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Portfolio

IBC Journal
December 2017

FOCUS ON
BUILT ENVIRONMENT

From

Editor-in-Chief's Desk

1. This IBC Journal is for understanding the requirement of quality in construction. Quality control was not known to builders and artisans of ancient India. Hindu Art which also includes Buddhist and Jain Art, has tradition of civil construction for more than two thousand years. Important artisan trades of that period include excavators, masons, carpenters, sculptures etc. Iron chisels and mallets were their main cutting tools. Artisans generally worked for life time on different projects. They were experts of their field and would produce quality work, as required. They did not need anybody to check. They would not accept their own work, if defective. The Hindu Art continued to flourish in whole country. It will not be without much exaggeration that some structures created between 10^{th} to 13^{th} century like Channakeshara Temple at Belur in Karnataka, has no parallel in whole world with regard to fineness and detailing. The quality control by others was not required.

2. It is interesting to note that threads of old traditions were picked up by builders of Swaminarayan temples. When they decided to construct temple, there was all India serach for artisans knowing traditional stone work. Only a few were found. The requirement was in hundreds. All the artisans were asked to call their close relatives. They could be in any profession. All of them were trained in stone sculpture work and they constructed Swaminarayan temples.

3. The scope for documentation in this Journal is quality in construction. Let us understand the requirement of quality in construction in the context of requirements of today. In our country, construction activity is increasing with the passage of time. Still by and large there a need to improve and enhance quality standards of our construction. By and large we have been controlling quality by conventional techniques. The alternative approach of total Quality Management as per ISO is also being adopted for some projects and broad understanding is necessary to develop capabilities for TQM. In order to give a complete overview for the whole subject, we have selected nine reviews of already published documents on information about organisations. We have also received seven papers from eminent authors.

4. Shri Deepak Narayan has given an overview of Quality management in Building Construction Works. He has described quality control, quality assurance, ISO 9000, Quality Assurance Plan etc. He has given procedures for quality related

documents. Besides, he has detailed role of Engineers and contractors also need for quality consciousness amongst key partners. Shri K. B. Rojoria and Shri V.K. Sharma has written on different horizon. They described role being played by workers and stakeholders in construction industry. They have defined quality and extend it even to design, management etc. Dr. K. M. Soni has defined Total Quality Management. He has also given historic background to quality in different areas and detailed terms like assurance management, TQM, zero defects. He has also brought out all aspects of safety and concept of continuous improvement. He has also maintained that quality is not absolute. It is a relative term. The quality is achieved by involvement.

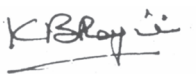
5. Shri Krishan kant has focused on total quality management in maintenance work. The quality maintenance is often neglected even through if is equally important as satisfaction and safety of occupants in involved. He has mentioned that professional approach is required for quality in maintenance. He also mentioned that Quality work is derived from latin word “Qualitas” which means what something is really like. He has covered wide scope for quality and mentioned that functionality is not to be compromised and safety of stakeholders is also important. Smt Padmaja Varma, Shri Shailendra Singh and Sunil Srivastav with their experience in vigilance commission talk of realities on the ground. They have described roles of chief technical examiner. For different subheads of construction work, they have listed defects observed. Besides case studies of different projects bringing specific quality aspects are given by them. Shri J. K. Choudhury has described quality assurance of E & M systems. The operation of E & M services become more effective with microprocessors and automation. But necessity of quality requirements is also of high standard. He has given Quality Assurance and Quality Control as also requirements from works point of view. He has also covered quality assurance aspects for power distribution, as also for air conditioning systems. Smt Veena Vilas Kantute has given quality assurance requirements for horticulture works; an often neglected field. Her tips for construction and maintenance works are very useful.

6. Some important related publications have been reviewed, with a purpose to make this journal more informative. Besides work already done for implementation of quality management system as per ISO, in our environment gives confidence for future projects. It was during last decade of last century that parliament library was constructed by CPWD. Under the leadership of Shri Jag Mohan Lal the project was implemented according to systems of ISO – 9000 and related ISO codes. It was an achievement of that time and set new trend. A very important publication of Indian roads Congress was Quality systems for Roads & Bridges – SP - 47 1998. It was used for the first time by PWD Delhi and a number of flyover projects were constructed according to their systems. Extensive documentation was done to follow systems based on ISO. In order to help engineers to implement future projects, standardised documentation was done by CPWD and a Quality

Assurance Manual for construction of concrete structures was published in 2002. It is basically contribution of Shri S. P. Banwait and this document is useful for projects to be implemented according to ISO. In fact similar documentation is required for building works. Besides, Delhi Metro has set a trend in following ISO standards. Therefore case study of a project implantation by L & T has also been given.

7. For following quality management systems in construction, it is necessary to know how to start and who will assist. A brief of IS /ISO 9000 – 2015, Quality Management system – fundamental and vocabulary is made available. It is called IS / ISO. IS stands for Indian standards and number is same as ISO standard. Basics are given in this document and a list of other documents to be followed as required is also given. The National Accreditation Board for certification Bodies (NABUS) under Quality Council of India, registers certification bodies. These certification bodies inturn give ISO certificate for organisations and projects. A small note for Quality Council of India adds to the knowledge base for proceeding towards implementation of ISO. Lot of books have been written on the subject. Abstract of three important publications has been given. The first one is "The Deming route to quality and productivity – Road maps and roads blocks" by William W. Scherkenbaoch. The second one is "Quality Assurance in Construction" by J. M. Duncan, Brain Fhospe and Peter Summer. The third one is "Total quality in construction projects – Achieving projects ability with customer satisfaction by Ron Badan Hellard. Besides a small brief about activities of BIS for activities related to ISO is given.

We are grateful to authors for those articles and authorities / authors for taking privilege to include brief about activities of these organisations and papers published. We hope this publication will be useful for raising standard for civil construction work in the country.



(K. B. Rajoria)
Editor-in-Chief

Quality Management in Building Construction Works: An Overview

Deepak Narayan
Former Engineer-In-Chief, Delhi PWD &
Past President, IBC.

Prologue

Quality consciousness amongst the key participants i.e. contractor, engineer and architect in building construction projects is required for ensuring quality of work to customer's satisfaction and to build confidence in the builder's capability amongst all concerned. Design inadequacies, construction defects, time and budget over-runs, untrained human resources, lack of delegation of responsibility and authority for proper co-ordination, are common concerns in building construction management which need to be addressed.

The relevant architectural and structural drawings should be made a part of the tender documents. Suggested programme schedule should also be made part of the tender document. Different milestones should be fixed in the tender document and in case of non-achievement of the milestones, remedial measures should be taken to make up for lost time. Timely completed projects invariably have better quality of work.

Top management can create an environment through leadership and actions, where all concerned are fully involved and in which a quality management system can operate effectively.

An informative article which needs to be read for supplementing with your ideas too

- Editor -

Introduction

Quality control is the procedure adopted and controls exercised to ensure that the materials proposed to be used in production, processes, and workmanship conforms to the prescribed standards and specifications. Quality assurance is a process which exercises various checks and balances at different stages of work right from inception till its completion to ensure that the work has been suitably designed and constructed as per specific, drawings instructions and specifications. Quality planning and quality assurance within the quality system is referred to as quality management. It facilitates the measurement of quality characteristics of a unit and compares them with the established standards and specifications.

The methodology of controlling the quality is based on regular inspections for verification of the finished products. The products which do not conform to the specifications need to be either discarded or rectified. The quality control should preferably be carried out by persons not directly involved in construction supervision activities, so that preventive activities and improvement plans are more effectively carried out. Statistical control can establish proper sampling plans with well defined acceptance or rejection criteria and testing of samples carried out through random sampling.

Quality assurance ensures that products and services comply with specified requirements of specifications. It involves checking the final quality in addition to checking the quality of products at various construction stages. Quality signifies the ability to satisfy the stated and implied needs, conformance to specifications and fitness to use. This is usually achieved through installing a quality management system which allows direct control of all the construction activities.

The international standards, of quality generally called ISO 9000, are accepted in our country. The ISO 9000 standards broadly are: ISO 9000: Quality Management, ISO 9001: Quality Management System – Requirements, ISO 9004: Managing the Sustained Success of an Organization – a Quality Management approach, and ISO 19011: Guidelines on Internal and External Audits of Quality Management Systems.

Quality Management Systems

The aspects which need consideration and implementation for proper quality management through quality systems approach of ISO 9000 are as follows:

(a) Fulfilling organizational and management responsibilities of all participants, explicit commitment to quality at all levels, training and documentation.

(b) Planned resources for needs of quality performance, activities of relevant programme schedule, including important milestones at different stages of execution of work.

(c) Processes for implementation, inspection and testing, performance evaluation, review and audits

The quality systems shall aim to achieve following characteristics of quality of product and services:

- Customer Focus – Meeting requirements of customer satisfaction including requirements considered necessary for intended use and statutory requirements

- Quality Policy – Meeting requirements of continuous improvement and effectiveness of quality management system. The organization shall establish, document, implement and maintain proper quality plan, and procedures.

- Management Responsibility – Resource mobilization, organizing required personnel with clear cut responsibility, authority and inter – relation for functioning and management.

- Management Review – To ensure that the requirements are adequately specified and understood and that the processes ensure continuity, adequacy and effectiveness.

- Design Control – Maintain documented procedures to control and implement work as per design and drawings.

- Purchasing and Resource Management – Ensure that procedures are in place to procure resource materials.

- Process Control – To plan the production (construction), installation and processes to ensure required quality.

- Inspection and Testing – To ensure that documented procedures for inspection and testing activities are in place.

- Non Conforming Products – Products which do not conform to specifications, shall be identified and controlled to prevent its unintended use. Non-conforming products shall be reviewed in accordance with documented procedures for: (a) Reworking to meet the specifications, (b) Accepting with or without repair with concession, (c) Suitability for alternative use and (d) Rejection.

The organisation shall establish and maintain a quality manual which incorporates (a) the scope of the quality management system (b) the documented procedures established for the quality management system and (c) a description of the processes of the quality management system.

Quality Assurance Plan

It is necessary that all stakeholders involved in the QA plan should have their internal QA systems clearly defined in form of a specific Quality Assurance Manual (QAM). The QAM for the project as a whole integrating all these plans should be prepared. Each stakeholder (i.e. Owner, Engineer and Contractor) will have his own internal QA procedures. It is necessary that there is total synergy amongst them for successful implementation of the project.

Quality assurance plan for a building construction project would essentially deal with the following aspects:

- **Organisation**

  The management of the owner shall be responsible for jointly reviewing the project through a competent organisation for the same. They may have Engineers (and Architects) as part of the organisation, or may entrust the work to Project Management Consultants (PMC). In this text, such authorized supervising personnel have been referred to as "Engineer".

  Personnel performing supervision of work shall have necessary competence on the basis of appropriate education, training, skill and experience.

- **Control of Data And Documentation: Project Related Documents**

  Drawings, specifications, work instructions and other project related documents shall be maintained. It shall be ensured that only the latest approved documents and drawings are used for the construction work.

- **Quality Related Documents and Procedure**

  For quality assurance of works, it is essential to document each and every operation and activity connected with the work and maintain the record of inspections, approvals/non-approvals and other statistical day-to-day information about the progress of work. These are normally recorded in the standard forms (to be specially evolved for each activity) and they constitute an important component of quality assurance. Each activity or operation could be broadly categorized as under:

- **Method Statement**

  The method statements give detailed proposals for execution of work by the constructing agency which are approved by the 'Engineer'.

- **Inspection Proforma**

  The inspection proformae are used for the purpose of seeking approvals from the Engineer or his representative before commencing any operation such as, pour cards for concrete, approval to reinforcement, approval to formwork, approval to setting out, approval to earthwork, etc. These are usually supplemented by standard checklists prepared for supervision of works.

- **Test Results**

  A set of proformae are utilised for recording the results of day-to-day tests carried out in accordance with the requirements of works.

- **Daily Diary of Work and Quality Records**

  Elaborate registers are required to be maintained at site to record the day-to-day operations, activities and events taking place at the site of work, such as equipments deployed, manpower deployed, activities carried out, different types of materials consumed, detailed observations of the activities at site, visits by the Engineer and follow-up of the instructions.

- **Non-Conforming Products**

  Detailed statements have to be prepared describing the procedures to be followed as soon as any result is obtained which is not conforming to the specifications. Such statements deal with the (i) procedures to be adopted for rectification of the particular component (ii) the long term corrective action, and (iii) immediate preventive actions in other similarly affected activities till the long term corrective actions are implemented.

- **Quality Audit**

  A separate set of proformae with detailed instructions shall be laid down for facilitating the audit of the quality assurance by an independent unit at periodical intervals.

- **Site Order Book**

  Important instructions shall be conveyed to the contractor through Site Order Book.

- **Setting Out of Works and Temporary Works.**

  A professional qualified surveyor is required to take responsibility of survey control and setting out both the temporary as well as the permanent works and establishing and maintenance of control stations. Proper records shall be maintained.

- **Methodology of Working**

  Method statements for the execution of the permanent work as per the drawings/ specifications shall be submitted by the Contractor to the Engineer for approval. The procedure for this shall generally include:

  - Submission of method statements to the Engineer
  - Checking of the proposal
  - Trials of method, if required

- Approval of the proposal
- Execution of permanent works, and
- On-going review of the method

- **Control of Materials**

The main aspects for materials to be covered in the QA Plan are as under:

- Testing of materials for source approval
- Inspection and certification of materials on receipt
- Testing of materials going into construction
- Test records
- Assessment and analysis
- Test frequencies and calibration schedule
- Storage and issue of materials
- Inventory

- **Control of Workmanship**

  To achieve the desired workmanship at various stages of work, it is necessary to carry out inspection in a regular and systematic manner. The contractor shall devise an appropriate system for such inspections and get its approval from the Engineer.

- **Protection during Construction Stage**

  In order to produce a quality end product, it is necessary to lay down procedures for preventing any damage or deterioration of the various materials brought to site as well as the works partially completed till the completion of the entire job.

Organization and Responsibilities of Engineer

A number of different category of building professionals shall be deployed appropriate to the project size and site requirements. The professionals shall be deployed in various categories commensurate with specific needs of the project. Proper technical staff alone can ensure proper quality of work during execution.

The engineers, architects and other professionals and supervisors for construction management of the project shall be deployed in adequate number. Some or all of following personnel may be employed as per requirements of the project:

Project Manager

Project Manager shall be responsible for supervision and monitoring of the project through quality assurance system including supervision and monitoring of the following:

- Establishment and setting up of testing laboratory
- Procurement, erection and operation of equipments
- Formulating methodology for testing
- Training of personnel in the laboratory
- Formulating the procedures for acceptance and rejection of materials and works
- Implementation of quality assurance
- Visit to site for solving day to day problems
- To ensure correct operation and record by conducting test-checks on materials, works etc.
- Checking of contractors weekly / monthly progress of works and work programme and advising them about improvements if signs of slippage are noticed.
- Taking all necessary actions to ensure proper contract administration
- Advising contractor on staff planning, scheduling and equipment utilization at the site. Procurement of any additional/replacement of equipments.
- Conduct periodical meetings with the contractor, QCE (Quality Control Engineer) and PE (Project Engineer) on matters relating to progress of works and other site problems regarding procurement of materials, arrangement of adequate labour, utilisation of machinery and equipment etc.
- Authorise and certify running account bills for payments.

Architect

- Organising architectural/structural drawings, keep record and issue to contractor and project engineers
- Supervising work with reference to architectural/structural drawings, give clarifications as required

Materials Engineer

- Carry out materials management including procurement and testing
- Screening process at source, source approval, certification of materials by manufacturers.
- Control of materials at site.

Project Engineer

Project Engineer shall supervise the work and accord acceptance to completed works. Project Engineer shall also inspect the work regularly and monitor day to day progress and also arrange to writing of daily dairy in respect of:

- Presence/non-presence of adequate number of competent workmen.
- Adequate number of supervision personnel of contractor at site
- Temporary and permanent bench mark details
- Daily work programme, adequacy of activity at site
- Adequacy of machinery and equipment
- All administrative matters

Quantity Surveyor

Quantity surveyor shall be incharge of recording of measurements, preparing running account bills, final bill, extra and substituted items including variations etc.

Quality Control Engineer

Quality Control Engineer shall oversee material sampling, testing in field laboratory and external laboratories. He shall ensure preparation, review and acceptance of quality plan and its operation at site, including management of quality related records.

Laboratory Technician

They shall perform testing of materials in site laboratory, keep records of all testing work and organise sending samples of materials to external laboratories as required.

Plant, Equipment / Instrumentation Engineer

Plant Equipment and Instrumentation Engineer shall oversee operation and maintenance of various machinery and equipments under use at site.

Environment Engineer

Environment Engineer shall ensure implementation of environment management plan consistent with provisions in the contract. He may be employed on-call basis / part time basis

Surveyor

He shall be involved in establishing bench marks and recording levels of temporary and permanent works.

Contractor's Supervision Management

Project team of the contractor shall include the requisite numbers of Project Mangers/ Project Engineers, Material Engineers, Quantity Surveyors, Quality Control Engineers, Plant and Equipment Engineers, Surveyors and Supervisors depending on needs of the project.

The onus of achieving quality control and ultimately the quality of the end product lies with the contractor's organization. He shall also be responsible for all aspects of deployment of efficient personnel at the site, liaisoning with the Engineer and owner and management of matters connected with cash flow, material procurement, contract management, preparation of invoices by Quantity Surveyor, preparation of monthly progress reports, daily work programme, weekly targets and monthly programme etc.. Project Engineer and Quality Control Engineer shall be responsible for all aspects of preparation, review, acceptance of quality plan and operation of the same at site. Material Engineer is responsible for material management including procurement, processing and quality control tests like inspection, approval and acceptance. Deployment, operation and maintenance of all mechanical and electrical plants and equipments are to be supervised by Plants and Equipments Engineer of the contractor.

The project quality control plan is required to be developed by the Contractor, in consultation with the Engineer. Notwithstanding the approval of the project quality control plan by the Engineer, full provisions of the conditions of contract shall remain in force and the Engineer shall have the right to amend any part of the project quality control plan as and where necessary to ensure that the quality of the works is consistent with the specifications.

The contractor's proposed quality control plan shall demonstrate his intention, willingness and ability to ensure the quality of the work and shall include:

- General quality control procedures
- Complete documentation to ensure that all materials to be brought to site comply with the requirements of the technical specifications and that such compliance shall be maintained throughout the currency of the contract
- A complete schedule of sampling and testing procedures including test type, frequency, timing and reporting
- Acceptance criteria for payment purposes and procedures in the event of substandard work or late test results
- Procedures for the checking, testing and approval of Temporary Works and Permanent Works
- Standard report formats for submission to the Engineer

Conclusion

Quality consciousness amongst the key participants i.e. contractor, engineer and architect in building construction projects is required for ensuring quality of work to customer's satisfaction and to build confidence in the builder's capability amongst all concerned. Design inadequacies, construction defects, time and budget over-runs, untrained human resources, lack of delegation of responsibility and authority for proper co-ordination, are common concerns in building construction management which need to be addressed.

There is a certain relation between the time and the quality. The relevant architectural and structural drawings should be made a part of the tender documents. Suggested programme schedule should also be made part of the tender document. Different milestones should be fixed in the tender document and in case of non-achievement of the milestones, remedial measures should be taken to make up for lost time. Timely completed projects invariably have better quality of work.

The standard of quality that the engineer's team of client tries to achieve should reflect the requirements set out by the client in the contract document. The contract document describes the design as per which the contractor is being asked to construct. The quality of materials and standards of workmenship ought to be controlled by the contractor on site by implementing quality plan. The plan establishes the resources required and the control of activities of specific processes, monitoring of activities and inspections and tests. The standards of workmanship can be maintained by providing adequate training, appropriate instructions and clear checklists to technical personnel

and workmen as well as by ensuing that there is proper site supervision, monitoring and feedback to ensure continuous improvement and quality.

In addition to the contractor's own quality control measures, the client's representative shall inspect the works to verify the compliance with the requirements of contract documents. Specific inspections may also be carried out during the construction phase as part of general contract management process. Top management can create an environment through leadership and actions, where all concerned are fully involved and in which a quality management system can operate effectively.

References

1. Quality Manual for Civil Works in Building Projects (IBC Publication).

2. ISO 9000 : Quality Management.

3. ISO 9001 : Quality Management Systems – Requirements.

4. ISO 9004 : Managing the Sustained Success of an Organisation.

5. ISO 19011 : Guidelines on Internal and External Audits of Quality Management Systems.

Quality Management in Civil Construction Sector

K.B. Rajoria
Former E-in-C, PWD Delhi & Past President, IBC

V. K. Sharma
Former Special Director General, CPWD

Prologue

Quality consciousness amongst the key participants i.e. contractors, engineers and architects in building construction projects is required for ensuring quality of full satisfaction of customer and to build confidence in the builder's capability amongst all concerned. Design inadequacies, construction defects, time and budget over-runs, untrained human resources, lack of delegation of responsibility and authority for proper co-ordination are common concerns in building construction which need to be addressed.

The author Shri K.B.Rajoria,who superannuated from the post of Engineer-in-Chief Delhi PWD and his co-author Shri V.K.Sharma who superannuated as Special Director General, CPWD are both well known experts in the field of 'Quality Management'. In this paper they have explained the seven Management Quality principles as per ISO 9001-2015 related to consumer focus, leadership, engagement of people, process approach, improvement, evidence based decision making and relationship management. International Standards Organization promotes development of standardization and related activities throughout the world to facilitate international exchange of goods and services and to develop co-operation in the sphere of intellectual, scientific, technological and economic activities. ISO -9000 is family of QMS designed to help organizations to ensure that they meet needs of the customer and other stakeholders while meeting the statutory requirements of product and services. Quality Management as per ISO-8402 is a set of 'all activities of overall management function that determine quality policy, objectives and responsibility to implement them.

A very interesting Article which needs to be given serious thought.

- Editor -

Introduction

The construction Industry is an important indicator of the development as it creates investment opportunities across various related sectors. Indian construction sector accounts for 40% of total development investment during the last 50 years. It employs around 10% of nation's working population and contributes to around 5% of national GDP. It is estimated that construction sector accounts for more than 75% gross domestic capital formation. Construction sector is labor intensive and employs more than 3.5 crore people and generates a wealth of over 200 billion rupees. Works that are undertaken in construction sector are either public works where the government or its agencies gets the work executed through contractor or some hybrid system like public- private partnership, build operate transfer etc or private sector works generally in areas like real estate development, institutional buildings and private housing. There are around 200 major construction firms in corporate sectors, more than 1.5 lakh Class-A contractors apart from thousands of small contractors who take up job as sub-contractors or work independently.

Areas of Indian construction industry range from urban infrastructures like metro rail, ports and airports, industrial corridors, dedicated freight corridors, development of 'Smart Cities'; irrigation and river linking; power projects; housing and building construction; retrofitting of old buildings; sewage, drainage and water supply. To cater to the demand of construction industry there is a fast growing sector of finished components, construction- chemicals, materials, equipments and machineries.

