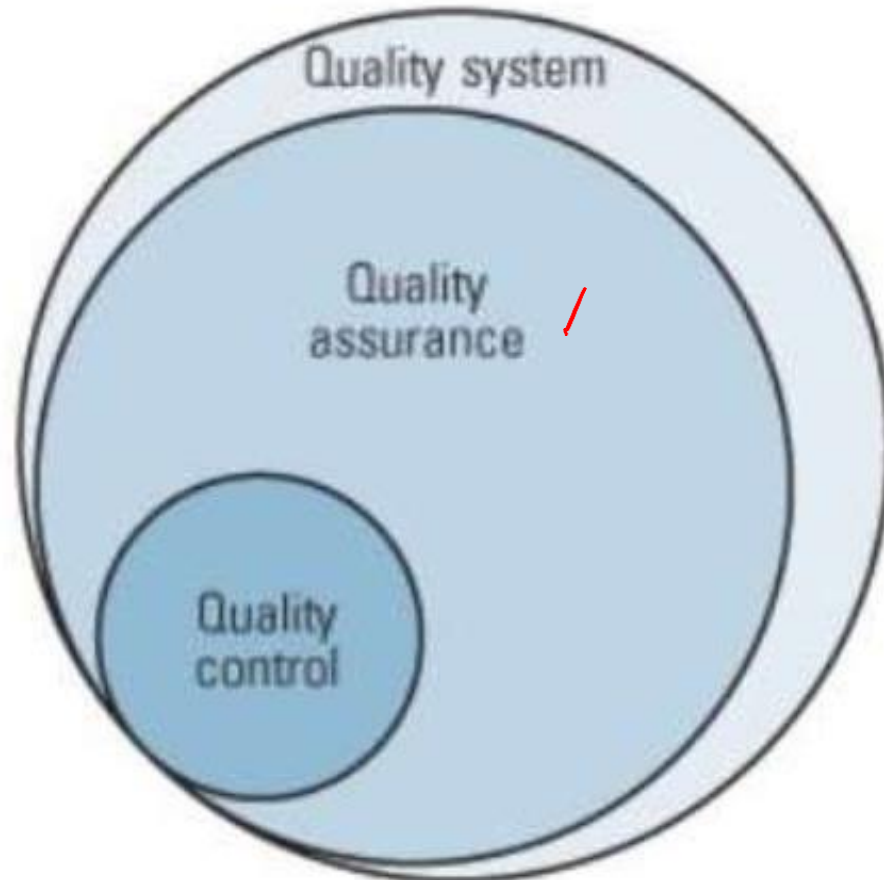
# Quality Management

1. **Quality Assurance:** The planned and systematic actions necessary to provide confidence that a product or facility will perform satisfactory in service
  - Planned and systematic working to eliminate non-conformities.
2. **Quality Control:** Establishing standards of performance, measuring actual performance, interpreting the differences and taking corrective action on the difference
  - Ensuring conformance to standards through process control.
3. **Quality Audit:** QA is to study the quality of a product by taking samples from time to time and analyzing them

# Quality Control and Quality Assurance Comparison Chart

QA	QC
A managing tool	A corrective tool
Process-oriented	Product-oriented
Proactive strategy	Reactive strategy
Prevention of defects	Detection of defects
Everyone's responsibility	Testing team's responsibility
Performed in parallel with a project	Performed after the final product is ready

# ISO 9000:2015 Quality Management Systems – Fundamentals & Vocabulary



**Figure 1: Quality System, Quality Assurance, and Quality Control Relationships**

# Total Quality

- Total Quality is a total system approach
  - People focused management system that aims at continued increase in customer satisfaction at continually lower cost
- Total Quality Management (TQM)
  - A participative management approach centered on quality aimed at long term success through consumer satisfaction.
  - Responsibility for quality must rest with person who does the work – this is called Quality at Source
  - It is a total organization wide effort through full involvement of the entire work force and a focus on continuous improvement to achieve customer satisfaction
  - It is an effective system for integrating Quality Development, Quality Maintenance, and Quality Improvement efforts of various groups in an organization

# Quality Assurance System



# Quality Assurance (QA)

QA defines as all the planned and systematic activities implemented within the quality system and demonstrated as needed, to provide adequate confidence that an entity will fulfill the requirements

The quality Assurance Manual provides a base document outlining

- Policy,
- Procedures,
- Responsibilities,
- Compliance,
- Acceptance criteria, and
- Documentation.