Workers, engineers and other professionals employed in the construction sector are expected to be proficient in their area of specialization. They are also expected to be deeply conscious of their responsibility to perform the task and deliver the product that conforms to laid-down standards and specifications. General perception about prevalent quality of construction is not very inspiring. Barring a few, quality in majority of works follows the dictum 'as good as it gets going'. There exists a high tolerance for the acceptance of non-conforming product which feeds into sluggish to casual process control of multifarious construction activities. Lack of awareness as to strict enforcement of quality procedures, inadequately trained workmen, engineers, architects, planners machine operators as also inefficient organizational structures are a few of the many causes contributing to average quality product. Quality management must therefore be understood in all thoroughness and implemented with all vigor.

Stakeholders

All those agencies, groups, people who are engaged in civil infrastructure development are the stakeholders in civil construction works. Government both

Central and State Governments are responsible for providing vision and policy planning delineating the contour of development at national down to village level. All civil infrastructure works are then developed more or less in accordance with the policy guidelines so laid down. The agencies involved in taking up works may be Government agencies like Public Works Department, autonomous organizations created with some specific mandate like National Building Construction Organization, Delhi Metro Rail Corporation to Semi-autonomous organizations, private organizations like Builders Groups and many other assorted bodies or organizations either devoted fully or partially in creating civil infrastructure. For Planning, design and construction there are Planners, Designers and Constructors in any infrastructure development project. . The organizations in their pursuit of creating structures engages the services of many people who have acquired skills and knowledge in the field of disciplines like Architecture, Civil, Electrical, Mechanical Engineering like Design Engineers specialized in designing Roads, Buildings ,Run ways, Water works like Dams, Jetties, ports etc; planners of Urban and Rural roads and building; experts in structural engineering, geotechnical engineering, concrete technology, deep foundations, tall structures, Pre-Fab structures, plumbing, Heating and Air- Conditioning(HVAC), Structural –Glazing, surveying etc; and most importantly skilled and semi skilled work force engaged on the building elements and machines; These and many other experts of relevant fields that are engaged by the infrastructure development organizations and agencies directly as a part of their organization or through procurement of their services will be stakeholders . Any project that is undertaken has to follow certain development guidelines hence it must work within certain restrictions and boundary conditions as laid down by the regulatory bodies and enunciated in many Building Codes, Acts, Municipal Rules, Environmental Protection Rules, City development plans, Area Development Plans and many other binding or mandatory rules as may be applicable (specific to areas, type of infrastructure and other socio-political conditions). These regulatory bodies in that sense become stakeholders. Civil construction being a complex entity it involves many players working in tandem with each other, all engaged toward achieving a common goal of completing the project that must satisfy the agency doing the job like builder/contractor, the agency on whose order the contractor takes up the job and finally the users or the client on whose demand the agency engaged the contractor. In many cases private builder like real estate developers act both as the construction agency, contractor and sometimes as the final user. Many other agencies and groups who are engaged in the supply chain of the project like building material suppliers, specialized machine suppliers and operators are also associated with the project development and will therefore be covered within the ambit of stakeholders. Broadly speaking stakeholders are Customers who buy or use the product (Public or client) and therefore will include all the suppliers who supply the products (PWD, contractors, builders), the organizations (policy makers, regulatory bodies, government) and all those who work in some capacity towards the delivery of product (Fig.1)

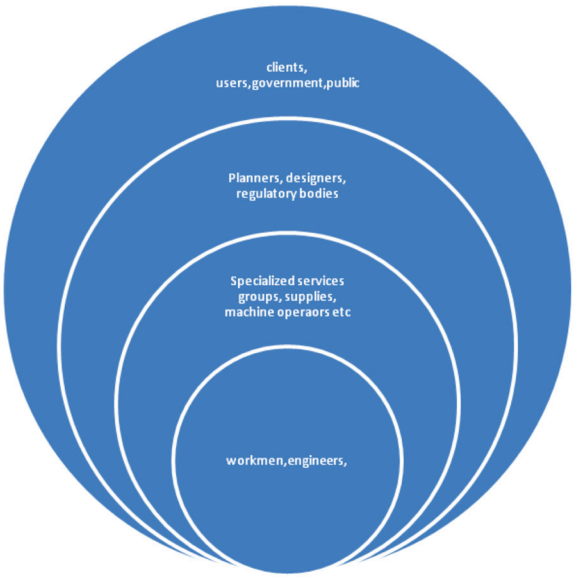


FIG. 1 STAKEHOLDERS IN CIVIL CONSTRUCTION

Quality

It was Aristotle who first analyzed quality in his logical work 'The Categories'. To him the qualities are hylomorphically- formal attributes such as 'white' or 'black'. He observed that 'One and selfsame substance while retaining its identity is yet capable of admitting contrary qualities'. Thus quality of a thing is its attribute or a property of something which run from one node (identity) to other node (contrary quality). It travels a path of conformance to non-conformance, good to bad or satisfactory to unsatisfactory. Because it travels a path it is capable of being subject to measurement. For Locke in 'An Essay of Human Understanding' quality is an idea of a sensation or perception. Commonly Quality can be understood as a degree of excellence. Quality of something depends upon 'the criteria being applied to and from a neutral point of view do not determine its value'. Quality being an intrinsic characteristic of a thing is thus value neutral. Quality as per the American Society for Quality (ASQ) is the 'degree to which a set of inherent characteristics fulfills requirement'. This 'fulfillment of requirement' generates 'satisfaction'. Civil constructions are basically a service rendered in the form of delivery of a product by the one (agency say a contractor) to the client (owner of the project say Government) then Service Quality (SQ) in its conceptualization is a comparison between perceived expectation (E) of the service or product with the perceived performance (P) giving rise to the equation SQ=P-E. It may be noted that 'P' and 'E' may keep on changing depending upon who is expecting whose performance. For student's expectations 'E', University delivering them a building will be university's performance 'P'. For University's expectation 'E', PWD's performance will be 'P' which in turn for PWD's expectation 'E' will be contractor's performance 'P'. It also indicates that Quality is positive only when

Performance exceeds Expectation. Expectation is a belief in the buyer/user of the product that is considered the most likely to happen. A less advantageous result gives rise to emotion of disappointment. Fulfillment of expectation will give satisfaction. For user/client satisfaction, it is essential that product's performance exceed their expectations. The word 'product' connotes a good idea, information, object, or service created as a result of 'process' and serves a need or satisfies a want. This word is more commonly used in manufacturing sector but for civil construction it can be validly considered as the project as a whole or its many components like beam, column, door etc which is tangible and is created out of certain process gone in its making. The word product for civil construction can be used interchangeably for the project or its construction component or elements without altering its characteristics like tangibility, capability of serving the need or satisfying a want.

When a client places his requirement he visualizes the product as one which satisfies his requirements both in terms of durability as also in terms of functionality of structures. Client's concept is then further developed by the planner or architects, design for its various structural elements are developed by the design engineer, standards and specifications are finalized for each of the element of the project duly referenced or written down to be followed by the project execution team. A kind of boundary conditions for the processes and the products are thus laid down which must be followed diligently by the field units to ensure that things are done the way they should be. One of the definition of Quality is 'doing things right first time' which only conveys the importance of the need to lay down standards and specification and their diligent follow up. Such written down standards and specifications form Quality Manual. Quality manual thus sets up bench marking for each of the element that goes into making of the project. It is important to note that element can never be fully replicated in the actual practice in the sense each one will be found differing from each other as also from its defined and laid down characteristics in the standards and specifications. Acceptance or rejection of a product will therefore depend upon whether it falls within certain allowable variation or not. Each of the product or element whether it is a column or a beam or a door will pass conformance test if variation is restricted within the allowable tolerance.

Concept of Quality can be further divided into two categories 1) Quality of Design- A badly designed building howsoever well constructed will not serve its intended function. Like any product civil construction project must be designed in most meticulous manner taking into account all the governing parameters that may affect project performance. Architectural and structural elements must satisfy client's requirements (within budget constraints) as also all the regulatory conditions as may be applicable to minimize uncertainty during project execution. Quality of design confers 'reliability' to the project undertaken .Reliability is the probability that the product will perform its intended functions without failure for specified time which in case of civil construction is its designed life cycle. Quality of design is a direct outcome of the quality of project planning process. Project planning therefore should be prudent, meticulous and detailed. It must lay down all the measures and metrics to control the process during construction phase and also define each of constructed element's characteristics.2) Conformance Quality-It defines

the degree of adherence of the product quality to the design, drawing and specifications. For Civil construction project conformance quality is the degree of adherence which each of the project element holds to what has been prescribed in the Quality Manual.

Quality Management

Evolution

Even a smallest of civil construction project involves many players, different kind of expertise and knowledge, apart from materials and machines all working through a set process culminating into a deliverable entity. This deliverable must not only perform higher than the expectation of the customer/client but its quality must be of consistent nature. Creating such conformance of product on a regular basis calls for an efficient management system of Quality. A management system works efficiently only when its different nodes are interlinked and inter-related to each other in certain hierarchical order. As it is a team of knowledge workers like engineers, designers, architects, planners who are responsible for the delivery of product, they are supposed to be efficiently linked in the overall structure of an organization. It comes to that it is the efficiency of the organization which is reflected in the consistency and conformance of the civil project. The discipline of quality management (QM) complements project management with a focus on customer/client satisfaction. This inter alia involves prevention of defects, management responsibility and continuous improvement. All organizations are geared to deliver some kind of services and so are true for any civil construction organization. Therefore quality management is very important to any organization. Knowing the fact that clients choose higher quality standards than normal goods, in old days it was the responsibility of the master craftsman to train the craftsman and also supervise their work performance. With passage of time when there was a growth of demand for the products and that too of consistent quality, it was the Industrial Revolution in Europe that solved the problem by replacing the master craftsman by automated machines and equipments especially in repetitive products. Fredric Winslow Taylor, a Mechanical Engineer sometimes called 'Father of Scientific Management' sought to improve industrial efficiency. He was one of the Intellectual leaders of 'efficiency movement' and part of his approach laid the foundation of Quality Management including standardization and adopting improved practices. Henry Ford was also important in bringing process and QM practices into his assembly lines. Later on Walter A. Shewart made a major contribution in the evolution of QM by creating methods for Quality Control (QC) for production using Statistical Methods, first proposed in 1924. Another pioneer who contributed to QM greatly was W. Edwards Deming, best known for his management philosophy establishing Quality, Productivity, and Competitive position. He formulated 14 points, major among them still hold relevance like 1) Break barriers between departments 2) Manager should learn their responsibilities and take on leadership3) Supervision should be to help people and machines to do better job 4) Improve constantly and forever the system of production and services 5) Institute vigorous program of education and self improvement. ISO 9000-2015 has adopted many of his management principles like Leadership, Engagement of People, Process Approach, Improvement, Evidence Based Decision Making, and Relationship Management. Over

the period especially after Second World War, there were many pioneering work done to improve Quality and Productivity in USA, Europe and Japan. A few of the Quality Management words popularized over the period are 1) Kaizan-Japanese for 'Change for the better' 2) 'Six Sigma' for process improvement- Define, measure, analyze, improve, control 3) TQM- A management strategy aimed at embedding awareness of quality in all organizational process 4) TRIZ- Theory of Inventive Problem Solving 5) BPR- Business Process Re-engineering, a management approach aiming at optimizing the work flow and process within the organization. 6) PDCA-It involves four stages a) Plan- It assesses project's current level of quality and where it needs to be. Then develop an effective and workable plan with specific target for meeting the quality. b) Do- doing or implementing such plan so developed. c) Check- Review and evaluate the results of implemented change and its effect on the project quality and ensure that there are no negative consequences. d) Act- Take action based on what was learned from implementing and evaluating the planned change. Continue repeating the cycle until quality objectives have been achieved.

Quality Policy

Quality Policy (QP) and Objectives: Policies are mechanism for controlling the behavior of an organization by governing the behavior of the people who work in the organization. Policy exists to ensure that organization functions in a way that is predictable, advisable and in the best interest of organization and the person. Policy in other words is 'underpinning principle' of an organization. For organization's quality policy, underpinning principle may be like 'To promote and protect organization as premium construction organization' or 'Organization in pursuit of excellence' or 'Organization that gives you value for money' etc. Policy goals emerge from such underpinning principles and will describe the range of desired outcome or what is to be achieved by implementation of policy. Policy goals for a construction organization may be like 'Strong and durable construction' or 'Minimum maintenance in project life cycle' or 'Durable, reliable and cost effective'. Policy objectives are those goals that can be 'measured'. If goal is say 'Minimum maintenance in project life cycle' then policy objective may be 'maintenance cost during life cycle not to exceed 10% of project cost at prevailing rate' or for 'Strong and durable construction' policy objective can be ' Zero maintenance cost in the next 10 years' etc. Policy objective is a written guide line contained within policy that helps reader understand what they have to do in order to adhere to the policy. These written guidelines should be unambiguous, clear and well worded otherwise organization's stated policy will have little value.

Quality Management broadly speaking is implementing and carrying out Quality Policy (QP). This is done within the framework of organization. For the purpose of Quality Management , it is the organizational set up of work execution agency that matters, same being involved in procuring the project and delivering the same to the client and responsible for quality of the product. To achieve their Quality Objectives and for creating necessary credibility that ensure them repeat orders the organizations must do Quality Planning and manage Quality Control (QC) and Quality Audit (QA) activities.

All activities and actions taken within the organization to implement Quality Policy will constitute Quality System. Quality Management is thus responsible for seeing that all Quality Goals and Objectives are implemented and corrective actions achieved including periodical review of Quality System to ensure effectiveness and to identify and review deficiencies. The quality of deliverables like civil construction project thus invariably become a consequence of 1) Efficiency of Organization 2) Efficiency of Project Planning 3) Efficiency of Project Management.

Quality Planning: Quality Planning is the key process while planning the project and plays important role in developing project management system. When a project is procured and client's requirements are known next step is to identify which organizational and regulatory standards are relevant to the project and how to satisfy them. Quality needs of the project, the required standards of the project and its components and how it can be ensured that these will be fulfilled in the final deliverable; will all be covered in Quality Planning process. Steps involved in Quality Planning may include a) Cost Benefit Analysis: Each project must be subjected to a Cost-Benefit Analysis covering different approaches to the project execution including risk assessment, uncertainties involved (each of such element being assigned some monetary value) to work out the course which yields best value for money. b) Benchmarking: Having finalized the method of project execution, next step is Bench Marking of project and its component. Benchmarking is evaluating and comparing the project performance against identified benchmark for the purpose of continuously measuring and improving project efficiency within the overall goal of improving project performance. c) Quality Management Program: It is a formal document that encompasses both Quality Control and Quality Audit procedures that address key aspects of assessing quality standards. It will focus on the processes that will be used to plan, implement, document and assess project quality level. It will define project policies, objectives, principles, responsibilities and accountability relating to project quality. The document will also outline how the project team will implement, perform and measure those policies. QMP will vary as per the need of the project. d) Quality metrics and measures: Quality Metrics are the parameters or the ways of quantitatively assessing the project level quality along with the processes to carry out such measurement. Metrics outline the standards the work will be measured against. Quality Metrics are measured throughout the project life to track and assess the project's level of conformity to the established quality base line.

Quality Control (QC): It encompasses all the techniques and activities of organization that continuously monitor and improve the conformance of the product or process to specifications. QC aims to reduce the variation of product quality from the one as laid down in bench mark standards. QC may also include reviewing the process and specifications and making recommendations for their improvement. QC aims to eliminate the causes of unsatisfactory product performance or at least narrow the source of variation. In other words, QC has the same meaning as the 'variation control' of product characteristics. Objective of QC program is to create a system in which product meets the design requirement including a system of periodical review, corrective actions and process improvement. In civil projects as materials and machines are brought from

the suppliers. QC also includes selecting and rating the suppliers to ensure that the products purchased meet the laid down quality requirements. It is an activity undertaken during product development process that is during the currency of project execution and performed on all material, equipment and activities in construction process. QC activities are thus in house activities built into the project management set up of the organization.

Quality Audit (QA): It describes all the planned and systematic actions necessary to assure that product and services will satisfy the specific requirement. QA creates a sense of assurance that all activities from planning, design, development, execution have been performed to achieve client's satisfaction. To be able to create this assurance, QA activities are kept independent of QC activities.QA is performed by independent inspection of project processes and products. The person performing QA functions should therefore not be associated with the activity being audited. There are two types of Audit. 1) Management and Quality System Audit 2) Product Specific Audit. An organization or a firm or a company may have QA cell within the organization working independently and dissociated from the work execution unit. Inspection by such QA cell will constitute First Party Audit where a part of organization will evaluate the performance of project unit. In case Client wants to assure himself about the quality of work being executed, he can engage some professional as a Second Party Audit. Audit conducted by a completely separate professional body having no stake in the audited organization will be Third Party Audit. Auditors in Third Part Audits are accredited professionals who audit to International Standards like ISO-9000 Series. First or Second Party Audit generally combine Quality System(QS) audit with the Product specific audit whereas Third Party Audit focuses on Management and Quality System and is not product specific.

QA program therefore assesses that a) Quality Plan and procedures are in place. b) Documents are controlled to avoid any misuse. c) Standards and regulations are being followed. d) Data system provides adequate and accurate information. d) Problems are attended and corrective actions taken. e) Product conforms to requirements.

The difference between QA and QC are listed in the Table 1.

Table -1: Difference between QA and QC

QA	QC
Doing things right the first time	Fix it whenever it goes wrong or going wrong.
It has to do with making sure quality what it should be.	It has to do with making quality what it should be.
A systematic set activity to provide confidence that requirements are established.	Process by which Quality is compared with applicable standards and keeps variations within certain bound.

An activity that evaluates the process right from design, development up to final delivery of project.	An activity that verifies if the product meets the pre-defined standards before acceptance.
Helps establish a better process.	Improvement.
Sets up a measurement program to evaluate process.	Verifies if specific attributes are there in specified product or service.
Identifies weakness in the process and improves them.	Identifies defects primarily for the purpose of correcting the defects.
Prevents the introduction of issues or defects.	Defects report and correct defects.
Evaluates QC effectiveness.	Evaluates if the activities are working for the purpose of determining defects in the functionalities of product.
Improves the process that is applied to multiple products.	Improve development of specific product or services.

Managing Quality

After receiving the requirements from the client, it is the civil construction organization that plans, designs, execute and deliver the project back to the client such that it fulfills his expectations , reassures him as to the quality of the work and generates a sense of satisfaction. From client's requirement to client's satisfaction lies the pyramid of quality management system built into organization and managed by knowledge work force. It is the organization; people working under it and their inter-relationship all inter woven in such a way that they are geared toward a common objective of Quality that satisfies the customer's requirement which is central to any Quality Management System(QMS). QMS can be appreciated in the following four levels.

Level 1-Quality Manual: It's a documentation of organization's Quality Policy, Quality Objectives, required standards, and other regulatory and statutory requirements.

Level 2- Quality Procedures: It spells out procedure to be followed for attaining the Quality Objectives of the organization and will cover a) Procedures to be followed for the control of documents, and records b) For QC and QA c) For controlling non conforming products d) For corrective actions and e) Preventive actions.

Level 3- Quality Plan: It will cover a) Areas and activities to be covered in the inspection plan both for the QA and QC b) Details to be covered in test report and inspection report c) Work instructions to control non conformance of product.

Level 4- Forms/Formats/Records: It will cover forms and records to create documented evidence to establish the fact that all quality procedures have been followed. It will also establish the fact of evidence based decision making. It will provide evidence of conformity

to requirements and of the effective operation of QMS. There will be mandatory and project specific records to be developed by supervisors, engineers and work inspectors as the case may be. It will cover check lists for the items being executed, calibration report for equipments, test reports for process and product, inspection reports, reports on corrective actions, preventive actions, internal audit etc and many others. The records must reflect full picture of various items executed at site and establish the fact of acceptable standard of quality of all the elements of construction project. Records shall remain legible, readily identifiable and retrievable.

Quality Management System (QMS) and Quality Assurance System (QAS): QMS belongs to that domain of Quality which is 'Internal' to an organization. It covers Internal Quality Control and Audit to supply confidence to the management that intended quality is being maintained by adhering to all quality procedures. QAS on the other hand is 'External' in the sense it covers those activities which inspires confidence in client that product will satisfy client's quality requirement. Any Quality Management and Assurance System therefore comprise of a) Effective interface between customer and organization which inter alia covers appreciation of client's requirement and developing an effective quality policy that ensures that the product /project delivered meets client's expectation b) Leadership role of top management in formulating quality policy and its effective implementation. c) Awareness of responsibilities by all concerned for the delivery of product of acceptable quality. d) Competent work force working in tandem to achieve organization's quality objectives. e) Documenting actions and activities of all the processes to supply assurance of quality to both management and client. f) Continuous improvement in performance that exceeds expectation.

Quality Principles of ISO 9001-2015

International Standards Organization (ISO) began operation in 1947 to promote development of standardization and related activities throughout the world to facilitate international exchange of goods and services and to develop co-operation in the sphere of intellectual, scientific, technological and economic activities. ISO -9000 is family of QMS designed to help organizations to ensure that they meet needs of the customer and other stakeholders while meeting the statutory requirements of product and services. Quality Management as per ISO-8402 is a set of 'all activities of overall management function that determine Quality Policy, Objectives and responsibility and implement them by means such as Quality Planning, Quality Control, Quality Audit and Quality Improvement within the Quality System'. Quality System as per ISO-8402 is the 'organizational structure, responsibilities, procedures and resources needed to implement Quality Management'. As per ISO-2015, there are seven management principles upon which the family of Standard is based. These principles are fundamental beliefs, rules and values that are accepted as true and can be used as basis for Quality Management.

Schematic diagram showing Quality System Network is shown in Fig.2.

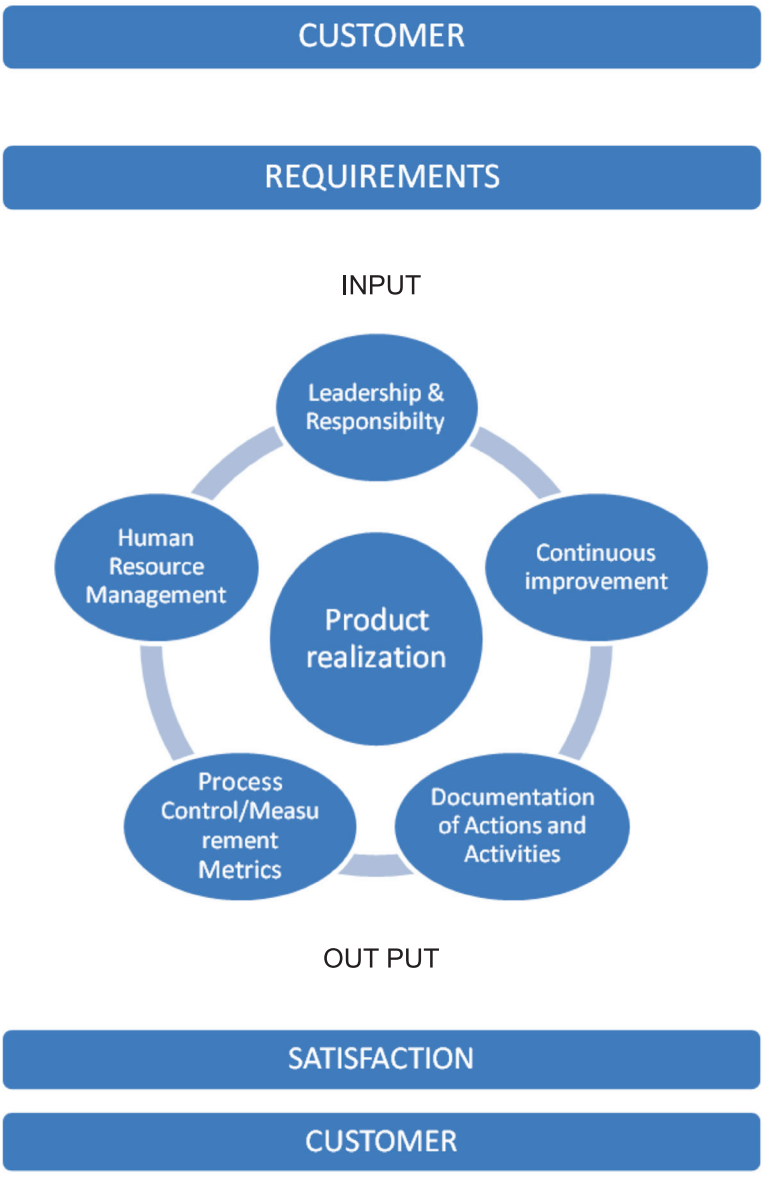


FIG. 2 QUALITY SYSTEM NETWORK

Quality Management Principle (QMP) 1- Customer Focus

The Organization must work to meet customer's requirements (need) and strive to exceed his expectation. Sustained success can be achieved when organization attracts and retains the confidence of customers and other inter-related parties. Understanding current and future needs of the customer and other interested parties contributes to sustained growth. It will lead to customer satisfaction, improved loyalty, enhanced repeat business, enhanced reputation of the organization, expanded customer base and increased revenue and market share.

Action to be taken include a)Recognize direct and indirect customers as those who receive value from the organization b) Understand present and future needs and expectation of the customer c) Link organization's objectives with customer's experience d)Communicate customer's needs and expectation throughout the organization e) Plan, design, develop, produce and support goods and services to meet customer's needs and expectations f) Monitor and measure customer's satisfaction g) Determine and take actions on interested parties' needs and expectations that can affect customer satisfaction h) Actively manage relationship with the customer to achieve sustained success.

Quality Management Principle (QMP) 2- Leadership

Leadership establishes unity of purpose and creates conditions in which people are engaged in achieving organization's quality objectives. Unity of purpose and engaging people enable organization to align its strategic policies, processes and resources to achieve its objectives. It will lead to a) increased efficiency and effectiveness in meeting organization's quality objectives b) Better coordination in organization's process c) Improved communication level and functions of organization d) development and improvement of organization's capability and its people to deliver desired results.

Actions that can be taken include a) Communicate organization's vision, mission, strategy, policies and process throughout the organization b) Create and sustain shared values, fairness, ethical model for business at all levels of organization c) Establish culture of trust and integrity d) Establish organization wide commitment to quality e) Ensure that leaders at all levels are positive example in organization f) Provide people all resources, training and authority to act accountably g) Inspire, encourage and recognize people's contribution.

Quality Management Principle (QMP) 3: Engagement of People

To be able to create and deliver value an organization requires an empowered, engaged and competent work force at all levels of an organization. Involving all people at all levels and to respect them at individual level is the key to organization's effectiveness. Recognition, empowerment and enhancement of competence facilitate the engagement of people in achieving organization's objectives. effective engagement of people will lead to a) Improved understanding of organization's quality objectives by people in organization b) Enhanced involvement of people in improvement activities c) Enhance personal

development, creativity and initiatives d) Enhanced people's satisfaction e) Enhanced trust and collaboration f) Increased attention to shared values and cultur throughout the organization.

Actions which should be taken include a) Communicate- to promote the understanding of importance of their individual contribution b) Promote collaboration c) Facilitate open discussion, sharing of knowledge and experience d) Empower people to determine their constraints to performance and take corrective initiative without fear e) Recognize people's contribution, learning and improvement f) Conduct survey to assess people's satisfaction.

Quality Management Principle (QMP) 4-Process Approach

Consistent and predictable results are achieved more efficiently when activities are understood and managed as inter-related processes that function as a coherent system. Quality management system consists of inter-related processes. Understanding how the results are produced by QMS enables the organization to optimize its system and performance. Benefits of process approach includes a) Enhanced ability to focus on key processes and opportunities for improvement b) Consistent and predictable outcome through a system of aligned process c) Optimized performance through effective process management, efficient resources and reduced cross functional barriers d) enabling organization to provide confidence to interested parties as to its consistency, effectiveness and efficiency.

Action which should be taken include a) Define objectives of the system and processes necessary to achieve them b) Establish authority, responsibility and accountability for managing processes c) Understand organization's capabilities and determine resource constraints prior to action d) Determine processes inter-dependability and analyze the effect of modification to an individual process on the system as a whole e) Manage processes and their inter-dependence/inter-relations as a system to achieve organization's quality objectives, efficiency and effectiveness f) Ensure that necessary information is available to operate and improve the processes and to monitor, analyze and evaluate the performance of overall system g) Manage risks that can affect outputs of the processes and overall outcome of QMS.

Quality Management Principle (QMP) 5- Improvement

The underlying principle is that organizations must constantly strive for improvement if they want to be successful. Given the competitive industrial environment, improvement is essential for an organization to maintain the current level of performance and to react to change in its internal and external conditions and to create new opportunities.

The benefits include a) improvement in organization's capabilities, performance and customer's satisfaction b) Enhanced focus on root-cause investigation and

determination followed by corrective and preventive measures c) Enhanced ability to anticipate and react to internal and external risks and opportunity d) Enhanced consideration of both incremental and break-through improvement e) Improved use of learning for improvement f) Enhanced drive for innovation.

Actions that can be taken include a) Establish 'improvement objectives' at all levels of organization b) Educate and train people at all levels on how to apply basic tools and methodology to achieve 'improvement objectives' c) Ensure that people are competent to successfully promote and complete 'improvement objectives' d) Develop and deploy processes to implement ' improvement project' throughout the organization e)Track, review, audit the planning, implementation, completion and result of 'improvement project' f) Integrate improvement considerations into development of new modified goals, services and processes g) Recognize and acknowledge improvement.

Quality Management Principle (QMP) 6- Evidence Based Decision Making

Decision based on the analysis and evaluation of data and information are more likely to produce desired result. Decision making is a complex process and always involves some uncertainty. It often involves multiple types and sources of input as well as their interpretation. It is essential to understand the cause and effect of un-intended consequences. Facts, evidence and data analysis leads to greater objectivity and confidence in decision making. The benefits of evidence based decision making are a) Improved decision making process b) Improved assessment of process performance c)Improved operational effectiveness d) Increased ability to review, challenge and change opinions and decisions e) Increased ability to demonstrate the effectiveness of past decisions.

Actions that can be taken include a) Determine, measure and monitor key indicators to demonstrate organization's performance b) Make all data available to key people c) Ensure that data and information are sufficiently accurate, reliable and secure d) Analyze and evaluate data interpretation using suitable methods e) Ensure people are competent to analyze data as needed f) Make decisions and take actions based on evidence backed by experience and intuition.

Quality Management Principle (QMP) 7- Relationship Management

For sustained success, an organization manage its relationship with interested parties such suppliers. Quality and timely delivery of goods and services by suppliers more often than not influence the performance of an organization. To optimize their impact, organization must manage its relationship. Managing relationship with interested parties will lead to a) Enhanced performance of organization through responding to opportunities and constraints related to each interested parties b) Increased capability to create value for interested parties by sharing resources and competence and managing quality related risks c) A well managed supply chain that provide stable flow of goods and services.

Action taken to optimize relationship management include a) Determine relevant interested parties (suppliers, partners, customers, investors, employees, societies as a whole b) Determine and prioritize interested parties that needs to be managed c) Establish relationship that balance short term gains with long term considerations d) Pool and share information, expertise and resources with relevant interested parties e) 'Measure performance' and 'supply performance' feedback to parties to enhance improvement initiatives f) Establish collaborative development and improvement activities with interested parties g) Encourage and recognize improvement and achievements by suppliers and partners.

The above mentioned seven Quality Principles are related to organization that has been entrusted with the delivery of goods and services. The working of the organization therefore needs to be understood, analyzed in respect of hierarchical linkages, decision making process and its flow throughout organization; Organization's implementation mechanism covering translation of decisions taken into action; System of review, analysis and corrective actions in respect of each of the processes that goes into delivery of goods and services. Quality management thus in the final analysis becomes managing the quality of organization.

Quality in Construction Works

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Prologue

Total Quality Management (TQM) is "the management approach of an organization, centred on quality, based on the participation of all its members and aiming at long term success through customer satisfaction, and benefits to all members of the organization and to society." In fact, in this approach, customer is the person who accepts the product of any process. Suppose, cement is received by a person, then person receiving cement is customer. When cement is mixed and concrete is produced in a mixer, the person receiving concrete to place it becomes the customer and so on so forth. Thus, participation of all members is very essential in TQM. Everybody must be involved, from all levels and across all functions.

TQM is not one time concept and is based on continuous improvement. Hence continuous improvement is essential in product, process, and management. Education and training are very important for continuous improvement process. Therefore, the management has to believe first in TQM concept that the same is possible and then make sure that education and training is imparted to all their employees. Early in the process, all levels of management must be trained to implement their part of the quality improvement programme. The author who is responsible for construction and maintenance of all Central Govt. properties in Western Region of India is extremely quality conscious.

A very interesting and comprehensive paper from one who has been at the helm of it.

- Editor -

Introduction

Quality is most commonly used word in all spheres of life so also in construction sector but probably is one of the most difficult words to define properly. When even definition is difficult, its implementation becomes much more difficult. Probably it is like beauty which is admired by everybody but may differ from person to person, so the quality also. Though quality had many definitions, ISO has defined quality as "The totality of characteristics of an entity that bears on its ability to satisfy stated and implied needs". It appears that due to standardization, definition of quality has been simplified but it is also not so. The definition is actually more complex than its simplicity. The last part which mentions about satisfaction of stated and implied needs is really very crucial as nowhere

the implied needs are described. In the definition, an entity may be a product, process or even an organization and in the context of civil engineering works, stated needs may be available in the form of specifications, conditions or bill of quantities but implied needs are not specified in the documents. For example, if flats are being constructed by an agency, stated needs may be taken care as they may be more or less same but the implied needs of the customers may be different but are also to be satisfied for qualifying to the quality. Thus, both customer and implied needs are to be identified. Nowadays, a customer is the receiver of a product, thus, even a contractor, engineer, quality manager, user or many others in the process may become customers at different points of time. As per the definition, each one has to be satisfied. Second part is the identification of the implied needs. Many times, even the customer is not able to express these needs as many of them may be unspoken needs and one may find difficult to express them. Many times, it comes to the notice that customer says that the quality is not good but he is not able to express what is not good as he is not able to express it again just like the beauty. Does it mean that quality is not achievable?

No quality guru so far has given a statement that quality is not achievable. So it has to be ruled out. Crosby, one of the quality guru asserts in the “Quality is free”, that quality is not luxury, unaffordable, originated by workers or something that originates in the quality department and thus affordable and achievable. Deming, another quality guru states that about 85% of all quality problems are caused by harmful management practices. It has also been stated that consequently, CEO intent on changing the way production workers perform – without changing the obsolete management system – will, at best, address only 15% of the problems. Juran, another quality guru is of the view that senior managers must personally take charge of leading change related to quality. If they try to delegate that, they will not get good results. According to Ishikawa, a Japanese quality guru, bad quality, meaning wastage, had an effect not only on business creating the waste but also on its customers and on society as a whole. Another Japanese quality guru, Taguchi described quality as the loss imparted to the society from the time a product is shipped and quantified as “Loss function”. It must be understood that most of the work stated above does not correspond to a construction work.

Quality Eras

Inspection : Inspection is considered the first era in quality process out of four eras described by Crosby and is probably still in vogue in most places in construction industry. Inspections are customary, costly and painstaking. Theory of probability is applied during testing by taking samples. Eventually, inspections do not contribute greatly to reducing the error rate. The problem is addressed after it has arisen. Thus, even 100 % inspections will not mean that all the defects have been removed or rooted out.

According to Crosby, second era was of the quality control in which emphasis was given on product uniformity with reduced inspections. Quality control is defined as “all those operational techniques and activities that are used to fulfil requirements for quality” (ISO). Therefore, emphasis in quality control is on techniques and activities. Inspections,

monitoring and feedback are carried out in quality control. It has nothing to do directly with the customer's satisfaction. Inspections do not ensure conformance of specifications of one hundred percent work. Inspections in a work may also result to corrective action rather than preventive action. Operational techniques and monitoring also lead to "paper quality" in which the papers assure the quality with or without any consideration of the work.

Quality assurance : Quality assurance as per ISO is defined as "all the planned and systematic activities, implemented within the organization for quality management, to provide adequate assurance that a product or service will satisfy given requirements for quality." Therefore, quality assurance is essentially a preventive activity and is therefore to be systematically planned in advance. The activity includes identification and planning of the checks, inspection and control of process as a part of quality control. Quality assurance also means establishment of a quality system which can demonstrate the requirements. Unfortunately, in many organizations, names have changed from the quality control units to quality assurance units without any change in the working or strategy or even in the attitude of the quality personnel.

Total Quality Management (TQM) : Total Quality Management (TQM) is defined as "the management approach of an organization, centred on quality, based on the participation of all its members and aiming at long term success through customer satisfaction, and benefits to all members of the organization and to society." In fact, in this approach, customer is the person who accepts the product of any process. Suppose, cement is received by a person, then person receiving cement is customer. When cement is mixed and concrete is produced in a mixer, the person receiving concrete to place it becomes the customer and so on so forth. Thus, participation of all members is very essential in TQM. Everybody must be involved, from all levels and across all functions. A culture of continuous improvement must be established. Emphasis should also be placed on promoting creativity.

TQM is also a philosophy based on the quest for progress and continuous improvement. In Japanese, process of continuous improvement has been termed as Kaizen. In quality improvement, waste and total cost must reduce. Quality improvement can only result from planned management action. Importance of TQM can be understood from the statement of Crosby's four eras of quality as organizations adopting inspections only say, "We don't know why we have quality problems" while in TQM, they say, "We know why we don't have quality problems". Errors can be caused at any stage of management and workers and thus, involvement of everyone is essential in TQM. Question is whether error can be stopped and the answer is very simple – no as it is natural to make errors. But the errors have to be eliminated and not at later stage but right at the stage it is likely to occur or it has occurred by preventing it or correcting it as the case may be. It cannot be passed on to other person or process. Thus, TQM includes self inspection.

Crosby has described fourteen step programme to achieve quality as management commitment, quality improvement teams, quality measurement, cost of quality evaluation,

quality awareness, corrective action, zero defects planning, supervisory training, zero-defects day, goal setting, errors cause removal, recognition, quality councils and 'do it all over again'. Deming also suggested 14 points which create consistancy of purpose, adopt new philosophy, cease dependence on mass inspections, end the practice of awarding business on the price tag only, improve constantly and forever the system of production and service, institute training, institute leadership, drive out fear, break down barriers between staff areas, eliminate slogans, exhortations, and targets for the workforce, eliminate numerical quotas, remove barriers to pride of workmanship, institute a vigorous program of education and training and take action to accomplish the transformation.

Thus, from the foregoing discussion, it is clear that the followings are to be considered for the quality;

- Quality means satisfaction of customer's stated and implied needs.
- Quality of a work includes durability and its life cycle concept.
- Quality is not originated by the workers or quality control departments but from the top management and includes one and all connected with it.
- Quality requires involvement of every one.
- Cost of quality is a loss to the society.

Concept of Zero Defects

Any variation that is caused while translating customer needs into correct specifications or while producing the required entity is considered as a defect. In fact, many people believe that it is uneconomical to eliminate all defects and some believe that defects or variations are normal, particularly in civil engineering works. But as per a quality guru, Philip B. Crosby, 'zero defects' are both technically and economically possible. An example has shown that once management demanded perfection, it happened and workers produced it. Of the three most common causes of workers errors – lack of knowledge, lack of proper facilities, and lack of attention, management concluded that the lack of attention was often addressed. Therefore, a goal was set to promote a constant, conscious desire to do a job right, the first time as per Garvin. The resulting programme was called zero defects.

Crosby argues that if management is serious about achieving zero defects, it has to be serious about prevention. He proposed four absolutes of quality management as given below:

- Quality means conformance to the requirements.
- Quality comes from prevention.

- Quality performance standard is zero defects
- Quality measurement is the price of non-conformance i.e. cost of quality.

As per Crosby, it takes a long time to transfer from conviction to conversion but as soon as the transfer process begins, it is a positive sign that improvement has started to take place. In fact management's policy of "that is good enough" has been considered a roadblock. Zero defects are only possible if each and everyone are involved in quality process.

In construction sector also, concept of zero defects can be implemented if zero defects concept is implemented in every product, every process and by every person in the process. Since, stakeholders in a construction work are many including architect, engineers, contractors, suppliers, local bodies, zero defects become more complex and very difficult to achieve.

Stated and Implied Needs

In a construction work, architects, planning engineers and supervising engineers consider stated needs stated by the customer. Therefore, needs are to be stated at the very initial stage and thereafter to be implemented. In a construction work, even if needs are stated initially by the customer, changes are likely to be cropped up during construction process, hence deviations from the stated needs become essential for customer satisfaction as samples are not available in a construction work as in case of factory made products.

Stated needs are compiled in the form of drawings, specifications, conditions - general or special and clauses of the contract. Implied needs are part of the dimensions of quality. The dimensions of quality for a product are performance, features, reliability, conformity to specifications/standards, durability, serviceability, aesthetics and perceived quality. Time and timeliness service, completeness, consistence, courtesy, accessibility and convenience, and responsiveness are the dimensions of quality for a service but are to be included in construction as the civil engineering is also a part of the service. Thus for a construction work, the dimensions of a product as well as a service are to be considered for a quality work. In fact, product plays a major role during construction and service dimensions play a major role during maintenance. It must be understood that a customer who is not expert in the architectural and engineering profession will not be in position to spell out all the implied needs and hence, these are to be considered by the architect, engineers and builders.

Implied needs are most important. An architect or an engineer has to plan and construct the structure which conforms to local bye laws, is safe during normal and exceptional conditions like disasters, conforms to prevalent codes and guidelines and satisfy to the customer for end use. A customer must feel happy and satisfied while using the work. In fact, it is more of the implied needs which contribute to happiness to the

customer and hence these are more important. Customer satisfaction leads to improve quality of his life and hence quality is largely based on the satisfaction of needs.

A building is a fixed asset and one does not change it easily and thus gets attached sometimes emotionally may be house or office for his/her life. Therefore, the dimensions of the quality and problems/comfort received from the asset during life of the building affect customer satisfaction. Thus, it becomes essential that the life cycle concept is considered by the architects, engineers and construction agencies. In fact, it is the maintenance stage from which customer forms a view about the quality of a work and hence, TQM in construction sector has to include life cycle concept. Life cycle concept includes all the stages right from the inception to dismantling. In fact, quality costs in a civil engineering structure should not only include prevention, appraisal costs and failure costs during construction but also such costs incurred during its useful life in maintenance stage. The needs of maintenance stage are to be considered while planning and executing a work. A work should require minimum maintenance and operational costs for a customer's satisfaction.

Thus, quality is not an absolute word but interrelated with stated or implied needs. Quality would depend upon the customer needs. For example, granite flooring cannot be said to be a quality work compared to cement concrete flooring just becouse granite flooring is of richer specifications. Both are to be assessed separately for quality. Therefore, the customer should be very clear of his needs otherwise customer may not appreciate the difference between quality and specifications as many times superior specifications are wrongly misunderstood the parameters of quality.

Human Resource Management

In TQM, everyone has to contribute to quality. Therefore, personnel involved in achieving quality, have to be quality conscious and trained. Thus, to achieve quality in any work, one must

- Know, understand and agree to the requirements of the job.
- Know how to do the job and why it is being done.
- Have the knowledge of materials, process and equipment to do the job.
- Know what to do when the things go wrong.

For above, it is essential that orientation and development training to the supervisors is imparted in quality which includes new materials, methods, and machinery in a systematic manner for the customer satisfaction. Therefore, the persons involved in construction or maintenance activities must have the knowledge and capability of doing quality works. Hence, personnel management i.e. right person for right job is essential to achieve quality.

In a civil work, it is said that if someone is doing the following, quality should not be expected from him;

- Accepting work not up to the standard may be because of urgency or any other reason.
- Delaying decision on rejecting the substandard work or taking action against the contractor for a substandard work.
- Passes the works on to others stating you do it somehow.
- Put off the job till somebody else takes over the charge.
- Blaming to others before finding out what he could do to solve the problem.
- Refused to listen and solve the problems.
- Technically incompetent

It is also said that most people want to do a quality job, contrary to general belief. Therefore management should ensure that;

- People engaged in construction or maintenance are technically competent and have the right training, placement, and knowledge.
- Quality conscious contractors are selected for the work.
- Co-ordination and feedback system is available.
- A system is designed to guide architects, engineers, contractors and workers.

Contract and Quality

Quality in construction is achieved through joint efforts of employer, architects, engineers, contractors and other stakeholders. Since, contractor not only arranges the material but implements the quality, his role in achieving quality is very critical. Therefore, selection of a contractor is extremely essential to achieve quality. Also, contract document and conditions play an important role in selection of a contractor; contract is thus also related to quality. Quality is to be included by the planners, engineers, quantity surveyors, and then quality managers. Hence, quality may depend upon:

- Client's coordination with the planners and his "stated needs"
- Planners (Engineers and Architects)

- Designers
- Supervisory staff
- Contractors
- Suppliers
- Quality control managers
- Workers
- Account officers making payments
- Quality concept being followed

Since drawings, designs, selection of contractor, inspections, time, quality control measures, specifications, rates, welfare and safety measures, payment conditions etc. are part of contract document; contract document also has a bearing on quality. As per Soni (2002), quality is also a function of contract document. Thus contact document has to be prepared considering the quality requirements.

As already discussed, men, materials and methods required in a work are arranged by the contractor and even money initially, hence, quality is largely dependent upon its implementation by the contractor. Thus, it is essential that a quality conscious contractor is selected to achieve the quality. Selection criterion of a contractor is also included in the tender or contract documents. In most of the cases, tenders are invited from registered contractors of engineering organisations and contractors credentials are examined only during their registration process, mostly based on documents submitted by them. Selection of contractors is made through the following processes:

- Pre-qualification criterion
- Qualification criterion
- Enlistment criterion
- Image building criterion

Pre-qualification criterion is included in many contract documents. The contractors are required to submit technical and financial bids after they qualify the criteria. Their technical bids are evaluated first and only suitable and eligible contractors are then asked to submit financial bids and if already invited, the financial bids of only selected contractors are opened. This process takes considerable time, therefore, it may appear to be time consuming and costly but ultimately proves to be advantageous to the employer. This process is adopted in major works. Since, the bidders are resourceful,

quality conscious, having large establishment and have limited competition, the quality of such works is normally good. The rates of such bids are normally higher than the bids invited from other criteria.

Qualification criterion, is included in many bid documents like in National Competitive Bid document prescribed by World Bank. After evaluation only the bids of the eligible bidders are considered in the competition. Though, it saves some time, but in case, any of the contractors adopts legal action particularly the contractor whose bid is found to be ineligible, it may take considerable time in finalization of the contract. Also, rates of ineligible bidder become void, a decision is to be taken to award the work ignoring his rates and that becomes a critical decision in case, his rates are lowest. Sometimes big firms may not include all the information particularly their commitments and if so, their bid may be interpreted to have misrepresented the facts. Few contractors may also not provide all the information particularly of ongoing commitments deliberately to get qualified in evaluation of assessed available bid capacity. Thus, probability of selection of good contractor based on this criterion is less than pre-qualification criterion.