# Elements of Quality Assurance System

- (a) Proper assessment of requirements of the road pavement project: design criteria, design life and minimum acceptable riding quality
- (b) Choice of quality materials and design: Evaluating pavement thickness and its composition for assessed traffic and sub grade conditions
- (c) Development of appropriate technical specifications and acceptance criteria.
- (d) Choice of construction method/ equipment/ plant.
- (e) Field supervision and quality control.
- (f) Assessment of quality of finished pavement.
- (g) Periodic inspection and maintenance measures.

# Quality is ensured and maintained by (IRC SP57-2000)

## 1. Quality Plan:

- Sets out specific quality practices, including quality control which are operational techniques of controlling quality.

## 2. Quality Assurance:

- Includes all those planned actions necessary to provide adequate confidence that the product will meet the requirements.

## 3. Quality Assurance Plan:

- Sets out planned actions required for quality assurance

## 4. Quality surveillance:

- The continuous monitoring and verification of status of QA activities to ensure that it is being followed.

# Quality is ensured and maintained by (IRC SP57-2000)

## 5. Quality policy:

- is a formally documented statement of management's intentions and directions as regards to quality.

## 6. Quality audit:

- Is a managerial tool used for reviewing the whole or a part of the quality system by internal or external agencies not controlled with operation of QA Plan.

## 7. Total Quality Management:

- Long term global management strategy to achieve and improve Quality and calls for participation of all members of the organization- for the benefit of its own members, its customers and society as a whole.

# Quality Systems - Quality Assurance (QA) (IRC SP 57-2000)

- Nominal QA (Q-1) – Village Roads (Represents a large volume of general construction mostly based on general experience without well defined methods or controls)
- Normal QA (Q-2) – ODRs & MDRs (Most Common type)
- High QA (Q-3) – SHs, NHs, Coastal Roads, Roads in high rainfall areas (over 2000mm) (Major Works)
- Extra High QA (Q-4) – Expressways, Roads in tunnels/urban underpasses, Roads built over high water table areas and reclaimed land (Exceptional Cases for every important structures or that with innovative design or construction features)

# Quality Assurance requirements (IRC:SP-57-2000)

<b>S.No</b>	<b>Item</b>	<b>Nominal QA Q1</b>	<b>Normal QA Q2</b>	<b>High QA Q3</b>	<b>Extra QA Q4</b>
<b>1</b>	<b>Adequacy and reliability of data</b>	<b>Local sources through in-house staff</b>	<b>Either in-house staff or other agencies</b>	<b>Through specialized agencies</b>	<b>As per Q3 using sophisticated methods</b>
<b>2</b>	<b>Design &amp; Drawings organization</b>	<b>In house verification</b>	<b>Independent checking</b>	<b>External organization</b>	<b>As per Q3 &amp; proof consultants</b>
<b>3</b>	<b>Contractual aspects contractor</b>	<b>From approved list of contractors</b>	<b>Approved list</b>	<b>Pre-qualify</b>	<b>Pre-qualification essential</b>

# Quality Assurance requirements (IRC:SP-57-2000)

<b>S.No</b>	<b>Item</b>	<b>Nominal QA Q1</b>	<b>Normal QA Q2</b>	<b>High QA Q3</b>	<b>Extra QA Q4</b>
<b>4</b>	<b>QA manual</b>	<b>Req.ments be covered in tender documents</b>	<b>As in Q1</b>	<b>Approval with two level control</b>	<b>Three level control</b>
<b>5</b>	<b>Defect year liability</b>	<b>1 year</b>	<b>1 year</b>	<b>can be longer for special items</b>	<b>As per Q3</b>
<b>6</b>	<b>Supervision</b>	<b>Owner supervision</b>	<b>Periodic visits by designer</b>	<b>As per Q2 and independent agency</b>	<b>As per Q3 and additional specialist</b>