An enlistment criterion is adopted by many organizations. The contractors are enlisted in various categories such as Class I, II, III, IV and V. Such enlisted contractors can thereafter bid as per organization's norms. Normally, there is no restriction on number of contracts being operated at a time by a contractor. Therefore some of the contractors try to take contracts beyond their capacities leading to time over run, mismanagement and poor quality. Few contractors also try to sublet the work though not on record and earn money without doing any work. The quality of such work is also poor as the profit is to be earned by both the contractors. Few contractors even resort to a practice of giving power of attorney to sub contractors just to avoid the action by the employer on subletting the work. Normally the quality of such work is also poor. As the category goes down, the number of enlisted contractors goes on increasing. Thus list of class V contractors is too long and of class I, the smallest. Thus the competition in the works, which are under the limit of class V, IV, and III, is very tough and the contractors may quote the rates, which are far below market rates, and thus such works lead to poor quality. Maintenance works and minor works are normally within the bidding limit of lower category of contractors also.

In some cases, particularly in private organizations, image criterion is adopted. If the quality and rates of a working contractor in the organization or somewhere else are found to be reasonable and satisfactory to the employer, employer directly enters into the contract with the contractor. Even the government organizations enter into such contracts particularly with Public Sector Undertakings.

Thus it is essential that quality contractor should be selected and if found otherwise, action right at first time should be taken against the contractor.

It is also surprising that responsibility of the work generally rest on supervisory engineers only and not even on quality control managers and most importantly on

contractor. Until and unless, everyone who is the stakeholder in quality, particularly contractor, is not made responsible, it is difficult to achieve desired quality.

Specifications and Quality

Specifications are backbone of a contract both in terms of materials and workmanship. A material of poor specifications with best of workmanship will never lead to satisfaction so also a best material with poor workmanship. Therefore, a right combination of material and workmanship and their incorporation in the contract are essential requirements of a quality work. Though every material particularly man made may be different from others, normally in government contracts, equivalent word is used. For example, tiles manufactured by various manufacturers may be having different specifications even if minimum standards prescribed by Bureau of Indian Standards, might have been followed by them. Thus, the rates of various brands of the tiles may vary but the contractor may opt to procure the cheapest, which is just passing the specifications prescribed in Indian Standards, as all the tiles will be considered equivalent. The brand names are not included in government contracts to discourage monopoly. Also monopoly items are considered costly as they lead to super normal profits though it may not be completely true in case of largely available materials where large substitutes are available. Thus, the quality becomes difficult to be achieved without proper identifications and incorporating in the contract documents. Hence, the role of architects, quantity surveyors, and planners becomes important who have a vital role in preparing contract documents.

Drawings and designs are part of specifications. Contractors quote the rates based on the specifications of the materials, intricacy and skill involved in providing and fixing. A single piece of granite slab fixed on the stairs will have different rates compared to pieces fixed, as wastage and cutting will be different in both the cases. As such even if the same material is used, specifications for fixing should be available in contract document for quality. If all specifications are not included, contractor may quote rates as per his wisdom and later will try to work according to rates quoted and not as per actual requirements or implied needs. Thus specifications in a contract are the part of the quality.

Contract conditions and Quality

Contract document may include technical specifications, general conditions and special conditions. Some conditions may have financial implications. If effect of such conditions is not included by the contractors or during evaluation of tenders by the employer, implementation of conditions becomes very difficult which may affect the quality also. For example, suppose a condition is included that the earthwork will be inclusive of rates of pumping of water in case of high ground water table expected or during rains. If the item of pumping water is not available in Bill Of Quantities and thus not payable separately as per condition available, contractor will avoid work during rains or will try to pump out the water as it may be costing more than earthwork in excavation

itself. Similarly if small patch is required to be plastered in a multi-storeyed building, cost of repair may be negligible compared to scaffolding cost and if a condition is included that cost of scaffolding is included in the plaster without considering site conditions, contractor either will not do it or will take course of arbitration. Similarly safety provisions and welfare provisions of construction workers are included in the conditions without considering their financial implications during evaluation of tenders which results mostly in non-implementation. When these measures are forced, the quality of the work is deteriorated as contractors recover cost of such measures from the work only. Thus the conditions, which have financial implications, should either be included in the bill of quantities or their effect be considered during evaluation of the bids.

Acceptance Criterion

Since acceptance criterion of a work is stipulated in the contract, quality of work should be same whosoever is engineer in charge. But even after specifications and contract clauses may be same, quality of work is likely to be different in two works even if same contractor has carried out the work at two places. This may be due to acceptance criterion set by engineers. Acceptance criterion of an engineer may be depending upon his/her qualification, knowledge, exposure, experience, morality and management. An engineer having an international exposure may have different acceptance criterion than an engineer having only local exposure for the same work. As acceptance of a work is important, rejection is equally or more important. Time factor has more weight age in case of rejection than the acceptance. Timely rejection of a work leads to better quality than decision. If concrete in a basement column is rejected after casting of ground floor, it is very difficult to recast or rectify the defects, but if the same is rejected before casting of beam of basement floor, it will be recast. Also there is a tendency of contractor to judge the acceptance criterion set up by an engineer. The contractor after an initial interaction with the engineer and a few site visits becomes fully aware of the acceptance criterion set up by the engineer. Therefore, it is the duty of an engineer to set up standard acceptance criterion and let it is known to the contractor, not only in terms of quality and workmanship but also for frequency of tests, sample preparation and material approval. Thus quality is a function of acceptance criterion of an engineer which in turn is related to his knowledge.

Contract Clauses

Contract clauses have a bearing on quality. For ensuring quality and timely completion of work, various clauses like performance security clause, incentive clause, compensation clause, timely payment clause, interest clause for delayed payments, deviation clause, price escalation clause, interest free mobilization and T&P advance clauses, material approval and testing clause, are included which are to be implemented by both the parties.

Mechanization and Quality

Mechanization is defined as the use of machines to replace manual labour and can also refer to the use of powered machinery to help a human operator in some task. The

use of hand operated tools is not the part of the mechanization but it is really a matter of concern that even these tools are not the part of every construction process. The benefits of mechanization includes improvement in productivity, quality, speed, construction technology advancement, industrial technology advancement, economy due to scale of work, employment potential etc.

Mechanization and robotic have great potential and can be adopted almost in every facet of building construction nowadays but unfortunately sparingly adopted. In fact, in road construction, mechanization has been adopted in a higher scale in the country in expressways which may be because of foreign firms entering into the competition in road construction. Use of mechanization in road construction has certainly resulted in quality construction in which durability and speed are also the major factors. Similarly, Delhi Metro Rail Corporation adopted mechanisation in their works.

In building sector, mechanisation is being adopted in high rise buildings. Mechanisation leads to quality due to eradication of manual errors, homogeneity and consistency of work. Another major advantage is saving of time. In India, due to inflation, cost of work increases and if time is curtailed, contractor or builder can save money and this saving leads to a quality work. This also increases customer satisfaction. Therefore, mechanization has to be adopted in building construction for achieving quality.

Safety and Quality

It is said that accidents do not happen, they are caused. Accidents lead to high cost and thus lead to deterioration of quality. Accidents are caused either due to unsafe act or unsafe conditions. Unsafe act is normally attributed to individuals while unsafe conditions are either attributed to engineering or the management as providing safe conditions is the responsibility of the engineers and management. Thus for safety management, both unsafe act and unsafe conditions are to be tackled. Unsafe act can be prevented through education and training, orientation programmes, display of posters, signage, safety task assignments etc. while prevention of unsafe conditions require management commitment, policy, resources, planning and development of effective safety programmes and execution through inspections/checklists etc.

Safety in construction is not limited to workers safety only. If the structure is not safe during its execution and thereafter during its designed life, it can pose safety problems not only to the workers but also to many others including structure. Therefore, a structure must be safe for its life period, which is possible only if it has been planned, designed, executed and maintained as per codes and quality standards. Thus safety is closely related to the quality. After liberalization and globalization, number of projects started in the country and a lot of financial investment started coming to the country, mechanization came simultaneously and safety became essential component in the construction sector.

Safety is said to involve 4 Es, Education, Engineering, Enlistment and Enforcement. Sometimes they are clubbed into 3 Es as Engineering, Education and Enforcement. Engineering include planning, execution and maintenance, Enlistment includes positive attitude of contractor and employer towards safety programme and its purpose while Enforcement requires strong will and determination including promotional measures like rewards, safety competitions, disciplinary actions and punishments. Investigations of accidents/incidents/near miss incidents also help for ascertaining corrective and preventive actions.

Engineer's concern in civil engineering includes safety of structures during construction, during occupancy (maintenance stage) as well as during dismantling of the building, safety of workers and even environmental safety. To ensure safety during its life, safety aspects are to be incorporated during its planning, design, execution and maintenance stages. Thus safety in construction includes:

- Safety of the structure during its construction and maintenance stage
- Safety of the workers
- Safety of the public in general

Structural safety is important during construction as well as maintenance stage. Thus a structural safety is to be considered for its life cycle. Provisions for safety during construction may include the followings:

- Foundation safety
- Structural safety during normal and critical conditions
- Fire safety
- Safety due to temporary structures erected for construction

Structural safety of a structure is important at execution stage and during post construction stage. Failure of a structure during execution stage is mostly due to some of the following reasons:

- Unsafe design
- Not following the correct design. The design might have been revised but old execution made based on old drawing. Old drawing is not destroyed, kept at site and even an entry is not made of its revision in the old drawing
- Collapse of temporary structures like failure of scaffolding, centering and shuttering

- Incorrect sequence of removal of props like removal of props from fixed side in a cantilever
- Removal of centering and shuttering before specified and required stripping period
- Use of different grades and types of materials not considered in the design like use of PPC in place of OPC and removing centering and shuttering specified for OPC.
- Poor quality of work
- Sudden change of conditions like partly constructed underground tank can float if water gets filled up around it due to sudden rains and there is huge uplift which is more than the load of the tank
- Poor detailing like no overlap of the reinforcement or even say no provision of weep holes in a retaining wall or in a boundary wall leading to water pressure on one side of wall not designed for.

Collapse of the structures at post construction period is also possible. These failures may be under normal conditions as well as during critical conditions like earthquakes, cyclones and floods. Some of the reasons are numerated in the followings:

- Removal of load bearing structural members
- Additions and alterations
- Due to changed conditions because of construction of other structures like underground metro construction may create distress in adjoining structures
- Natural disasters like earthquakes etc. for which the structures are not designed
- Aging of structures and residual strength not adequate to take loads
- Poor maintenance conditions leading to deterioration of strength of the structural members
- Changed use like a building designed for office building being used for library or a cinema hall
- Poor drainage conditions around the building or rise of ground water table leading to reduction in bearing capacity of the soil

Safety during maintenance stage includes safety of the structural as well as non-structural members, their repair and maintenance and also safety due to temporary structures or arrangements made for carrying out maintenance. Some of the services are not compatible to the life of the structure like plumbing services. But plumbing and sanitary pipes are not changed after their useful life leading to seepage, which corrode the reinforcement and lead to distress in the structure.

Workers safety is to be planned and implemented during construction as well during maintenance operations. Workers safety is not given due recognition due to the followings:

- Economic considerations
- Non- availability of safety equipment including personal protective equipment (PPE) affecting quality due to unsafe environment.
- Old and outlived machines and equipment affecting quality.
- No provisions of site and work specific safety measures.
- No provisions for health and welfare measures.
- Poor knowledge of machines, equipment and the safety provisions affecting quality also.
- Unawareness
- Due to bad workmanship affecting quality
- Non adoption of safety measures by workers
- Workers not abiding to safety rules

Short-term economic consideration is main reason of non-adoption of safety measures by the contractors because they appear to be economical however ultimately in long run they may prove to be costly. Some contractors may not make available even basic safety PPEs like helmets and safety belts and may feel that they have achieved economy but even small accidents in two years may lead to higher cost than the cost of safety equipments. Safety equipments should be adequate and as per site requirement and are to be planned according to site and work specific requirements. Workers with safe environment have high productivity due to higher efficiency.

But it is not always necessary that contractors do not make available safety equipments or do not make safety provisions. Many times workers do not follow safety rules and even may not use them. Even workers sometimes meet accidents with their own bad workmanship like not providing correct joint in props or not taking out nails from

earlier used props. Most of the labour in the country is illiterate and unskilled. Also, the labour do not give high attention to the awareness of the safety measures and also the contractors do not make them aware as they are not sure about the labour workforce whether the same workers are going to work for them.

Like structural and workers safety, public safety is also to be considered during construction as well as during maintenance stage. The provisions for public safety may be required due to the followings:

- Storage of construction materials on public roads or public places.
- Fall of construction material due to no provision of barricading and curtains.
- Direct access to site because of no barricading.
- Deep excavations in close vicinity of existing structures without taking sufficient precautions to affect other property.
- Excavations in unprotected areas without protecting them with barricading and without display of warning signs.
- Air, water or noise pollution like adopting driven piles for foundation in a habitat area.
- No provisions of basic facilities to workers thereby encroachment by them to public facilities or their misuse

In the country, though there are adequate laws, rules and regulations, but are hardly implemented fully. Main reason is absence of safety or even civic culture. Normally a common man may not make use of ready mix concrete as it may prove him costly compared to cast in situ concrete. But during this process he will spread all the materials and cause inconveniences to others. Also a person who has affordability, may not really bother about public inconvenience due to his status in the society like an influential person may adopt driven piles for his building even if causes a lot of noise pollution for the residents in the area. Therefore public safety is really not given due importance in the country but this may not last long particularly in cities as the people are now more informative to laws and their rights.

Safety is to be planned in construction activities right from the concept stage of the project. At present no provision is made in the estimates for safety provisions and as nothing is available free of cost, final result is before us. Even if the employer through contract provisions like in Central P.W.D. contracts makes the safety provisions mandatory, cost for safety provisions finds no place in justification cost statements. Therefore first step should be to include the cost of safety provisions and labour welfare measures in the preliminary estimates and also in the justification. Though it may depend

upon the size of the project, beginning can be made from any amount say 0.5 %. Idea has been generated that the items of safety requirements can be included in the bill of quantities (BOQ) and it sounds quite well that if the items were paid for, certainly they would be implemented. Suppose barricading is made part of the BOQ, it will be done being part of items. Labour welfare measures like provisions of toilets, canteen facilities, accommodation, crèche etc. can also be made part of BOQ. But major problem in the cities particularly in metropolitan cities is the availability of land and the objection of residents in the vicinity of the site for construction of such facilities. Even now many employers do not provide the place for construction of huts for labour what to talk about construction of other basic facilities. In such circumstances, whole concept of making them part of BOQ sound hollow. In the time to come, there will be a need of construction of multi-storeyed dwelling units for labourers, which can be taken on rent by the contractors where all other facilities will be built in. In those circumstances, the provisions of the cost component will be required to be taken in the estimates.

Planning for safety is really a tough job for non-engineered structures where even structural safety measures are not adopted. This may be due to poor conditions of people, unawareness of safety norms, non-availability of designers and standard designs and greed. For a check on non- engineered unsafe, sub standard structures, the role of local bodies, public, government, and engineers is important. The engineers should play a major role in dissemination of knowledge of structural safety norms to stop non- engineered unsafe construction. Probably subsidy in earthquake prone regions can be extended to make their dwelling units earthquake resistant so that loss of lives and property during earthquakes could be minimized.

If safety is to be designed, it should consider all the provisions whether for the structure, workers or the public. If the structural safety is considered, design codes and National Building Code are available along with many guidelines, reference manuals, and computer programmes. Therefore there should not be a safety problem if the structure is designed according to codal requirements. Design is to be carried out by a structural designer who has an expertise in it. At present there is no government or autonomous society/institute who certifies the designers. Therefore, it is the high time that some engineering body starts registration of designers for the benefit of the public and the society. It is essential that not only structure is designed but also the entire temporary and safety structures are designed. If a road is under widening or a culvert or a bridge is under construction, there should be no reason that diversion is not designed and commuters are left to high inconveniences. Similarly if a slab is being cast, its centering is not designed. If for fire safety, a corridor or staircase is to be designed, it should be done according to the codal requirements. Therefore it is important that safety process is included in the design process whether it is earthquake safety, fire safety or workers safety requirements. Local bodies like fire authorities have made mandatory to get the drawings cleared by them before execution. Some banks that are financing the construction activities have also made mandatory requirements for providing loans only if the reputed institutions certify the structural designs. This is a good beginning in the field of structural safety. Local bodies can also enlist reputed and qualified structural designers

and clear the drawings for construction only if they certify these. It must be understood that safety is complementary to the quality.

Continuous Improvement

TQM is not one time concept and is based on continuous improvement. Hence continuous improvement is essential in product, process, and management. Education and training are very important for continuous improvement process. Therefore, the management has to believe first in TQM concept that the same is possible and then make sure that education and training is imparted to all their employees. Early in the process, all levels of management must be trained to implement their part of the quality improvement programme. Continuous improvement helps in customer delight i.e. the state in which customer gets more than what he expects for satisfaction.

Crosby suggested for scheduling zero defects day to signal employees that the organization has a new performance standard. Such observance certainly sends a signal to the employees but there should be no fear in the employees and there must be clear message among the employees that they are not being singled out and targeted for not achieving quality standards.

Quality measures that are appropriate to every activity have to be established to identify areas needing improvement. It may be preparation of drawings as per local bylaws, drawings which are not only safe during normal conditions but under critical conditions like earthquakes, accuracy and adequacy of drawings so that they are understood by the supervisors easily so that no wastage of time or money occurs due to inaccuracy or inadequacy of drawings, complete specifications to avoid rejections due to incomplete details/descriptions from the customer, regulating agencies or from any other stakeholder and detailing of processes, safety measures etc. In many cases, it has been observed that even some consultants feel that initially half cooked drawings may be submitted and when the observations will come, it will be corrected which is the concept against TQM. Therefore quality measurement is required and then costs of quality have to be estimated. It must be understood that the cost of quality is essentially cost of poor quality and thus these are to be identified and curtailed/eliminated to make quality improvement profitable.

Thus training and skill up gradation of all the stakeholders like architects, engineers, contractors and workers is the part of quality.

Awarding the Work on Lowest Price Offer

Deming was of the view that purchase departments should not operate orders based on lowest price offer which leads to supplies of poor quality. This may be true in many cases in civil engineering works also. Therefore, for getting a quality work, it may be good idea to seek long term relationship with good supplier or contractor or even enter into contract not for a single work but for a package of works which are to be executed for

a client in near future so that the agency gets benefit of continuity of work and the client of the lower cost. A detailed analysis needs to be made on this very important aspect and present procedure to be modified, particularly when rates are unworkable. In such circumstances, quality cannot be achieved.

Quality, Quantity and Speed

In the management concept, management sets the goals based on quantities for individuals and performance appraisal is made on the achievements. So the quantity plays a very important role in the assessment of the appraisal of an employee. On the other hand when we talk about the quality, it is the customer or the client who makes the assessment. And if the customer is not satisfied with the quality, it also goes against the employee and the employee's appraisal gets affected so much that the employee may be shown the door. Therefore, the question arises which one to choose – quality or quantity?

And then there is speed which is closely related to quality and quantity both. Many experts say "choose two out of three as one can't have all three unless he/she is Mr/Ms Extraordinary or Mr/Ms impossible". In actual situations there may be three probabilities as detailed below:

- High quantity and high quality but low speed. Like if one is a designer or planner, or even in supervision, high level of quantity and professionalism may be possible only if he/she get sufficient time to do so resulting into slow speed.
- Low quantity of work at high level of quality produced at a faster speed.
- High quantity of work at low quality provided at a fast speed.

In a civil engineering project this becomes further difficult as process uniformity is difficult to achieve due to manual construction in many items. Therefore, an engineer has to maintain a balance in all three even if he/she is not able to achieve all three at a time and here are his/her managerial capabilities which are important to deal with the situations.

The client expects quality, quantity and speed all three from the civil engineers. Sometimes the client changes the engineer in search of these three but soon leads to same situation or even worse as it is very difficult to get Mr Extraordinary and if he gets, he wants to complete the project at same cost. Thus there is a question whether there is a cost of quality, quantity and speed. Law of economies of scale states low cost with higher production or quantity. Does it apply to construction also? Is there any cost to quality? Few organisations like CPWD have started adding cost of quality assurance. In some projects, third party quality assurance is also included. Such quality supervisors charge their fee though it is a matter of debate whether occasional inspections lead to achievement of the quality. Probably it is also presumed that quality assurance would

require setting up laboratories and frequent testing of materials. Law of economies states cost saving in case large quantities are produced as fixed costs get distributed over large quantities. In a project, fixed cost may be establishment cost and generally establishment is created according to the project. Hence, cost saving can probably be achieved only in case of very large projects continuously in progress for sufficiently long time like continuous production in a factory.

Then there is a question whether speed also comes at a cost? Few organisations have a provision of incentives in case a work is completed before schedule date of completion. It means, in case a project is completed at a faster speed, it is costly as organisation has to pay incentive. It is also known that if a project is delayed, it results into cost overrun as time overrun is said to be directly related to cost overrun. Hence, in both conditions, speed has a cost. But discussion is not limited to this cost. For speedy construction, one has to invest more on materials, labour or on technologies and this can be considered as cost of speed. This cost goes on increasing in case there is a large gap in the supply and demand. Recently concluded commonwealth games showed that there is a cost due to gap in supply and demand. During the games, workers were not available even at a high cost and materials were more expensive than during normal time as during that period a number of projects were in progress. It shows that gap of supply and demand has a cost bearing. Law of Demand says that with increase in price, demand decreases. Law of supply says - supply increases with higher prices. But there are instances when even at higher prices, neither demand can be reduced nor supply can increase due to time constraints.

Then there is a question whether speed, quality and quantity are achievable with normal set up? Basic difference between developing countries and developed countries is the availability of infrastructure and technologies which play an important role in the quantity and speed including in the quality and non availability of the infrastructure and technologies further makes difficult to achieve these three in developing countries. But then the infrastructure comes at a cost and a developing country cannot cope up with the developed countries. Thus cost may be an important factor in the quality, quantity and speed of desired entity. Few years back, road work was being done manually at a very slow speed. Now machinery has come and the speed has gone up so also the quality and quantity. If the cost of manual construction is compared with latest mechanised construction, it has come at a cost. Delhi Metro has been constructed at a speed and Delhi Metro Rail Corporation tried to achieve quality and quantity and was successful to a large extent but at an additional cost. There are some people who are good in Mathematics and apply it in the works without considering its implications. If a work of 'A' quantities and 'B' specifications (quality) is to be completed in two years and its cost is 'X', as per their calculation, it can be completed in one year also at the same cost as there is no increase in the quantity or deviation in the quality. Thus according to their calculation, there is no cost to speed rather they show saving due to establishment cost required for a lesser time. Suppose a client says to construct a stadium and normally it takes one year but if the time is said to be compressed with high speed, does it not add to cost? Speed means earlier than the normal like an emergency situation. And we

know that even a doctor and hospital charge more in case of emergency. It appears that speed has a cost even if other two i.e. quality and quantity are constant. Let us analyse it. Speed comes in construction normally through mechanisation, skilled workers, new technologies, processes and highly technical and professional supervisors. For example, in a building work, it may be use of mechanisation and use of highly sophisticated tools and equipment, skilled workers capable of using new technologies and processes, new technologies as used by Delhi Metro for tunnelling, like use of trenchless technologies, use of pre engineered buildings and experts professionals. Will it not cost extra for all these factors? In a private organisation, it can be considered but question is whether government organisations should consider cost of speed in their justifications and then whether vigilance and audit authorities would accept it? And more than that, question will be asked how to implement and measure it? Thus though cost may be higher in employing skilled labour, mechanisation and money but it is the time which saves cost due to saving in price escalation.

As already stated, quality is a relative term and not absolute one. It is also known that poor quality work involves wastage; wastage of material, labour, finance and resources. This is the reason that a contractor avoids rectification or redoing the work. But if he has to do it, the work becomes costly than even a good quality work. Hence, quality work can only be achieved if it has been done right for the first time. This is again the principle of TQM or zero wastage. So to achieve a quality work, everyone involved in the process has to go for a quality work right at the first instance, be the contractor, engineer or worker. And if work has been done as per quality standards right at the first instance, it would eliminate multiple levels and frequency of inspections. It is known that some companies even do not require sample checking and produce best quality products. In fact, a contractor who adopts quality as his motto seldom requires redoing the work while this is not true in case of a contractor adopting poor quality.

Quality does not mean only quality of construction but also quality of professionalism in the work, be it architectural, structural or functional. Thus contribution from consultants, architects and designers is equally important. But professionalism may require time. Thus to achieve quality and quantity in a compressed time than the required, becomes a problem. For example, if a designer has to do design job and he is also involved in various routine works where he has to devote considerable time, he cannot produce quantity and if he produces quantity, he cannot produce quality. Therefore, professionals like consultants are also to be selected carefully.

So remember, quality is an outcome of teamwork and not of an individual. And then if team is not motivated, desired results cannot be achieved. Also motivation factors are different for different people so management has to see how they can motivate the stakeholders engaged in achieving the quality.

Concluding Remarks

From above, the following conclusions can be drawn;

Quality is not ;

- Absolute
- Specifications
- That concerns only workers or engineers or contractor

Quality is ;

- A relative term
- That satisfies customer stated as well as implied needs
- Starts from top
- Needs to be planned, implemented, monitored, reviewed and incorporated in quality policy with required changes
- A function of safety, durability, contract document, HRD and mechanization.
- Related to quantity and speed

Quality cannot be achieved through ;

- Inspections/quality control/quality assurance
- Engineering officers without involvement of the contractor
- Stipulation of men, materials, methods, and payment conditions only in the contract document.
- Acceptance of lowest bid even if it is below market rates

Quality can be achieved through;

- Involvement of each and every one involved
- Continuous improvement
- Zero wastage

Thus, TQM is the answer of achievement of quality which in turn is based on teamwork.

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Total Quality Management in Maintenance Works

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Prologue

A building with lack of attention to the quality aspect of maintenance operations will lead not only to poorly maintained building which will be a drain on resources but also will impair building use, whereas a well maintained building will function smoothly and represent an appreciating asset to its owners. A professional approach is therefore required to quality control of building maintenance. Quality in maintenance works does not mean only quality of construction but also quality of professionalism in the work.

The author who is former UN Expert has a rich experience in the field of effective maintenance in VIP Buildings in Lutyens' Delhi which includes Rashtrapati Bhawan, Secretariat Building and heritage colonial style properties with sprawling gardens. He has explained that quality of performance of the building and its services including all installations is very important to the serviceability and functional utility of the asset. Reliability of the various components of the asset and services can only be ensured provided these are maintained to laid down standards and norms which ensure that the chances of failure are minimal. While concluding he has given some useful suggestions for cost effective quality control in maintenance jobs.

An informative article which needs to be read for supplementing with your ideas.

- Editor -

Introduction

The word 'Quality' is derived from the latin word 'Qualitas' which means: "What some thing is really like". Quality Control endeavors to bridge the gap between 'What was conceived and designed' and what is finally 'achieved' and helps in Controlling of variability of quality in production and acceptance so that end product is "Uniform" in behavior.Quality in maintenance can be said to mean satisfaction of customer's stated and implied needs. It is not what we do…. It is how well we do it.

We are all very conversant with the concept of quality control and quality assurance in the field of construction and lot of literature is available on the same subject. However

one has to keep in mind that whatever assets are created are to be maintained if they are required to serve the purpose for which these were created. General tendency is to ignore the fact that investment in construction of any asset, be it building or infrastructure project is done only once but the investment to keep this asset in proper functioning order is required to be done for its entire life and at many times it is much more than the original cost of the building or infrastructure.

Advantages of quality control in maintenance can be summarised as longer life, efficiency, serviceability and user safety, better working environment and satisfaction at minimal costs.

Maintenance

"Building maintenance is the totality of all actions that keep a building functioning effectively." Prime aim of maintenance can be simply stated as preserving a building or asset in its initial stage, so that it effectively keeps serving its intended purpose, fulfills its function satisfactorily to accepted standards besides retaining value of investment and keeping asset in a condition in which it continues to present a good appearance.

Total Quality Management

Total Quality Management (TQM)is defined as "the management approach of an organization, centred on quality, based on the participation of all its members and aiming at long term success through customer satisfaction, and benefits to all members of the organization and to society."

Total quality Management in maintenance works ensures that mistakes are not repeated and are as a matter of fact minimised. All stakeholders such as contractors, engineers, maintenance personnel and users have to work in close coordination to identify problem areas and work on them to find solutions so as to prevent their recurrence. Use of latest technologies and other tools available is essential.

Quality assurance does not depend only on the activities at site but involves various aspects of quality management right from design stage to completion, namely:

- Personnel for design, planning, procurement and execution.
- Organizational structure of client, consultant, contractor.
- Quality inspection, methodology of working, quality audit, quality records.

All the above put together is total quality management

Quality Control Aspects in Maintenance

A building with lack of attention to the quality aspect of maintenance operations will lead not only to poorly maintained building which will be a drain on resources but also will impair building use, whereas a well maintained building will function smoothly and represent an appreciating asset to its owners. A professional approach is therefore required to quality control of building maintenance.

Quality in maintenance works does not mean only quality of construction but also quality of professionalism in the work.

Objectives

- To ensure that the functionality of building is not compromised at any time
- Safety and security of occupants, visitors and installations is taken care of.
- Laid down standards for hygiene and cleanliness are maintained and proper arrangements for waste disposal are ensured so that there is no adverse effect on environment.
- User satisfaction is kept as the prime moto and response time is minimal.
- All activities are carried out within permissible budget.

Advantages

- Better quality control in maintenance imparts longer life to buildings/ roads/ structures/ services.
- Confidence of users in the maintenance team/organization and reliability of system.
- Economic utilization of materials and other resources.
- Better working environment, higher productivity, loyalty to organization and user satisfaction.
- Lower running cost of maintenance and operation of various services/ facilities.

Importance of Quality Control in Maintenance of Assets

Quality of performance of the building and its services including all installations

is very important to the serviceability and functional utility of the asset. Reliability of the various components of the asset and services can only be ensured provided these are maintained to laid down standards and norms which ensure that the chances of failure are minimal.

Types of Maintenance

Types of maintenance are summarized in BS: 3811 as shown in Fig.1

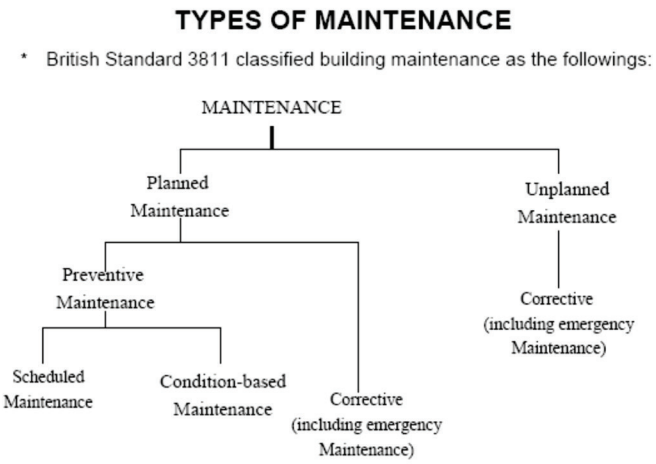

FIG. 1 TYPES OF MAINTENANCE

For effective quality Control in maintenance, emphasis has to be on planned maintenance wherein one can plan and pre decide inputs, time of operations to be carried out resources requirements in terms of skilled/unskilled man power and machinery/ equipment and optimization of their use. Preventive maintenance amongst various types assume more significance as it is the “the maintenance carried at pre-determined intervals or corresponding to prescribed criteria and intended to reduce the probability of failure or the performance degradation of an item.” Trade off between normal repair works and preventive maintenance is shown in Fig. 2.

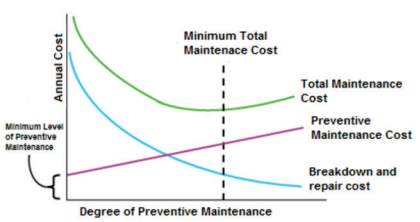

FIG. 2 TRADE-OFF BETWEEN REPAIRS AND PREVENTIVE MAINTENANCE

User Aspect

Another aspect which is very important to keep in view, as far as maintenance is concerned is the human aspect. When any asset is being created the users are normally not available and are not interacting with the persons who are constructing directly. On the other hand when building is occupied, the all users/occupants are very much concerned with the different aspects of building such as:

- Functional Utility
- Aesthetics of the Building
- Serviceability of the Services Provided
- Safety and Environment
- User-friendliness and
- Efficiency of the various installations and reliability thereof

Life-Cycle Cost

To ensure quality in maintenance of building and services, it is essential that attention is paid to all those factors which affect the maintenance aspects directly or indirectly during lifespan of the building and its services. To appreciate this it will be very necessary to understand the concept of life-cycle Cost (LCC) and total cost of the asset.

A building is a fixed asset and users/occupants do get attached to it for long durations and at times for life time. Therefore the users look towards life time satisfaction also for life of buildings. Life of building depends upon the original concept/design and specifications. Hence life cycle of building and its performance during the planned life is very much dependent on quality of construction and more so on maintenance provided. Thus, it becomes essential that the life cycle concept is considered by the architects, engineers and construction agencies. Since it is the maintenance stage from which user forms a view about the quality of a work, TQM necessarily has to include life cycle concept. Life cycle concept includes the total cost of building and its fittings and fixtures from inception to disposal as determined by an analytical study and estimate of total costs experienced during the project life with consideration for operation costs. The needs of maintenance stage are to be considered while planning and executing a work.

Life cycle cost Analysis

A life-cycle cost analysis (also called whole-life cost) gives the present value of the total cost of the investment.

The life-cycle cost is calculated using the formula:

LCC = capital cost + present worth of maintenance and energy cost - present worth of salvage value

Total Cost

While taking overall view of the building it is necessary that not only the cost of initial investment in the construction/development of the infrastructure is taken into account but also the expenses that are likely to be incurred on its running maintenance and operation are also accounted for. The total cost involved or the life of the structure/ asset is called total cost (Fig.3). It is therefore essential that the total cost of the building or asset is kept to the minimum and just by minimising cost in the initial stages of construction one may not get the best product as for the lifespan of the building the cost incurred on its maintenance planning and operation may be much higher.

This concept helps us in finalisation of specifications and selection of materials which are most suitable for the asset being developed. The materials which are used have to be sustainable, easily available and susceptible to good maintenance at reasonable cost.

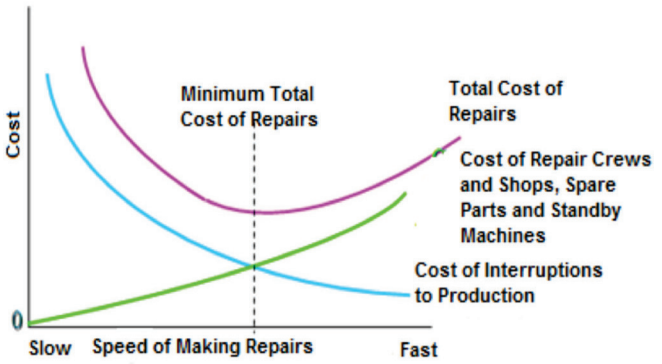

FIG. 3 SPEED OF MAKING REPAIRS

Elements of Quality Control

Basic questions that one needs answers to formulate its strategy for proper quality control system in maintenance are same as anywhere else i.e.:

- What do we want?
- How to get what we want?
- How to determine that we got what we wanted?

The answers to above three questions lead us to the elements of quality control i.e.;

- Formulation of specifications
- Selection of materials to be used.
- Method to be followed (process control)
- Norms of acceptance (acceptance control)

Specifications

Formulation of specifications is taken up in planning stage and should be done based on following considerations and keeping in mind that the a right combination of material and workmanship and their incorporation in the contract are essential requirements of a quality work:

That the specifications finalised are:

- Workable and practical and not idealistic
- Attainable with local technology
- Not rigid but with a scope of flexibility
- Economical

Selection of Materials

Selection of materials is extremely important for quality of maintenance works. Close attention is required to be paid for selection of materials while planning and constructing the building. It should be kept in view that the materials required for maintenance works/replacement will be available when the building is in use and can be replaced with convenience at economical cost. Too much variation in the fittings and fixtures should be avoided for the sake of ease and economyin maintenance works in addition to quality. Material used should be such that they are easy to maintain aesthetically pleasing.

While selecting material for maintenance and housekeeping etc.one should ensure that selected material will not harm the existing fabric of the building should not be lost sight of. For example certain materials containing acid in them cannot be and should not be used for floor cleaning/polishing as they damage the flooring.

Care that is exercised approving materials during construction is also required their use in maintenance as these are used for ensuring protection of existing fabric and their sustained performance. Other factors that help in better quality control in maintenance woks as regards use and procurement of materials are:

- Purchase from reputed suppliers / own setup.
- Testing by contractor's and owners quality assurance teams and also by independent agency.
- Materials to be tested / approved before start of project and use for maintenance.
- ISO 9000 certificate to be preferred.
- All records of testing to be maintained

Workmanship of Work

As is true for construction, it is more true for maintenance that the workmanship is of high order as one cannot afford to disfigure the original work. To do same work as original in an existing set up requires higher skills. Therefore it is necessary that deployment of only skilled workers under experienced supervisors, workers with trade qualification is insisted upon.

Stages of Implementation

Each project has components of project cycle including planning stage, construction stage, installations and testing, operation and maintenance stage. Each stage has significant impact on life and functionality of buildings, maintenance efforts and expenses and satisfaction of its users. While talking of quality in maintenance it would be worthwhile emphasizing those components of each of the above mentioned stages that affect the life cycle cost of building, its functionality, ease of maintenance and user satisfaction besides being environmental friendly and status symbols.

Pre-construction stage

- Properly conceived design keeping in mind functional requirements and maintenance of various components.
- Accessibility to services areas must be addressed properly. Proper design of services and use of adequate sizes of pipes keeping in mind the user behaviour, skills available for maintenance.
- Avoid thin members, unapproachable corners and areas that are difficult to maintain.
- Plan for glass panes cleaning, installation of coolers, air conditioners etc. with provisions for their upkeep. Avoidance of leakages/ seepages is a very important aspect which must be taken care of in planning stage by proper design of wet areas and services. Adequate slopes in wet areas

and roofs after good water proofing system must be ensured.

- All services and installations must be tested and recorded.
- Suitably drafted specifications, acceptance norms.
- Planning for materials which are available now and if required in future and that are durable.
- Proper documentation of all documents.

Construction Stage

- Use of good quality materials after approval of samples with consideration for their future maintenance and replacements.
- During construction stage it should be ensured that suitable construction techniques are adopted, adequate quality control measures are taken, special attention is paid to services and testing of lines, effective supervision throughout and sound remedying of defects is ensured.
- Need of good workmanship needs no emphasis. Proper detailing of elements and various fittings and fixtures will ensure good workmanship and quality work which in turn will not only give longer life to the facility but will ensure their long term functional service.
- As built drawings, documentation of relevant records and compilation of operation and maintenance manual.

Post Construction Stage

- List defects which remained even after proper supervision and rectification thereof.
- Study of steps for suitable maintenance .
- Feedback data to the designer for future guidance.
- QA/QC records ensure that verification can be done even at a later date

Operation and Maintenance Stage

- Draw out maintenance schedules
- Material/spares requirements and adequate stocks there of
- Use of software for maintenance

- Regular drills for fire-fighting etc
- Mark each equipment with details of capacity, name of manufacturer / supplier, brief specifications and last serviced on.
- Calibrations of various machines/equipments to be checked periodically.
- Operation manuals to be kept at site.
- Feed back to be given for prevention of problems in subsequent designs.

Inspections

Quality is planned in and not inspected in maintenance. To ensure proper quality importance of inspections can hardly be over emphasised. Inspections can be routine, to ascertain existing problems, take feedback of the occupants, check the quality and timely completion of works already executed or annual inspections which are undertaken to ascertain the requirements of various works to be executed in the next year and prepare financial projections for the same.

Detailed inspections will be carried out at fixed intervals say at a gap of five years. During the inspections serviceability of various installations, the structural safety of the building components and functioning of all services will be checked thoroughly to assess remaining life of building equipment and requirement of any major works if required.

Feedback

Feedback is normally regarded as an important procedure of providing information about the behaviour of materials and detailing for the benefit of the architect/engineer designing new buildings, which will result in lessening maintenance costs. It is an equally valuable source of information for the persons responsible for maintenance. Every maintenance organization should develop a simple way of communicating its know-how, firstly for benefit of others in the organization and secondly for the benefit of the building industry as a whole. There should be frank and recorded dialogue on an on-going basis between those who occupy and care for buildings and those who design and construct them.

The information on feedback can be obtained from occupants, inspections, records, and discussions.

Multi Tasking

Multi tasking is the new norm. It not only helps in speeding up works but also helps reduce direct costs and improves overall efficiencies. Thus multidisciplinary training programmes should be organized for the workmen to impart them knowledge of various skills.This will open up better prospects for the workers also. After suitable tests, they

can be entrusted with multidisciplinary responsibilities. This approach of multidisciplinary skill will help in improving the quality of maintenance and shall also result in speedy attendance of maintenance complaints which may have required attention of two/three disciplines at a time. Multidisciplinary skill among the workers should be encouraged.

Safety in Maintenance

Accident : Any occurrence that interrupts or interferes with the orderly progress of activity in question. Following are normally the causes of accidents and must be taken care of by the maintenance team/organization:

- Lack of experience and training of the person and effects of drugs and drinks
- Fault of machines and equipment
- Environmental factors
- Physical handicaps
- Use of PPE, toolbox talks and adherence to safety manual provisions is as important for maintenance works too.

Maintenance Manual

For every major establishment maintenance manual should be prepared which includes proper documentation of the works which have been done including but not limited to:

- As built drawings
- Structural drawings
- List of all installations giving details of their year of manufacture, name of supplier with salient details. Maintenance schedules as recommended by the manufacturer, expected life of the installation and date of last inspection
- Schedule for regular cleaning
- Schedule for servicing of various equipment and installations
- General maintenance requirements
- Schedule for replacement of parts with frequency and specifications

- Instructions in case of emergencies
- List of parts and spares to be maintained
- List of agencies are authorised maintenance and repair of the installation

Such manual will be useful to the maintenance team in giving quality output by preplanning all activities as per requirements.

Organisation

A well thought of organisation set up is required to be put in place to ensure execution of maintenance works. The operation has to be tailor made keeping in view the broad perspective and objective of the organisation and level of maintenance required.

To ensure due attention to various maintenance aspects a proper maintenance setup is very much required and has to be established keeping in view the quantum of maintenance works. This maintenance setup or organisation could be fully in-house or maybe outsourced. It can also be combination of both. It has been found that associating the maintenance agency from the conceptual stage of the project/building goes a long way in ensuring quality maintenance. The maintenance team should be consulted while finalising various installations and services as these are to be maintained by them in future. Once they are associated in the initial stage, the team would be fully conversant with the services and installations provided along with the details of their manufacturers/ suppliers and specific requirements and this team would be in a very good position to take over from the construction team without any difficulty.

Training

Training is another aspect which needs to be emphasised. All those who are associated with the maintenance works should be sensitised to the needs of the users in respect of their requirements, priorities and environmental and health safety measures then only they can give a quality service. Need for training and developing expertise which will ensure improved workmanship and behaviour of the workers. Motivation and commitment, documentation and response time are very important items as maintenance person acts as ambassador for the set up.

Quality Control for Minimal Maintenance

All buildings, however well designed and conscientiously built, will require repair and renewal as they get older. Quality control measures have to be built in from the very concept of the proposed building. While taking up initial planning or construction, maintenance aspect has always to be kept in view. For better performance of the building envelope the following ways help to minimize troubles at later stage.

- Due attention be paid to maintenance requirements of the facility from the planning stage. The agency which is likely to be entrusted with the work of subsequent maintenance and upkeep of the facility should be involved from the design stage itself. Their inputs will be very valuable in ensuring economical maintenance during the lifetime of the facility. This aspect needs greater attention as the defects that are built in at planning stage are difficult to be addressed at subsequent stages.

- Detail and choose materials during construction so that the job of maintenance is less onerous.

- Specifications adopted should be practical and based on local practices. Durability considerations and maintenance of various areas should be kept in view.

- Fire and life safety requirements should be built in at the time of design.

- Detailing of components should be done to ensure that they are conducive to effective operation and maintenance.

- Accessibility for maintenance purposes of areas and services requiring maintenance is taken care of. It is necessary that service personnel are able to reach the service easily, safely, have adequate working space, safe working conditions and adequate lighting provisions. Cleaning of façade and replacement of glass panes needs to be kept in view while finalizing exteriors.

- In addition to designing a building for structural adequacy, consideration should also be given to environmental factors such as moisture, natural weathering, corrosion and chemical action, user wear and tear, pollution, flooding, subsidence, earthquake, cyclones etc.

- Design phase should cover such items as the owner's anticipated future requirement for the building taking into account of the building's physical performance and its functional suitability. This may lead to decisions regarding.

i. a change of use for the building and the effect of any conversion work on the life cycles of existing components or engineering services; and

ii. availability of replacements.

- The present use of the building anticipating any likely upgrading and their effect on the life cycles of existing components or engineering services.

Suggestions for Effective Quality Control in Maintenance

A few suggested steps for effective quality control measures in maintenance works. At present there is no schedule of rates which can be directly used for maintenance activities. It would be desirable to have separate schedule of rates for maintenance works. Works can be divided into categories:

- Works which are labour intensive
- Works that require more of material and machine the input and labour input is minimal

Engagement of multi trade personnel and training thereof. Most of the minor tasks require different trades and coordination of the same becomes difficult and results in quality issues. If multi trade personnel are available and are trained for various activities assigned to them, not only works will be done speedily but also economically with satisfaction to users.

Proper documentation of the works done cannot be over emphasised. As buildings age many a times repairs/retrofitting are required to be done for which it is very necessary to have as many drawings especially structural details and service drawings to take up the quality works of maintenance.

Provision for adequate financing the maintenance works with quality material, equipment and manpower, can be done only with adequate provision of finances and this has to be organised by the management.