# Quality Assurance requirements (IRC:SP-57-2000)

S.No	Item	Nominal QA Q1	Normal QA Q2	High QA Q3	Extra QA Q4
7	Materials	Purchases from established traders	Established traders/suppliers	As Q2 and with own source	As Q4 and Third level testing-standard lab approval
8	Cement, Steel, Bitumen	Manufacturer test certificate	As Q1	Regular testing at specified frequencies	As Q3 in independent agency check
9	Aggregate	Tests at mix design stage/ at change of source	As Q1 and change of source/stack	Sampling and testing daily at product source	As Q3



# Quality Assurance requirements (IRC:SP-57-2000)

S.No	Item	Q1	Q2	Q3	Q4
1	Aggregate	Hard broken	Crushed preferred	Crushed/ screened mandatory	As Q3
2	Mixing	Site mixing accepted	Plant mixing preferred	Plant mixing mandatory	As Q3
3	Paving	Manual accepted	Paver preferred	Paver mandatory	As Q3
4	compaction	Static equipment accepted	Vibratory equipment preferred	Vibratory equipment mandatory	As Q3
5	Geometry check	Top layer	Top lay	All layers	As Q3 and sophisticated equipment

# Quality Management in PMGSY

# Quality Assurance in Rural Road Development

- Quality assurance encompasses all the broad aspects of road development: Design, Construction, Maintenance and Rehabilitation; it forms the crux of the whole process of a successful road development system.
- It is aimed at ensuring that the end product is a pavement with the desired level of serviceability.
- PMGSY roads are expected to be of very high standard, requiring no major repairs for at least five years after completion of construction
- Quality of Road Works – Responsibility of the State Governments

# PMGSY – Initial Stages

- *Rural Road Construction before PMGSY Quality*
  - *Control Stage* - an activity in isolation.
- *PMGSY in the initial stages*
  - No clarity on quality systems.
  - Legacy of Works Department style.

“Learning by doing” – switch over from QC to QA.

The Goal - TQM.

# Good Quality Road Construction: Requirements

1. Detailed Project Report
2. Quality Awareness and Consciousness at all levels
3. Good knowledge about Standard Specifications
4. Avoiding use of unsuitable material particularly gravel
5. Use of graded aggregates and controlled concrete in concrete works
6. Use of appropriate grade of bitumen for various bituminous courses
7. Sincere efforts for Testing of material and workmanship, maintenance of QC laboratories and QC records

# Quality Management in PMGSY

- Decentralized Planning.
- Standards and Specifications
- Methodical Project Preparation and Scrutiny
- Appropriate Institutional Arrangements
- Transparent Procurement
- Three Tier Quality Mechanism
- Defect Liability clubbed with Routine Maintenance
- Well laid down Operations and Programme Monitoring
- Web Based Online Monitoring, Management and Accounting

# QC Mechanism (1/2)

- Quality Assurance Handbook for Rural Roads
  - QMS and QC Requirements
  - Equipment and Test Procedures
- Quality Control Registers
  - Register Part-I-Record of test: *Consists of three sections-Earthwork, Granular construction & Bituminous construction*
  - Register Part-II-Record of abstract of tests conducted & Non Conformance report
- Quality Control Lab to be established by Contractor
  - QC Tests are regularly conducted, and recorded
- Standard Bidding Document – Ensure QC & a Performance Guarantee by the Contractor
- A three-tier QC Mechanism
  - *A three tier quality management mechanism has been operational zed for ensuring that the quality of assets created confirm to prescribed standards*

# Three Tier Quality Management System

- First Tier by the PIU – In house quality control by executing agency
  - Ensure that all the materials utilized and the workmanship in execution conform to the prescribed specifications
- Second Tier by the SQC/SQMs – Independent Quality Control setup of the State Rural Road Development agency
  - Responsible for QC – ensure that the contractor and the PIUs are working to achieve quality standards
  - Periodic inspections of works will be carried out by QC Units
- Third Tier by the NQMs – National Quality monitoring system as operationalized by National Rural Infrastructure Development Agency (NRIDA)
  - QA mechanism – ensure that the State Quality control systems are working satisfactorily
  - Inspect the road works and report to NRIDA
- The three systems are not interchangeable and need to work in tandem
- SQM & NQM Guidelines