Regular monitoring of buildings and services is key to the quality concerns. Regular inspections ensure that the likely problems to come to the knowledge of the management and maintenance personnel and steps are taken well in advance to attend to the same.

Conclusion

Quality maintenance works is very important as it is directly related to the satisfaction of an users. Consumer satisfaction can be achieved with professional approach, use of latest technologies, preplanning, and responsive approach. Well-conceived and designed building with maintenance aspects in mind, Good construction go along with in ensuring that the maintenance will be of high quality and to the satisfaction of users.

Quality Compromises in Civil Construction as Observed during Intensive Examination of Work - Preventive Measures

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Technical Examiner, CVC

Prologue

Workers, Engineers and other professionals engaged in construction sector are expected to be proficient in their area of specialization. They are also expected to be deeply conscious of their responsibility to perform the task and deliver the product that conform to standard and specification as laid down in the contract.

Inspite of restriction imposed, deviations do take place during the execution, Govt. has set up an organization - Chief Technical Examiner Organization which is mandated to carry out intensive examination of all public procurement contracts including construction contracts. Its main objective is to make public procurement process most transparent, fair equitable, efficient, economic and conducive to achieve value for the money spent.

Smt. Padmaja Varma along with Shri Shailendra Singh both have extensive experience as Chief Technical Examiners in CVC. They have put forth the quality compromises of various kinds which have been observed during intensive examination of Public Construction Contracts. The paper gives a gist of such common lapses, deficiencies along with a number of interesting case studies. Efforts have been made to find the causes leading to these common lapses. While concluding, the authors have given a number of preventive measures in order to ensure that public procurement of goods or services conform to the specified quality.

A very interesting Article which needs to be given serious thought.

- Editor -

Introduction

One of the cardinal principles of public procurement is to procure works or goods or services of specified quality. For this purpose, detailed quality standards are stipulated in the contracts. Any compromise in the quality defeats the very purpose of prescribing quality standards in the tender document/contract, besides causing financial loss to the Government in terms of recurring cost on maintenance of such assets of lower quality. Chief Technical Examiner's Organization (CTEO) of Central Vigilance Commission has been mandated to carry out intensive examination of Public Procurement Contracts (which includes construction contracts) of various organizations under the jurisdiction of Government of India. During course of intensive examination of public Construction contracts, quality compromises of various kinds have been observed.Some of the commonly observed deficiencies in the quality of construction works are discussed below-

Earth-work

- Site conditions different than those specified in agreement items
- Excessive offsets and side slopes than admissible
- Earth not stacked/levelled/neatly dressed at disposal place
- Less sand filling under floors
- Proper quality of earth not used
- Proper compaction of earth under floors not done
- Compaction not done as per optimum moisture content
- Compaction not checked by proctor density method where specified

Concrete-work

- Under ream not formed properly
- Initial pile load test not conducted
- Less strength of concrete due to excessive slump
- Over size/disintegrated/soft aggregates used
- Sand with more silt content used
- Honey combing noticed

- Less thickness of PCC under floors
- Mechanical mixers not used
- Curing not done properly.
- Beams /columns found bulged and not in plumb.
- Steel boxes not used for measuring aggregates
- Rerolled steel was used in place of steel from primary source as stipulated.
- Less reinforcement provided
- Proper overlaps not provided
- Lesser diameter binding wire used
- Cover of mortar blocks of adequate strength not used
- Expansion joint not properly located/not provided
- Steel centering and shuttering not used
- Wrong classification of RCC items
- Reinforcement found exposed
- Throating and drip mouldings not provided to chajjas
- Design mix not used though specified in contract

Brick-work

- Hollow vertical joints
- 38 mm thick brick tiles against 44 mm
- Large size opening left
- Wider joints
- Expansion joints filled up
- Ordinary bricks used
- Raking of joints not done

- Efflorescence tests not conducted
- Poor ratio of mortar and less curing
- Reinforcement not provided in half brick walls
- Cross walls not properly bonded with long walls
- Brick on edge not provided where required

Stone- work

- Bond stones not provided/ not marked
- Levelling course not provided
- Individual stones were not of proper dimensions.
- Hollow joints
- Poor quality of cement mortar
- Thick masonry joints
- Craps, pins and dowels not provided in stone veneering/lining work
- Dressing of stones not done properly.
- Poor workmanship in maintaining lines and levels

Wood-work / Aluminium-work

- Species of wood used were other than specified.
- Cracks/dead knots apparent in wood
- Kiln seasoning not done where specified
- Less size of stile/rail
- Coal tar/wood preservative not used for timber in contact with masonry
- Size of hold fast found less
- Glass panes of less thickness provided
- Fittings were not ISI marked.

- Screws of proper size not used
- Local make flush doors used
- Less size and number of hinges
- Aluminium sections of approved brand not used
- Aluminium sections provided were lighter than specified weight / size.
- Proper sealing between frame and opening not done
- PVC weather strip/EPDM lining not provided
- Less thickness of anodizing/powder coating
- Aluminium work specified in square meter, but drawing did not give details of aluminium sections.
- Wire gauges not turned at right angles in rebate

Steel Work

- Standard steel section not used
- Single piece section not used
- Flush butt welding not done
- Metal beading and glazing clips not provided
- Inferior quality hinges and fittings used
- Steel hinges not fixed by cutting slot
- Brass striking plate not provided
- Windows not fixed at top and bottom

Flooring

- Less width and thickness of glass strips
- Smaller size chips used
- Less thickness of flooring

- Less thickness of kota/marble stone/granite used
- Flooring sounding hollow
- Large panel size than specified
- Poor workmanship with reference to line and levels

Roofing

- Undersize side/end laps in roofing sheets
- Rusted MS hooks of lesser diameter.
- Less diameter and thickness of bitumen washer
- Brick coba treatment having cracks, local undulations, sounding hollow, less thickness inadequate slopes
- Water proofing treatment done by nonspecialized firm
- Guarantee bond not obtained
- Gobar and straw not used in plaster over mud phuska
- Less thickness of PVC sheet in khurra
- Non ISI rain water pipe

Road Work

- Undulations in surface
- Slopes, line and levels not maintained
- Over size aggregates used
- Consolidation not done properly.
- Less thickness of individual layers of WBM/BM/SDBC/DBC
- Stack measurement of aggregates not done
- WBM paid as per stack measurement
- Less contents of bitumen and constituents aggregates

- Proper density of layers of pavement not achieved
- Less flexural strength of cc pavement
- Non proper expansion/construction joint
- Non uniform corrugation on finished cc pavement
- Proper density of layers of pavement not achieved
- Less flexural strength of cc pavement
- Non proper expansion/construction joint
- Non uniform corrugation on finished cc pavement

Water supply, Sanitary Installations and Drainage

- Non ISI SCI/GI pipes used
- Under weight SCI/GI pipes
- Clamping of GI pipe not done at proper spacing
- Under size MS holder bat clamp
- Clamps not fixed in cc blocks
- Less lead used in joints
- Defective nahani traps
- Testing of water supply and sanitary system not done
- Under weight bib taps/pillar taps/stop cocks
- Brackets of wash basin etc. Not provided
- Under weight PVC water storage tanks provided
- Under weight gully gratings and manhole
- Inferior quality SW/RCC pipes used
- Water tightness of joints and slopes not checked

Case Studies

Case Study-1 : In a works contract related to construction of Main Power Block for a thermal Power Plant, (cost -Rs. 230 crores)PSU, the prescribed tender conditions provided use of structural steel of 'SAIL' make only, use of re-rolled steel was not at all permitted. It was noticed that the contractor was subsequently permitted to use re-rolled steel, which was available at cheaper rates, on the ground that SAIL steel was not available in the market. Alternative steel of similar quality sourced from other primary suppliers was not considered as an option. The contractor used more than 2500 MT of re-rolled steel in the work which was permitted without any corresponding reduction in rates due to its cheaper price. Recovery of Rs. 158 lakhs from the contractor was advised.

Case Study-2 : As per the item nomenclature in a contract for a thermal power project, surface cleaning and preparation on steel structural members was to be done with wire brushing or mechanical tools depending upon the condition of surface. But, at site surface cleaning and preparation was done only with wire-brush, whereas certain members of structural steel required cleaning with mechanical tools because of scaling.

Case Study-3 : Huge quantity of unsuitable sand was found lying at the batching plant sites of various civil construction packages in a power project. Such unsuitable material in general should have been removed immediately from the site so that the contractor is not tempted to use them. In this case use of this piled up rejected material by the contractor cannot be ruled out.

Case Study-4 : Field test laboratory set up by the contractor at cooling tower site (cost Rs. 62 crores) was not operational. Thus, the very purpose of setting up laboratory for quality assurance was defeated. (The contractor had got this work on nomination basis.)

Case Study-5 : In a power project, the thickness of paint over structural steel members was found less than the required. The painting was a high value activity and any deficiency in painting thickness will obviously adversely affect the durability of steel structures beside undue financial benefit to the contractor. In the same project, honey-combing, bulging and undulations were observed on concrete surface in various locations, even the repair was done in a shabby manner and with a weak mortar.

Case Study-6 : In a nuclear power project costing Rs. 260 crores, the quality of finishing work was found to be poor. Even in the critical areas where very stringent quality requirements was set out, inferior finish, was observed at number of locations. Running cracks in the pavement were also observed.

Case Study-7 : In a RR stone masonry drain work of a nuclear power project, bond stones were not provided at all, which are necessary for the stability of the stone work. Similarly, the joints in the stone masonry were observed more than the maximum permissible size of the joints, which is also indicative of poor quality of construction.

Case Study - 8 : In a work amounting to Rs.283 Crore, being executed by a banking organization on EPC contract basis; the contract provided carpet area of flats in the range of 117-118 sqm. However, the carpet area provided by the contractor was approximately 98 sqm which is much lesser than stipulated. Vitrified tile flooring in hostel rooms was not matt finished as required, height of balcony railing was found 960 mm instead of 1100 mm, width of corridor was found approximately 1450 mm instead of 1500 mm, some RCC columns were found out of plumb and having non uniform size and shape and many columns were out of centre line by 60 to 90 mm. RCC beams were found bulged.

Case Study-9 : In a works contract costing Rs. 250 crores, for the construction of a premier Medical College and Hospital building being undertaken departmentally by a Ministry, the original plan was for the foundation to be filled in since the building was to be built on a site having hilly profile. However, after the award of this work the design of the foundation was changed to a "concrete slab over columns" at the same site. This resulted in the construction of a basement of 10,000 square meters with a height of 1.4 meters which had no functional utility, causing infructuous expenditure and undue benefit to a contractor. In the same work, the method of fastening the exterior stone façade cladding of the building was also altered for inadmissible reasons.

Case Study-10 : In number of projects, RCC work with design mix concrete was being executed by volumetric method. The contractors were not only saving cement and hire charges of batching plant but also were compromising on quality of work.

Case Study-11 : In one case, it was found that while dispatching the material from contractor's stores, the items, which were earlier rejected, deformed and rusted were mixed with the other items ready for dispatch to erection site. It was only during CTE's inspection that these items were pinpointed and were segregated from the other items before sending the same to the site. Such lapses prove that supervision at the time of execution is not given due importance by the PSUs particularly when the executing agency is another PSU.

Case Study-12 : The contract documents stipulate mandatory tests for ensuring that the material represented by the sample conforms to desired quality standard. It is observed in many cases that the materials are not tested at proper frequency. This not only defeats the objective of mandatory tests, but also gives opportunity to the contractor to bring sub-standard materials and save on testing charges

Case Study–13 : In a work costing Rs 33 crores, large variations in the proportions of ingredients of concrete from batch to batch and from ratio mentioned in the design mix report were seen, the contract condition stipulated placement of concrete at site by a line stationary pump or by a placer boom. As per another provision of contract agreement, permissible slump limit was given as 25 mm to 75 mm. The two conditions appeared contradictory.If concrete is to be pumped; slump should be in the range of 100 mm to 150 mm. Further, use of super plasticizer was not permitted. As per records maintained at site the actual slump during execution was 30 mm to 75 mm and W/C ratio in some of

the batches was as low as 0.27, which is again contradictory. This fact raises a doubt on the authenticity of values recorded in site records.

Case Study- 14 : As per design mix report done in case of one work costing Rs 218 crores, 28 days compressive strength of concrete cubes, using cement content @ 410 kg/m3 with admixture was 45.7 MPa against requirement of 31.6 MPa. It was quite possible to obtain more economical design by reducing quantity of cement. As per IS: 456, minimum cement content for M25 concrete is 300 kg/m3. Use of excessively high cement in the concrete has led to infructuous expenditure without any functional or strength requirement. In the same work, workmanship of RCC and other works was found very poor such as RCC columns found projected by more than 50 mm which may affect structural stability, lap length of 700 mm provided in 20 mm main bars of column instead of requirement of 960mm. Steel stirrups were not bent inside at 135^0 in columns. Width of wooden window frame was found 103 mm in place of 125 mm. Beams and masonry were out of line.

Case Study-15 : - In a thermal power plant construction contract (costing Rs 160 crores), "Trash Rack" made of structural steel used to stop river debris entering the water used for steam generation was stipulated to be procured from specialized manufacturer. It was found that the contractor was allowed to fabricate trash rack by setting up fabrication facility at site. This resulted in serious quality compromise as well as undue financial benefit to the contractor

Case Study 16 :- In a work (costing-Rs.96 crore), executed by a PSU , it was found that one fire rated door, already fixed, was damaged/partially dismembered due to rain. The thickness of calcium silicate board was found 8.0 mm against specified of 10.0 mm as in its nomenclature. The combined thickness of calcium silicate board and commercial ply was found as 11.41mm against requirement of 14mm. The in tumescent seal strip was not found continuous all around the shutters and there was huge gap between the shutters and also between shutter and frame. The door assembly was supposed to have 120 minutes fire rating. No testing of entire assembly was done before fixing of these doors as required in the item nomenclature itself. Thus on one side, the fire doors have not been provided as per the specifications provided in the nomenclature of item and secondly, in absence of prior testing these may not have the desired fire rating. In the same work, vegetation/grass was observed on the surface of road, which shows poor quality of sub grade preparation and may further damage the road. For supporting air-conditioning ducts and cable trays at roof, the supporting system was found rusted and shabby.

Case Study 17:- In a case of railway track laying and minor and major bridges costing Rs. 177.5 crores, pile driving through conventional tripod method was used instead of piling rigs as stipulated. No load testing was carried out on test and working piles to ascertain load carrying capacity. Stone ballast was being laid on the track manually instead of stipulated method by using WMM paver, for better finish. Grooved rubber pads costing about Rs. 40 lakh failed in testing. Frequency of tests for cement, aggregate, water, etc.

not defined either in contract or IRS specifications. Only one sample of concrete was tested though the supply of concrete was from different source.

Case Study 18 :- Density of semi dense asphaltic concrete pavement provided in top layer of main runway of an airport was found in range of 1.966 gm/cc to 2.051 gm/cc against the requirement of 2.385 gm/cc. Density for underlying layer of dense asphaltic concrete was found in range of 1.86 gm/cc to 2.086 gm/cc against specified 2.387gm/cc

Causes Leading to Quality Compromise

During interaction with officers of the organization at various levels and contractors, it was seen that some system deficiencies apart from negligence from contractor and project staff attribute to quality compromises. They are

- Works manual, standard specifications not existing.
- Works manual specification not updated considering various amendments and emergence of new building materials.
- Lack of coordination between planning and execution unit.
- Non-establishment of testing facility in time
- Non-mobilization of required plant and machinery to meet the specific requirement of quality of particular item of works
- Unauthorized/indiscriminate/unchecked sub-contracting of various parts of the works to inexperienced/incompetent contractors.
- Absence of certification of workers deployed
- Deploying unskilled cheap labour for skilled job.
- The planning and executive staff of some organizations are not properly trained and sensitised in good construction practices.

Conclusion

A few system improvements are suggested which may help organizations to prevent these common lapses.

- Updating of construction manual and standard specifications.
- Involving site staff at the stage of planning itself so as to enable them to give practical inputs as well as to understand the quality parameters laid by planning staff.

- Making the pre bid meetings mandatory. The organizations should improve the tender documents considering contractors suggestions on the basis of their merit. After addressing the queries raised by the contractors and considering their suggestions, the contractors should be made aware that quality compromises shall not be accepted.

- Imparting practical training to supervisory staff on the modules similar to those designed by IBC.

- Imparting skilled development training to workers of different categories similar to the skill development programmes designed by IBC

- Making it mandatory to employ certified workers (clause 19e of CPWD tender document) for selected trades.

Quality Assurance of E&M Systems

J. K. Choudhury
Former Chief Engineer CPWD

Prologue

Building should be completed with all services so that after completion the building can work without requirement of subsequent fitments which are not only time taking but will disfigure the buildings. Most Electrical and Mechanical (E&M) services come with automation and microprocessor control which makes the operation more efficient and economical. For example; the entire lighting system can be automated resulting in substantial energy savings. The entire water supply system can be automated. The BMS can take over the operation of the entire central AC System. In fact modern sub stations can be unmanned with substantial manpower savings. All such automation results in substantial savings in operational costs besides elimination of human errors while handling sophisticated equipments.

The author who is a well known expert in the field has dealt in detail the quality assurance aspects of Electrical and Mechanical systems. Quality assurance as per ISO is defined as "all the planned and systematic activities, implemented within the organization for quality management, to provide adequate assurance that a product or service will satisfy given requirements for quality." Quality assurance is essentially a preventive activity and is therefore to be systematically planned in advance. The activity includes identification and planning of the checks, inspection and control of process as a part of quality control. Quality assurance also means establishment of a quality system which can demonstrate the requirements.

A very informative Article – A must read

- Editor

Introduction

Quality:

- A measure of excellence or a state of being free from defects, deficiencies.
- Fitness for purpose.
- Quality is a perceptual, conditional and somewhat subjective attribute and may be understood differently by different people.

Quality Assurance (QA):

- Is a way of preventing mistakes or defects and avoiding problems when delivering solutions or service to customer.
- Part of quality management focussed on providing confidence that quality requirements will be fulfilled.
- The planned activities implemented in a quality system to ensure quality requirements for product/service will be fulfilled.

Quality Control: (Q.C) :

- Is a procedure or set of procedures intended to ensure that a manufactured product or performed service adheres to a defined set of quality criteria or meets the requirement of the client or customer.
- The observation of techniques and activities used to fulfil requirements for quality.

What is a Quality from User's Point of View:

- Reliability of service
- Safety
- Get required useful life
- No breakdowns in service
- Based on latest technology to ensure efficiency, energy savings
- Value for money
- Meets the user expectation and requirement

In last 10/20 years there has been tremendous improvement in quality of products and their service. Concepts like zero error have been implemented. The whole world is one family driven by competitive technology, consumer satisfaction resulting in more products at economic price flooding the markets.

Example :

Consider various consumer products like car, tv, phone. Compare their quality, affordability now and 20 years back. Most products are affordable even to poor people.

Quality to Include Maintenance Also

- The building is designed for a useful life in excess of 50 years. It calls for sound professional maintenance based on proper staffing, preventive maintenance and adequacy of funds. Periodic review is required for up gradation of the specific systems and replacement of worn out items. Maintenance is not to be treated as inferior to construction. It should not be treated as a breakdown activity. Site engineers to be given adequate financial and technical powers to attend to site problems instantly without waiting for approvals from higher ups.

- The building specifications and components should ensure safe, efficient and economical operation and maintenance of the building during its entire tenure of scheduled life. For example, many items like central air conditioning, IBMS (integrated building management system), Waste water recycling, Zero discharge building, automated water supply system, rain water harvesting, Building envelope insulation, electronic surveillance, solar power/heating/lighting , power back up with DG sets and UPS to give un interrupted power supply etc require additional cost but the additional investment will be paid back in few years on account of lower energy cost and higher productivity.

E&M Systems, Useful Life

- Rotating machinery: 7-25 years.
- Static equipments like transformers, Electrical panels, cabling : 25years.
- Electronic items like computers: 5-7 years.
- Any equipment may breakdown any time, which req uires immediate rectification/replacement.

E&M systems are designed to give uninterrupted service with use of standby systems. Standby systems are vital which are mostly missed in our planning. Examples: A modern power supply system works with support of standby transformers, DG Sets and UPS.

QA with Modern Technology

- 2 lakhs people die every year on our national highways. Analysis: defective roads/lack of electronic surveillance, drivers mistakes/ defective vehicles. Non application of technology.

- As per Govt. RTI Reply deaths in Mumbai railway accidents: Deaths in last 11 years till 2012: 23473. Out of these, 14554 while crossing the railway tracks.

- Contrast-Delhi Metro, since start more than 15 years back, hardly any death on account of train operation, except suicides.
- Japan Bullet train, Shinkansen started operating since 1965. Not a single accident so far. Operating at 320 km/hour.
- We have to apply technology and proper maintenance to minimise accidents and deaths thereof.

Example, Delhi Gurgaon Express Road

- About 30 KM.
- About 100 die every year, about 50 % are pedestrians crossing road. In absence of CCTV most accident culprits cannot be traced.

What the planners missed :

- Road cross over bridges.
- Absence of CCTV, electronic surveillance.
- Electronic tolling.

Recently they had to forego tolling, (annual collection more than 200 crores). The High Court did not allow long waiting of vehicles at the toll gates since they could not manage the volume of traffic) in absence of electronic tolling.

Quality Assurance in a Govt. System

- It starts with a preliminary estimate (PE) which contains all components of the work.
- AA is approval of preliminary estimate.
- Any items missing in PE cannot be executed. Execution of such items will be considered as unauthorised and irregular.
- Similarly, cost exceeding 10 % of AA requires revised sanction.
- So, take care, PE contains all the required items and estimate is realistic and not conservative requiring revised sanction.
- Revised sanction is subject to intensive bureaucratic checking which may take years. A practical engineer will generally not require a revised sanction.

Elements of a Quality Work

- Proper design and specifications based on latest technology.
- Cheap specifications is a penny wise pound foolish policy.
- Use only reputed makes and approved vendors in work. This is as per CVC guidelines. Are we using the best makes of materials and equipments in work?
- Executing agency to be capable, reputed for quality work, proven by past record.
- Sub-contractors also to be skilled, specialised and with proven track record.
- Skilled manpower, supervisor, engineer, modern tools and safe construction practice:
- Execution based on approved drawings, supervision by departmental engineers, and use of proper makes of materials and equipments. Factory inspection of specified materials/equipments, by engineer before despatch to site
- Factory fabricated quality is always superior to site fabrication. Insist on reputed factory manufacture. Example: Doors/ windows/steel fabrication items.
- Example: Painting of steel items in a standard factory is 14 -16 tank process compared to simple painting at site. Factory painted items are practically rust free. Modern cars are practically rust free.
- Quick decisions at site. Trim and empowered site management for quick decisions to ensure no time and cost overrun. Mostly time overrun causes cost overrun.
- Ideally only 3 levels for work execution: site engineer, his supervisor who is the project manager and one level higher, with full technical powers for deviation/extra items/substituted items or any technical matter.
- In most Govt. departments there are as many as 6/7 levels and with limited powers at site level which results in delay in decision making leading to time and cost over runs.
- No incentive for timely completion of projects and no disincentive for delay.

- There is no emotional commitment to excellence, problem solving. Time and cost overrun is taken as routine.

Example

A project of national importance with A/A of 11 crore (in 1995). Estimate revised to 14 crores at 80 % progress stage. No revised sanction. Project stalled for many years for want of revised sanction. After uproar in parliament, revised sanction given after 10 years, amounting to 32 crore.

More than 90 % of Govt. projects delayed for years. Rough cost of each year delay is about 5 % of project cost.

E&M Components of a Building

- Internal electrification
- Lifts
- Fire protection to include automatic fire detection, alarm, PA, fire fighting with wet riser/ sprinkler system/ fire signages.
- Central AC, Ventilation, heating, pressurisation.
- Water supply including recycling, STP, water harvesting.
- Power distribution system including substation, DG sets, UPS.
- IBMS
- Solar power, lighting, heating.
- LAN/EPABX/electronic surveillance, access control etc.
- Traffic management, barrier gated car parking management.
- Other specific user requirement like audio-visual system, conference system, PA system, stage lighting, swimming pool. Sports lighting, incinerators etc.

Building should be completed with all services so that after completion the building can work without requirement of subsequent fitments which are not only time taking but will disfigure the buildings. Most E&M services come with automation and microprocessor control which makes the operation more efficient and economical. Example: the Entire lighting system can be automated resulting in substantial energy savings. The entire water supply system can be automated. IBMS facilitates all the services under central

electronic monitoring. The BMS can take over the operation of the entire central AC System. Electrical Substation must have SCADA panel for electronic monitoring and data logging. In fact modern sub stations can be unmanned with substantial manpower savings. All such automation results in substantial savings in operational costs besides elimination of human errors while handling sophisticated equipments.

Importance of E&M Services

- E&M System costs 40 to 50 % cost of building project.
- On account of smart buildings consisting of electronic inbuilt safety and monitoring systems, and a variety of services, the cost of E&M components is increasing.
- Life: Building: 50-75 years. E&M services: 25 years. Electronic services: 5 years.
- Life cycle cost of capital, operation/maintenance/ energy cost of E&M systems will be much higher compared to civil cost.
- Hence importance of planning E&M systems consistent with latest technology, energy efficiency etc.

Checklist for a Modern Office Building

- Is it green?
- Energy efficient
- Centrally air conditioned
- Maintain proper IAQ (Indoor Air Quality). Pollution free indoor environment.
- LED Lighting
- Comprehensive fire protection
- Comprehensive electronic surveillance
- Wi-Fi, modern data, communication management
- 100% reliable and quality power supply backed by stand by systems, UPS.
- Waste water recycling, STP, water harvesting

- Automated water supply with microprocessor control
- IBMS
- Renewable energy system: solar power/heating/lighting.
- Paryavaran Bhavan, built by CPWD in Delhi is a net power zero building on account of solar power systems installed.
- Car parking and traffic management with electronic surveillance.
- Properly operated and maintained by skilled manpower and dedicated engineers backed by maintenance from respective manufacturers.
- The contract provides for comprehensive operation and maintenance.

Certain Building Economics

- 100% reliable, uninterrupted quality power supply, extra cost: 1-2% of building cost.(use of DG back up, UPS back up and stand by systems)
- Complete electronic surveillance, data/communication facilities, Wi-Fi, add 3% of building cost.
- Central AC, no need for window/split units: 8 % of building cost.
- Solar power/lighting/heating: 2.5% of building cost.
- Total comes to about 15 % of building cost.

By proper space management, if you can reduce area by 15 %, with the costing of a conventional building, you can have a smart air conditioned building.

Conventional QA System in a Govt. Department

There is an inspection by QA engineer, which looks like a vigilance inspection. The inspection is done based on the agreement with the contractor and actual execution along with deviation, extra items executed etc. Invariably the intention is to rectify the defects and to penalise officers if they have misconducted. It is beyond the scope of the QA engineer to examine if the agreement provides:

- For sound design
- Use of best materials and equipments
- Executing agency is capable,

- The supervising engineers are capable, and
- Provides for inspection in the factory
- Provides for operation and maintenance to ensure proper working after the completion of work.

In CPWD, for E&M systems, the rules provides for subsequent operation and maintenance by the agency for a period of 5 years.

Note : We are using a large number of equipments of foreign origin, on account of their superior quality. But mostly engineers are not allowed to go abroad for factory inspection. We are getting equipments without factory testing. Is it correct?

QA for a Power Distribution System Based on Proper Design

What is a modern power distribution system?

It provides quality power with no-break, uninterrupted, so that the modern offices and establishments work without any break and loss of productivity and service.

Components of a Modern Power Distribution System:

- In coming supply- more than one source.
- Incoming and outgoing HT Panels.
- Transformers, including standby.
- Standby DG Sets.
- Standby UPS.
- LT Panels: Normal, essential and UPS.
- Interconnection by Bus ducting.
- Supported by PLC/SCADA Panel for electronic control and monitoring.
- Substation earthing, safeties etc.
- Cabling by UG system.
- Integrated substation, indoors (Vs. Outdoors).

Now let us discuss what is being generally designed

- Incoming supply : one source in place of two.
- Non-use of VCB HT panels.
- Use of oil cooled transformers in place of dry type and non-use of OLTC to ensure constant voltage output without voltage fluctuations which are damaging to the electrical installation.
- Non-provision of standby transformers and other standby systems.
- Non provision of adequate number and capacity of DG Sets
- Non-provision of UPS
- Non provision of best quality and branded LT makes to ensure quality
- Non provision of PLC/SCADA Panel for electronic controls and monitoring/ data logging to minimise human error and eliminate unnecessary labour cost. Modern substations can be completely unmanned and remote monitored.
- Use of cabling for interconnection in place of bus-ducting, which is technically far superior.
- Use of OH (Overhead) system in place of UG (underground) which is subject to damage in case of cyclone, rains, storm etc . In case of coastal areas subject to cyclone etc. there is large-scale destruction of OH power distribution systems resulting in disruption to daily life of people.
- Non-use of pre-wired DBs which completely rules out loose wiring which leads to short circuit and fire.
- Non-use of fire retardant wires in wiring

All the above superior features may cost additionally 1-2% of building cost but will result in uninterrupted and quality power supply. But for want of technical awareness most of our designs miss on these features.

In Absence of an Appropriate Design, How a QA Inspection can Ensure Quality

Energy Efficiency

- Replace incandescent lighting by T-5/ LED Lighting.
- LED: 40,000 hours compared to 8000 for CFL. Saves about 30 % energy.

- Auto switch off, when not needed.
- Task lighting.
- Day lighting.
- Automation /IBMS. (Integrated building management system.)

Air-conditioning

- Maintenance of temp., humidity, air changes, fresh air, IAQ (indoor air quality), absence of odours and harmful biological containments.
- All future office/business/hospital/educational buildings to be air conditioned for optimum working environment and efficiency. All the new IITs, IIMs, AIIMS etc. are coming with central air conditioning.
- Life of central AC Plant: 25 years. Window/split units: 7 years and no control over temp, humidity, air quality, air changes, sound, uniform distribution etc.
- Central AC Plant energy cost will be about 50 % less compared to Window units.
- Cost of central AC will be about 8 % of building cost. If you can manage with 15 % less space (which is quite possible with modern computerised offices), the cost of a centrally AC building will be less than conventional buildings without AC. AC is not a status symbol but a necessity to ensure efficient working of personnel.
- Dust and humidity is harmful to electronic systems.
- Pollution Control: PM 2.5 pollution level in excess of 100 is harmful to humans. In Delhi it exceeds 300. In centrally AC building, with suitable indoor air quality control with 99 % filtration, this level will come down to less than 30 (micro gram per cubic meter).

How to reduce AC Load:

AC accounts for 50 % of energy cost of air conditioning buildings.

Reduce AC Load by

- Green environment.
- Building orientation and shading.

- Double glazing of windows and heat reflective glass to reduce heat ingress.
- Roof and wall (exposed)/ Envelope insulation.
- Energy efficient AC equipments.
- Variable frequency drive.
- BMS.

With the above measures the heat load will be reduced by as much as 25-30 %.

What is Fire due to Short Circuit?

When electric wires feeding a load is shorted, the resistance of the circuit becomes very low, thereby increasing the current (voltage/resistance) to a very high value. Heat is current square times. It ignites a fire. If this fire is not detected early by fire detection system, may spread to start a major fire in the building.

The electric circuit contains a number of circuit breakers to automatically switch of the circuit in case of higher current. Fire due to short circuit is generally on account of defective installation or lack of maintenance.

What is Electrocution, which leads to death?

When a person touches an electric pole or any device whose body has been electrically charged, a current will pass though his body. If the current is excessive, the person may die. This happens when the earthing of the body of the equipment fails. When the earthing works, most of the current will go to the earth through earth wire to earthing system and the person is protected. Electrocution is primarily on account of the failure of the earthing system and no maintenance thereof.

Some questions arising because of lack of Quality Assurance

- Why street lights and traffic lights stop working? Internationally their working at 100 % is taken for granted. So also electric supply. Is it due to sub-standard equipments and maintenance?
- How many people die on account of open doors of moving trains and buses and buses stopping in the middle of the road? Metro does not allow this.
- How many crimes remain unsolved in absence of CCTV?

- Why, while preparing PE, we don't include CCTV and electronic surveillance?
- We spend lakhs of crores on buying vehicles and building roads but totally miss out on inbuilt safety features. Why?
- Except in metro cities like Delhi and Mumbai, the entire power distribution system is OH, subject to frequent damages and disturbances and make the cities ugly. Is it on account of lack of technical and aesthetic awareness?
- Bullet trains were stared in Japan in 1965 and in last 50 years there is not a single accident. They run at 320 km/hour. What is their QA?
- In last 10 years more than 20,000 people have died on the local train system in Mumbai whereas this figure is nil in Delhi Metro. Is it on account of technology?
- In our country more than 90 % projects are subject to substantial cost and time overrun. Can this position be rectified?
- From Shanghai to Beijing, there are 50 pairs of bullet trains a day travelling at 200-300 KM/hour. (5 lakhs people per day) This is a train system for the public or elite?
- Do we as a nation, follow a policy of penny wise and pound foolish policy in relation to use of materials, equipments and selection of executing agencies?
- Why we don't have engineering colleges giving degrees/diplomas in Maintenance Engineering?

Quality Assurance in Horticultural Works

Veena Vilas Kantute
Former Director Horticulture, CPWD

Introduction

Horticultural work is integral part of any project. No project is complete without horticulture. Many times plantation effectively conceals any visible aberration of built form.

However it has to be often executed only in the conditions created by the project executed till the site is made available for horticultural works without following deficiencies.

- The water pipelines (very essential for of plants) may not be laid.
- The planters may be filled with debris (malba) or any available.
- The planters may not have "weep holes" required for survival of plants.
- There is hardly any time available to make necessary changes

Such shortcomings affect the quality of horticultural works in long run and make the quality assurance in Horticulture a tricky subject. Extra efforts are to be made to create specifications as per the site conditions. The ideal estimates prepared at planning stage need to be split and/or revised. To ensure the quality of the horticultural works following points need to be given due importance.

In Case of Original Works

- The quality cannot be quantified or checked after execution, in terms of numbers, without jeopardizing the life of the plant material.
- There is need to create detailed specifications for plant material.
- No matter how detailed are the specifications, the quality would depend on the season and can be judged only by experienced Horticulturist.
- The quality would change with weather and other site conditions including

availability of water on site and activities in the vicinity.

- In the varied weather conditions quality (or the specifications of plant material) will change differently with time, depending also upon the above conditions.
- Thus it makes supervision at execution very critical.
- That also creates seasonal hindrances, like non availability of plant material as per specifications in particular season e.g. if specifications indicate plants with flowers & after site availability, execution has to be done in non flowering season.

In Case of Maintenance Works

- Regular supervision and inspection by experienced horticulturist can ensure quality as only he can judge the quality of particular plant material, vis a vis weather variations and suggest measures for improvement.

IBC ABSTRACTS

A brief summary is given hereunder of some of the important documents published on the subject of 'Quality Control, Quality Assurance, Quality Management and Quality Management Systems in Built Environment'

I. CASE STUDY – IMPLEMENTATION OF ISO -9000 IN CONSTRUCTION OF PARLIAMENT LIBRARY PROJECT, NEW DELHI

(Abstract of write-up given by Shri Jag Mohan Lal, former Add. Director General, CPWD. Shri J.M. Lal was Chief Engineer (Civil), in charge of project)

1. **Introduction –** Construction Industry will have to commit itself to Quality Management, in order to gain competitive advantage in the emerging global trade scenario. Therefore, concept of and principle of quality have assumed a greater significance. The general tendency for quality management has become order of the day.

2. **Project -** The Parliament Library Project was taken up for execution, by CPWD adjoining to Parliament House in Lutyen's Delhi during 1994. Its estimated cost was about Rs. Two Hundred Crore. It was planned as a multi – dimensional institution of national importance, to be used by VIPs foreign dignitaries, etc. It was decided that to provide adequate confidence to project team and in turn for customer satisfaction, the desired quality would be achieved by following ISO quality systems. ISO 9002, Quality Systems, a model for quality assurance in production and installation was considered relevant. This model contained 18 elements of quality system requirement and the methodology adopted to implement them in this project, practically referring to foundation system. Adoption of their Quality Systems resulted into conferment of ISO – 9000 Certification on Parliament Library Project Team (Civil). This team was first Civil Engineering organization in the country to have been conferred with Internationally a claimed ISO – 9002, Quality Systems Certification by Bureau of Indian Standards (BIS), accredited by Road – Vorr – de – Certificate, Netherlands.

3. **Quality -** Quality is a degree to which a specific product conforms to a design or specification. ISO – 9000, define the quality as the totality of characteristics of an entity that bear on its ability to satisfy stated and implied needs. An entity may be an activity or a process, a product, an organization, a system or a person, or any other combination thereof. Quality Assurance to all the planned any systematic activities implemented within the quality system and demonstrated as needed, to provide adequate confidence that a product or services will fulfill requirements for

quality. Total Quality Management is management approach of an organization centered on quality, based on the participation of all its members and aiming at long term success through customer satisfaction and benefit to all members of organization and to society. Quality System is organization and to society Quality system is organization structure, procedure process and resources needed to implement quality management.

4. Quality System requirements

4.1 Management Responsibility

4.1.1 Quality Policy – It is to be formality expressed by top management and was defined for this project by stating that (i) building work meets the functional needs of the client, (ii) Aesthetically building conforms to architecting drawing, specifications, as proposed by Architect. (iii) Building is structurally sound, cost effective, maintain quality of various components conformed to standards laid down. (iv) There is no time and cost over runs to the extent possible, for which corrective action shall be taken. (v) Policy is under stood and implemented at all levels.

4.1.2 Organization – For Architectural design and drawing a consultant architect, for structural design, Central Design Organization of CPWD. For planning services, Project Manager and for execution a project team made functional. This team consisted Chief Engineer – Superintending Engineer 1 No. Executive Engineer 3 No. Assistant Engineers – 6 No. Junior Engineers – 10 No. and Draftsmen – 2 No. As per requirements, the responsibility, authority and inter relationship was defined and documented. People with such delegated responsibility were given freedom and authority to stop the work, reject substandard work and take action to prevent internal of any non - conformities. The team also identified resources requirements and provided adequate resources including trained personal for management, performance of work and verification activities including the internal quality audits. The superintending Engineer was appointed as management representative, who besides other responsibilities, was responsible for establishment, implementer, maintaining and reporting of quality system. He was to keep Chief Engineer updated with all concerned issues regarding quality like shortcoming in the system, recommended remedial measures, solutions, decisions and implementation.

4.1.3 **Review Committee -** A management Review Committee was setup with superintending Engineer as Chairman and Executive Engineers as Members, to look in to the effective functioning of the quality system and to suggest modifications if required. The period of review was at least once a year and record of such reviews was kept.

4.2 **Quality System –** Quality system was necessary to make sure that everyone had common understanding and staff should know what was expected. Documentation of quality system was necessary to render it amenable to management control. Even changes at different stages were also required to be documented. Documents maintained at PLP project were (i) Quality Manual – Main reference document used in establishing and implementing the quality system. It describes the quality management system and is permanent reference in the implementation and maintenance of system, (ii) Procedure Manual – The Rule book in which operational procedures described, to ensure product quality, (iii) Purchasing Date – It gives specific quality practices, resources and sequence of activities relevant to a particular product, project or contract. The purchasing data for this project work contract document and sub-contracting details, specifications, work/job instructions, check list etc.

4.3 **Contract Review –** The purpose for review was to ensure contract understanding and capability of meet the requirements specified by CPWD working on behalf of Lok Sabha secretariat. Drawings and specification were approved by them for the project and electrical engineers, architects etc. also participated at that stage. Still interaction was one with them for any variation considered necessary, within financial limitation 5% of project cost.

4.4 **Design Control –** Project team's role was limited to site supervision and control. Architectural changes were to be done by Architects and design change by CDO CPWD. As required, modified drawings were made after super-seeding earlier drawings.

4.5 **Document and Date Control –** A master list of documents meant for quality control was maintained with details of up to date revisions. All drawings issued through Drawing Register. All document and drawings were numbered. No change was allowed except when initiated by concerned authority.

4.6 **Purchasing**

4.6.1 **Evaluation/Prequalification of Sub Contractors –** For selection of Architects, proposals were asked for from shortlisted firms. The Board of Assessors adjusted the best entry and Architectural form was selected. It was noted as project was equally important. Therefore, agencies were shortlisted for both the jobs. The project was divided under two parts - for the Foundation work with water proofing one contract and building work with other special agency as main contract. Specialized agencies were shortlisted for the plumbing work etc. and main contractor was to select out of specialized again.

4.6.2 Purchase Date – All necessary details of soil investigation, site availability, security restrictions, traffic restriction, avoidance of disturbance in adjoining buildings, technical specifications conditions of disturbance etc. were made part of under document for foundation work.

4.6.3 Verification of Purchased Products – Cement and steel were supplied through central stores CPWD. For high tensile steel wires, reputed firms specified, items like stainless steel plates, planks and tubes of AISI 309 grade, sand stone Jali etc. were procured by department and supplied, for other materials like paint, aggregate, sand tests were done regularly. Storage of materials was checked. For work executed inspection were carried out regularly.

4.7 Control of Customer Supplied Material – No material was supplied by customers

4.8 Product Identification and Traceability - The project was divided in nine blocks and Cartesian coordination system followed for identification. Similarly each panel of diaphragm wall and each road area was numbered. Cube tests register indicated locations. All data properly documented.\

4.9 Process Control

Process was planned by contractor and sequence of construction decided. Detailed instruction for each activity and sub-activity was given and recorded. Procedure for various processes followed. Check lists/job instruction were issued. Trained personal deployed for specialized jobs.

4.10 Inspection and Testing

Documented process followed for inspection and testing to meet requirements of product. Inspection and test plans were made and documented, which included (i) Inspection and testing of incoming materials (ii) Inspection and testing during construction (iii) final inspection (iv) Inspection and test records. For failure in tests procedure for control of non-conforming product becomes applicable.

4.11 Control of Inspection - Measuring and Test Equipment: Only correct and proper testing and measuring equipments were used, properly maintained and calibrated. Equipment Register was maintained to identify equipment need as per purchase data, method for calibration and its frequency. These were inspected periodically and calibrated at

specified intervals from approved laboratories/agencies. It was ensured that equipment was not damaged and there was no loss in calibration.

4.12 **Inspection and test status -** The inspection and test status of a product is to be identified by suitable means, to ascertain conformance or non-conformance. The status of work can be (i) yet to be inspected (ii) inspected and passed (iii) inspected and rejected. The rejected work to be repaired, rectified or utilized under concession after approval of designated authority. S.E. was the designated authority. The status was seen from Site Order Book, Inspection Register and check lists. Cross marking given for rejected work/materials. Compliance is indicated against entries and only accepted material work measured.

4.13 **Control of Non-Conforming Products -** For non-conforming work suitable marking given at site and entries are made in Site Order Book. Suitable report is prepared for these work indicating identification, quantum, details of fault, defect etc. and stage at which identified. The Action committee decide in one of following ways (i) dismantled and redone (ii) accept without dismantling and with or without repair or concession (iii) put to alternative use with modifications as required (iv) Register scrap. Reviews are recorded and documented. Appropriate steps taken to avoid recurrence of non-conforming works.

4.14 **Corrective and preventive Action –** The root cause for non-conformity was ascertained and preventive action taken to avoid reoccurrence. For this purpose "Corrective and Preventive Action Committee" Was formed under S.E. The committee was to take action by (i) use of appropriate sources of information like process, operation etc. which affected quality, concessions, audit result, quality records, service repots etc, (ii) Determine steps needed for prevention, (iii) intimating suitable preventing action and make it effective and (iv) relevant information submitted to management.

4.15 **Handing, Storage, Packaging, Preservation and Delivery –** The purpose is to prevent damages, ensure safety and protection as also protection of as built structure. After receipt, the material was accounted for, data of procurement recoded, inspected, checked test certificate taken as required. Precautions taken to ensure that no damage occur during handling and storage.

4.16 **Control of Quality Records –** Documented procedures were maintained for identification, collection, in clear access, filing storage, maintenance and disposition of quality records. These records were readily retrievable. Master list was maintained for identification. Records kept after completion for settlement of input claims.

4.17 **Internal Quallity Audit –** The purpose was to verify as to whether quality activities comply with planned arrangements, as also to determine effective of quality system. The audit was undertaken by independent person. For this purpose procedure and check lists were proposal. As per audit reports, creative action taken and record kept. Audit was carried out once a year.

4.18 **Training –** Training was necessary to give required technology input as also for continuously improving performance. Training needs were established on the basis of task assigned to staff vis-9-vis their qualifications and experience on the job training organized and other training aide given like Library support, vides film support etc. Training records maintained. As required training courses were arranged by C.E.(Training) CPWD.

4.19 **Servicing –** It was out of preview.

4.20 **Statistical Techniques –** Watch was kept on frequency of various lists, limits of tolerance to acceptance criteria, frequency of testing and calibration of equipments Data recorded as required on statistical techniques and experience of department.

5. Conclusion

The ISO -9000 principles are generic in nature but oriented towards manufacturing sector. For application in construction, extra efforts were necessary. The project team was conferred with ISO-9000 certification through continuous improvement which consisted of measuring key quality and other processes including in all areas and testing. Finally action for improvement, by meticulous planning and following a systematic approach, it was possible to evolve quality systems conforming to provisions of ISO-9000 for execution of building project. Additional records were required to be maintained in larger interest of user and durability of the building and services. It was worth to do so.

II. QUALITY ASSURANCE MANUAL FOR CONSTRUCTION OF CONCRETE STRUCTURES (BRIDGES AND FLYOVERS) – 2002 – CPWD-GOVT. OF INDIA

Introduction – The Manual was developed for Guideline on Quality Systems for Road Bridges – IRC -1998 CSP – 47. The most important point to mention is that the first application for Quality Systems on the basis of above document was done by PWD Delhi in Years 1999 -2000, on a few flyover projects of Delhi, when Author was Engineer-in –Chief PWD. On the basis of the experience gained, this manual was published by CPWD. May be this was a first manual on Quality published in India. Therefore, it is considered desirable to being out a brief abstract of content of this manual.