# First Tier QUALITY CONTROL

- The first tier shall be with the PIU/senior Engineer of the PIU in charge of the work.
- The Contractor shall establish Quality Control laboratories and get the contractually stipulated tests conducted.
- The test results shall be recorded in the prescribed Quality Control Registers.
- Engineers of the PIU shall witness the carrying out of a percentage of tests as described in Para 3.
- All the concerned officers shall record their observations in the Quality Control Registers.
- No payment to contractor unless QC lab established

# Second Tier QUALITY CONTROL

- The second tier shall comprise periodic inspection by the State Quality Control Coordinator (SQC) and his staff (SQMs) engaged by the Nodal Agency, independent of the PIUs
- Objective is to monitor whether Executing Agency is carrying QC as per specifications
- The functions of the SQC should be as follows:
  - To coordinate and supervise first tier Quality Control arrangement.
  - To coordinate and control the activities of State Quality Monitoring arrangement, and ensure compilation of action on the reports of State Quality Monitors.
  - To facilitate and coordinate the activities of the National Quality Monitoring arrangement and ensure compilation of action on the reports of National Quality Monitors.
  - To prepare monthly abstracts of SQM visits and an Annual Quality Report based on the Reports of SQMs and NQMs and action taken thereon.

# Third Tier QUALITY CONTROL

- The third tier shall comprise National Quality Monitors (NQMs) appointed by the NRIDA for the purpose, who shall be retired Senior Engineers from State/Central organizations.
- Objective: Independent Monitoring of Work Quality with a view to guide the State and not a fault finding mechanism.
- These NQMs will carry out Quality testing of PMGSY works on random sampling basis from the prioritizing list, mainly in order to confirm that the programme implementation and State Quality Control System is working satisfactorily.
- The NQMs are expected to make constructive suggestions relating to procedural aspects in addition to locating problems at individual work level.
- The SQC will be responsible for reporting compliance on the issues raised by NQMs and observations of NRIDA in this regard.
- NQM to visit three districts in case of normal area and one/two districts in case of hill area in a single visit.
- The observations now to be entered on web-site with photographs

# NQMs

- Empanelment Committee
- NQMs from Retired field engineers
  - SE & CE level officers
  - Experience in road building
  - Integrity
- Periodic Performance Evaluation of NQM Reports – Independent Performance Evaluation Committee
- Reports are forwarded to Empanelment committee
  - Under performing NQMs are dropped from the list
  - Moderately performing NQMs are counseled

# QC Mechanism (2/2)

- QC and a Performance Guarantee by the Contractor
- 5 year post construction maintenance & defect liability with the contractor
- Another 5 year maintenance contract with renewals
- Performance based payment system
- Regional Review Meetings with PIUs, SQMs & NQMs at regular intervals

# Concerns

- Poor Quality of DPRs – few observations
  - Soil and material Investigations – Not serious; doubtful reports
  - Inappropriate pavement designs
  - Provision of side drains – not attended
- Availability of well equipped laboratories at the site during construction?
- Incompetent / ill trained contractors – not fully aware of road building

# A Way Forward

- Robust Quality Management System is in Place
- Quality Conscious Design and construction of Roads - Attitudinal Change in the Engineers and Contractors
  - Recognition of good designs / practices / construction works
  - Awards / rewards
  - Incentive mechanism
- Annual Conference-cum-Exhibition on “Rural Roads / Low Volume Roads / PMGSY Roads” by NRIDA

# Learning Resources

- Quality Assurance Handbook for Rural Roads, Volume – I: Quality Management System and Quality Control Requirements; First Revision, National Rural Roads Development Agency, Ministry of Rural Development, GOI, New Delhi, Dec. 2016
- Quality Assurance Handbook for Rural Roads, Volume – II: Equipment and Test Procedures; First Revision, National Rural Roads Development Agency, Ministry of Rural Development, GOI, New Delhi, Dec. 2016
- IRC SP057:2000. Guidelines on Quality Systems for Roads, Indian Roads Congress, New Delhi, 2000.
- <https://pmgsy.nic.in/guidelines-quality-assurance-and-control-mechanism>
- ISO 8402-1994. Quality Management and Quality Assurance - Vocabulary