2.0 Guideline for using Manual – The IRC: SP47, has described four standards of Quality Viz Q1, Q2, Q3 and Q4. The Q4 standard is highest and the manual gives guidelines for achieving Q4 standards for flyovers and bridges. To achieve best possible quality, the quality management planning is to be done in advance. Besides, planning and monitoring, it is also necessary to have documentation of activities which also play a very vital role in assuring and achieving high quality standards. The Manual gives guidelines for testing of basic ingredients and site activities. Beside, method statements of activities commonly involved in the construction of flyover are given. It is also important to deal non-conformity products and procedure to be followed for deciding their acceptance.

2.1 Quality Assurance Plan for basic construction materials – Basic material in construction are either raw like earth, sand stone aggregates etc. or manufactured like cement, steel or bitumen and can be manufactured or assembled. Materials from natural resources include coarse Aggregate, fine aggregate, water, earth, lime, close graded granular sub base material. For these materials, essential tests are listed and the frequency is given. Besides, details of tests to be performed by contractor, Employer or Engineer and Independent agency are given. The reference to BIS code or IRC standard, to be complied with is also given. On the basis of these details, the acceptance standards of materials is also given.

2.2 Quality Assurance Plan (QAP) for site activities – The contraction activity at different stages is to be tested/checked acceptance and payment. The QAP for all these activities has been described. Details include – (i) Tests essential for every activity, before acceptance are given (ii) frequency of testing of material or lot is given, (iii) Reference of BIS Code, IRC Standard or other relevant references is given (iv) Acceptance standards are given. Only after completion of testing of items/site activities, as per this QAP, a particular work is accepted.

2.3 In house/on Site Testing Facility – For good quality control, frequent tests at site are necessary by establishing testing laboratory. Tests to be conducted are specified. For individual test size of sample is also specified. Besides, testing is also given. To ensure uniformity, standard data sheets have been developed.

Besides, all the facilities and standards essential to be provided in site laboratory are also given.

2.4 **Independent (Outside) Testing Facilities –** Total tests to be conducted are specified. For many tests, laboratories at site are not equipped. These are to be conducted in independent laboratories. The laboratories listed in the document but there should be independent assessment.

2.5 **Site Documents –** Such documents are to be maintained at site, which are required to form part of permanent documentation. Such items may include tests conducted at site, instructions issued to the contractor, record of drawings issued to contractor, inventory of materials at site etc. Such documents play important role for assuring quality of work as also making total management easy. For these documents unique identification number is given. The record of such documents to be kept in Master Register.

2.6 **Check Lists and test performances –** For efficient execution of work it is essential that work done at various stages should be as per standard procedure. Therefore checks at various stages are necessary. For this purpose, check lists are evolved for all important items of work. These check list are to be filled by site staff, while allowing contractor to proceed with work. Even for approval of agency/supplier, check lists are necessary for in house testing, record, standard formats are evolved. These formats are to be checked in a separate register.

2.7 **Method Statement –** For execution of work is a set procedure, the contractor is required to prepare method statement for each and every job. The Owner/ Department has to approve these statements, before execution of each item of specialized work like bearing, expansion joint, reinforced earth, launching of segment etc. Specialized agencies employed, should give method statement.

2.8 **Non Conforming Product and Procedure –** While working at site, situation occurs when some particular item/product does not fulfill certain test standards but is otherwise acceptable as it passes alternative tests. These items can be accepted at lesser rate.

As per these guidelines, and methodology given in different chapter of this book, the site staff can follow the manual. End result should be extra high quality as desired under Q.C system of IRC : SP:47.

III. QUALITY MANAGEMENT SYSTEM IN CONSTRUCTION SITES OF L&T DELHI METRO SITES - AN OVERVIEW

1. **Company Policy –** As per policy of the company, QMS is established by the site management on the basis of ISO-9001 requirements. These policies are (a) Top management driven focus on quality (b) To analyse customers requirements (c) Define process and interaction (d) Availability of infrastructure (e) frame work for continual improvement (f) Entering customer satisfaction (g) Confidence to customer and interested parties (h) verification system from interested parties and (i) Verification of system.

2. **Company Policy for QMS as per ISO 9001** (i) Leadership – Company must have a well defined vision guided by management and committed to customer satisfaction. Vision includes committed (a) Professionally managed management (b) Total customer satisfaction (c) Enhancing shredders value (d) Innovations (e) Empowered team (f) Enhancing global value (g) Continuous Learning and (h) Meeting of expectations of employers, share holders and society (ii) Quality Policy – To be well defined along with objectives as also management commitment and communication. There shall be commitment for continual improvement of Quality Management system according to ISO. (iii) There should be QMS – ISO 9001 certification from approved agency.

3. **Pretender Submissions –** After analyzing tender document, the submissions are (a) Model Project Quality Plan (b) Resume of key personnel (c) Control of construction methodology (d) Major construction equipment/plants and (e) Quality organization chart.

4. **Drawing Listing –** A list of drawings as received is made and all revisions are to be recorded. Superseded drawings to be returned to planning/issuing Department. For anything connected with drawings, it should be recorded in register. The drawing register to be updated everybody.

5. **Product Quality Rating –** Properly trained learn has to be given on scale “1 to 10”. The grading 10 is for excellent. For rating less then eight, it is necessary to have internal review. The rating is to be shared during monthly/management review meeting.

6. **Project Quality Plan and Method Statement –** (i) Project Quality Plan (PQP) is based on Master Quality Plan and it is as per ISO 9001 requirements. A Quality Manual is to prepared, reviewed and maintained. Common Management Procedures and project Management procedures are to be drafted in coordination with headquarter. These are to be reviewed as required and implemented. Project Quality plan to be made for site team. Section Technical Head to make method statement after considering technical requirement and tender requirements. It is to be reviewed by Quality Safety Head & can be reviewed on the basis of input

from Quality & Safety Department. After review, it is submitted to client and after incorporation of their comments, the training is given to the team and it is issued to the share holders with copy of formats and instruction plan. It is to be verified by internal audit.

7. **Inspection and Test Plan -** Various steps of this purpose are (a) Major activities and construction materials are identified, (b) Testing requirements are identified (c) Base code/specification to be referred like BIS, Railways (d) Items are tabulated and summarized (e) Frequency of testing is finalized (f) Test requirements finalized (g) Inspection and test planning is finally submitted to approving authority (h) The approval is sought and minutes received are incorporated in ITP (i) The approved ITP is distributed to all concerned Departments such as Quality/Site store (j) Revision of ITP if any shall be recorded (k) Material receipt register is prepared and updated daily (l) Sampling details are recorded in the Material Testing Register (m) Minimum of the lab approval are taken for testing of materials and NABL approved labs are used.

8. **Internal Site Lab Installation –** (a) Site Lab needs to be installed (b) Basic testing and mix design facility to be established (c) Testing process to be displayed (d) Initial and regular training for testing procedure to be done (d) All tests to be recorded in standard formats (e) Joint testing where ever possible should be done.

9. **Organization and Competent Staff –** (i) Key Personal - (a) To be identified as per technical knowledge and experience (b) Organization chart for all sections to be prepared (c) Staff requirements as per job needs are updated on monthly basis (d) Organization chart is updated and quality basis.

10. **Inspection of Site Activities and Works (i) Daily Inspection -** (a) All activities to be inspected daily by Engineers (b) Inspection to be recorded in format as prescribed (c) Inspection to be verified by quality and (d) Joint Inspection with client to be done.

    (ii) Specific time Inspection – (a) Segment mould (b) Tunnel Boring Machine - pre assembly(c) Ring Segment Assembly (d) Steel Shutter Assembly.

    (iii) Mock – Up (a) Special/Critical works one mock – up to understand the criticality and methodology (b) key team involvement for shutters (c) Congested Rebar section and concrete finish and (d) Checking and convincing alternative technology.

    (iv) Factory visit for source approved – (a) Critical work if under taken by vendor then factory visit required (b) Approval of vendor on the basis of visit report (c) Regular visits required for consistency.

(v) Visit for source approval (Bulk Material) – (a) Bulk Material to be identified like aggregate, steel etc (b) Prime source to be visited (c) Source to be ensured throughout (d) New source approved, only if required.

(vi) Pre approved source – (a) Source to be shared to all, (b) one visit per source (c) Pre approved vendor if assured on the basis of technical/ commercial feasibility (d) Long term control with manufacturer like steel, admixture (e) Project consistency to be maintained (f) Pre approved admixture assessed on the basis of trial mix (g) Strength and working parameters are verified (h) Short listed vendor from pre-approved list to be selected.

(vii) Documentation (a) Standard format to be used as per approved statement (b) Documents are generated where they have direct impact on quality (c) Traceability of documents is implemented (d) Each department to develop proper standard filing system, which makes working simple.

11. Non Conformance Report (NCR) – (a) Control of NCR (b) Summary of all NCR to be prepared (c) Cause analysis to be done (d) Correction/Corrective Action/Preventive Action shall be taken (e) Training to control report NCR (f) Non conforming product shall be identified and dealt separately.

12. Training (a) Regular training to recollect old learning (b) New technology (c) Moto – first time right and every time right (d) Improvement of grey area (e) Reduction of re work area.

13. Audit

(i) Audit – (a) Verification of installed system – ISO 9001 (b) Internal audit as per audit calendar (c) Regular quarterly audit .

(ii) Internal Audits by site Quality Management Department as defined in Project Quality Plan, at regular intervals.

(iii) Internal Audit by Headquarter – Quality Management Department at Headquarter and Management representative at site.

(iv) Site Quality Management Department to audit all department once and then quarterly.

(v) Management Review Meeting

14. Continual Improvement

(i) Coordinate and assist in production of Departmental Manual Method Statements, Deptt. Procedures, Deptt. instructions, Inspection and test plans and record forms .

(ii) Evaluate effectiveness of quality system

(iii) Developing customer supplier relations within system

(iv) Performing audit and report to Project Manager

(v) Create cohesiveness

(vi) Developing customer supplier relations with system

(vii) Regular meetings with customer

(vii) Revision in format requirement is assessed and periodically done

(viii) New technology used as per requirements

(ix) Project site progress and quality parameter are assured on monthly basis

15. Role of Quality Control

(i) Plan, organize and performance all QC inspection's for the permanent works.

(ii) Perform QC inspections for temporary works

(iii) Inspect purchased and supplied materials as per departmental requirements

(iv) Assist in updating and filling of QC documents and forms for quality control aspects

(v) Product quality rating for finished work

(vi) Prepare all required records of laboratory and field tests to monitor quality

(vii) Calibrate all equipment i.e. weigh bridge

(viii) Perform all laboratory and field tests to monitor quality.

(ix) Monthly Quality Report to be submitted to clients

(x) Assist in closing Non Conformity Report

16. Handing over of site

(i) Master list is prepared

(ii) All documents in original are indexed and filed

(iii) Conformation that all documents are in place

(iv) Extra copy as per tender requirements are made

(v) Documents are formally submitted to clients

(vi) Maintenance Manual is prepared for maintenance of structure, giving brief details of materials used

IV. IS/ISO 9000:2015 QUALITY MANAGEMENT SYSTEMS:- FUNDAMENTALS AND VOCABULARY (FOURTH REVISION)

The fourth revision was adopted by BIS on recommendations of Quality Management section committee and approval of Management and systems Division council. It is identical with ISO 9000, 2015.

1. Scope

It describes fundamental concepts and principles of quality management, which are universally applicable for, (i) organizations seeking sustained success, (ii) customers seeking confidence of organizing ability, (iii) organizations seeking confidence in supply chain, (iv) organizations seeking improved communication, (v) organizations performing conforming assessment against requirement of ISO 9001, (vi) providers of training/assessment/advise in quality management and (vii) developers of related standards.

Terms and definitions applies to all and developed by ISO TC76

2. Fundamental Concepts and Quality Management Principles

2.1 General – Today's organizations work with accelerated charge, globalization of market and emergence of knowledge as principal resource. It can have direct impact on organizations reputation. All concepts, principles and their interrelationship shall be seen as a whole and not in isolation.

2.2 Fundamental Concepts

2.2.1 Quality – For organization, it promotes a culture that results in behavior, attitudes, activities and processes that deliver value by fulfilling needs of customers etc. Thus it has to satisfy customers. Beyond its interested function and performance; it includes perceived value and benefit to customer.

2.2.2 Quality Management System – QMS comprises activities by which organization identifies its objectives and determines processes and resources to activate desired results. It is interactive process. It enables long term. It is means to identify actions t address, intended/unintended consequences in providing product and services.

2.2.3 Context of an Organization – Understanding the context of organizations process. The process determines factors which influence the organizations purpose, objectives and sustainability. It considers internal and external factors.

2.2.4 Interested Parties - Beyond customer, all interested parties to be considered.

2.2.5 Support – 2.2.5.1 Top management support to include – adequate human

resources, monitoring processes and results, evaluation work and responsibilities and implementing appropriate actions. Responsible action, deployment, maintenance, enhancement and disposal of resources.

2.2.5.2 People

2.2.5.3 Competence

2.2.5.4 Awareness

2.2.5.5 Communication

2.3 Quality Management Principles

2.3.1 Customer focus

2.3.2 Leadership

2.3.3 Engagement of people

2.3.4 Process approach

2.3.5 Improvements

2.3.6 Evidence – based decision making

2.3.7 Relationship Management

For 2.3.1 to 2.3.7 these are statement, rationale, Key benefits and possible actions.

2.4 **Developing the QMS using Fundamental Concepts and Principles.**

2.4.1 QMS Model, 2.4.1.2 System, 2.4.1.3 Process and 2.4.1.4 Activity

2.4.2 Development of a QMS – It is a dynamic system that evolves over time with periods of improvements. A formal system is to be evolved along with ISO 9004 and ISO 9001 to assist organization to develop a cohesive QMS. It should provide framework for planning executing, monitoring and improving the performance of QM activities. It is ongoing process. It is PC to be monitored and audited.

2.4.3 QMS standards, other management systems and excellence models.

QMS developed by ISO/TC176, are based on common principles. They enable organizations to identify risk and opportunities and contain guidance for improvement. Innovations, ethics, trust and reputation could be regarded

parameters for QMS. Other standards like ISO 9001, address this QMS standards by ISO/TC 176 provides comprehensive set of requirements and guidance for QMS, ISO 9001 success. Similarly for components there are different ISO standards and need to be integrated. The objectives, processes and resources relating to quality, growth, funding, profitability, environment, occupational health and safety, energy, security and other aspect can be covered by integration. The organization can perform an integrated audit of its management system against requirement of multiple standards like ISO, 9001, 14001, ISO/IEC 2700

3. Terms and Definitions

3.1 **Relating to person** - Relating to person or people top management, Q.M.S. consultant, involvement, configuration authority and dispute resolver configuration authority and dispute resolver.

3.2 **Related to organization -** Organization, context of organization, interested party customer, provider, external provider association and metrological function.

3.3 **Related to activity -** Improvement, continual improvement, management, quality management, quality planning, quality assurance, quality control, quality improvement, configuration management change control, activity, project management, configuration objective.

3.4 **Related to process -** Process, project, quality management system realization, competence acquisition, procedure, outsources, contract design and development.

3.5 **Related to system -** System, infrastructure, management system, quality management system, work environment, metrological configuration, measurement management system policy, quality policy, vision, mission, strategy.

3.6 **Related to requirement -** Object, quality, grade, requirement, quality requirement, statutory requirement, regulatory requirement, product configuration information, nonconformity, defeat, conformity capability, traceability, dependability, innovation.

3.7 **Related to result -** Objective, quality objective, success, sustained success output, product, service, performance, risk, efficiency, effectiveness.

3.8 **Related to data, information and document -** Data, information, objective evidences, information system document, documented information, specification, quality manual, quality plan, record, project management plan, verification validation, configuration status accounting specific case.

3.9 **Related to customer -** Feedback, customer satisfaction complaint, customer service, customer satisfaction code of conduct, dispute.

3.10 **Related to characteristic -** Characteristic, quality characteristic, human factor competence, metrological characteristic, configuration, configuration baseline.

3.11 **Related to determination -** Determination, review, maintaining, measurement, measurement process, meaning equipment, inspection measurement test, progressive evaluation.

3.12 **Related to action -** Preventive action, corrective action, correction, concession, deviation permit, release, rework, repair scrap.

3.13 **Related to audit -** Audit, combined audit, joint audit, audit programme audit scope, audit plan, audit criterion, audit evidence, audit finding, audit conclusion, audit client, audit guide, audit team, auditor, technical expert observation.

Annexure A - Concept relationships and their graphical representation - There are three primary forms .

1) **Generic relation –** Subordinate concepts inherit all the characteristics of it, super ordinate (front) e.g. relationship of steering summer, autumn and winter to season.

2) **Positive relation –** Subordinate concepts within the hierarchy form constituent parts of the super ordinate concept i.e. spring, summer, autumn and winter can be defined as parts of concept year.

3) **Associative Relation –** These are helpful in identifying the nature of relationship between one concept and another within concept system e.g. cause and effect, activity and location, activity and result, Its and function, material and product. The interrelationship is mutual and both sided.

Concept diagram have been given for thematic grouping of clause 3.

References

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2. 1087 - 112000 Terminology work – Vocabulary – Part Theory and application.

3. 3534.2 Statistics – Vocabulary symbols – Part 2 Applied station

4. 9001 – QMS Requirements

5. 9004 – Sustained success of an organization

6. 10001 : 2007 – Customer satisfaction

7. 10002 – 2004 – Customer satisfaction

8. 10003 : 2007 – Customer satisfaction
9. 10004 ; 2012 – Customer satisfaction
10. 1005 : 2005 QMS – Guidance for quality plan
11. 10006 : 2003 QMS – Guidance for configuration management
12. 10007 : 2003 QMS Guidance configuration concern
13. 10008 QM – Customer satisfaction - electronic
14. 10012 : 2003 – Measurement management system
15. ISO /TR 10013 – Guidance for QMS documentations
16. ISO 10010 – QM – Guidance for financial and economic benefits
17. ISO 10015 – Guidance for training
18. ISO/TR 10017 – Guidance for statistical techniques for ISO 9001 – 2000
19. 10018 : 2012 QM – People involvement and complex
20. 10019 – 2005 Selection of QMS Consultant and their senior
21. 10241 – 1 Terminological entries in standards Part – 1
22. 10241 – 2 Terminological entries in standards Part – 2
23. 14001 Environment management system
24. ISO /TS 16999 – QMS for automatic production
25. ISO/IBC 17000 – Conformity assessment – Vocabulary & General
26. ISO 19011 : 2011 Guidance for auditing management system
27. ISO/ITC 27001 - IT Security
28. 31000 Risk management
29. 50001 energy management system 30 IEC 60050-192 Electro technical
30. ISO/IEC Guide 2 – Standardization 32 ISO Guide 73 Risk Management
31. ISO/IEC Guide 99 – Metrology 34 Quality Management Principle.

V. NATIONAL ACCREDITATION BOARD FOR CERTIFICATION BODIES (NABCB UNDER QUALITY COUNCIL OF INDIA (QCI)

1. **Quality Council of India (QCI) –** QCI was set up in 1997 by the Govt. of India and Indian Industry represented by Associated chambers of commerce and enduring of India (ASSOCHAM), confederation of Indian industry (CII) and Federation of Indian Chambers of Commerce and industry of India (FICCI), to establish and operate national accreditation structure and promote quality through National Quality Campaign. It also oversees effective functioning of the National information and Enquiry services. It is registered as nonprofit society with its own memorandum of association. QCI is governed by council of 38 members, equally from Government Industry and Customers. The Chairman is appointed by the Prime Minister of India on recommendation of Industry and Government. The Nodal Ministry of QCI is Ministry of Commerce and Industry – Department of Industries policy and promotion. It functions through executive board in specific areas i.e. Accreditation for Conformity Assessment Bodies, Health care Establishments and Education Vocational Training Providers. It also has exclusive Board for promotion of Quality NBQP. It provides strategic direction to the quality measurement in the country, by securing recognition for India conformity assessment systems at the international level.

2. **Genesis of Accreditation –** Accreditation is a worldwide system for attesting competence and assuring of equivalence of conformity assessment activities, which are testing, inspection and certification (ISO/IRS 17001:2004). It provides for an independent, third party assessment to ensure that accredited conformity assessment bodies have the competence to perform specific tasks. The assessment covers verifying compliance of management system as well as requirements of impartiality and technical competence. This system facilitates trade and reduces technical barriers.

   The certification is third party attestation related to products, processes, systems or persons (ISO/IEC 17000 : 2004).

   There are several benefits of accreditation. These are (i) Attestation of competence by an authorized body (ii) Recognition of technical competence (iii) Customer confidence and satisfaction (iv) Minimize risks (v) Avoids retesting/inspection (vi) Increased efficiency (vii) Marketing advantage and increased business and (viii) International recognition.

3. **Accreditation -** An International Net Work – Accreditation is an International net work managed by International Accreditation Forum (IAF) and International Laboratory Accreditation Cooperation (ILAC) IAF is global association of accreditation bodies, certification body associations and other organizations involved in various fields including management systems, products, services and personal. Its web site usual www.iaf.nu provides information on certification body

accreditation, location of its members, MLA (Mutual Recognition Arrangement) signatories worldwide. IAF provides worldwide acceptance of certification of conformity issued by certification bodies accredited by an Accreditation Body Member.

ILAC is the international authority on laboratory and inspection accreditation with membership of accreditation bodies and affiliated organizations throughout the world. Its website www.ilac.org provides information on laboratory and inspection accreditation as also location and of its members including MRA (Mutual Reorganization Arrangement) signatories worldwide. ILAC promotes increased use and acceptance by industry as well as Governments of the results from accredited laboratories and inspection bodies including results from accredited organizations in other countries.

Both MLA and MRA facilitate mutual recognition of accredited certificates and reports between economies of signatory bodies and to create an international framework to support international trade through the removal of technical barriers.

4. National Accreditation Board for Certification Bodies (NABCB)

(i) About NABCB - NABCB a Constituent Board of the QCI, in the national accreditation body which provides, accreditation to certification as well as inspection bodies in accordance with ISO standards, international requirements/ guidelines and NABCB accreditation criteria (ii) Chain of conformity assessment – (a) International Accreditation Bodies IAF/ILCA (b) Regional Accreditation Bodies PAC and APLC (c) National Accreditation Bodies (NABCB) (d) Certification/ Inspection Bodies (e) The product/Services provider and (f) The customer.

(ii) Policy

(a) It provides service in accordance of with natural and international norms and committed to provide equal opportunity to all the applicants with transparency integrity and confidence

(b) It provides accreditation services to Certification/Inspection Bodies established as legal entities with the SAARC nations. Relevant location in other countries can also be included

(c) It strives for international recognition of its accreditation, schemes through international and regional forums like IAF, ILAC, PAC, APLAC and other multilateral arrangements

(d) The above policy is pursued by complying to the ISO/IEC17011. Conformity Assessment – General Requirements for Accreditation Bodies Accrediting Conformity Assessment Bodies, the international standard

for accreditation bodies and other international/national standards and IAF, ILAC, PAC and APLAC requirements/guidance documents.

(ii) Objectives

(a) To be equally accessible to all applicant certification/inspection bodies wish to be accredited to the NABCB Accreditation Criteria within scope and capacity and within geographical limitations decided by the Board

(b) To upgrade criteria of accreditation in line with International requirements

(c) To be impartial in its decision making on criteria and process of accreditation

(d) To see mutual recognition of the accreditation scheme internationally

(e) To be independent of any undue influence of any stake holder and to conduct its business professionally

(IV) NABCB Accreditation Programmes

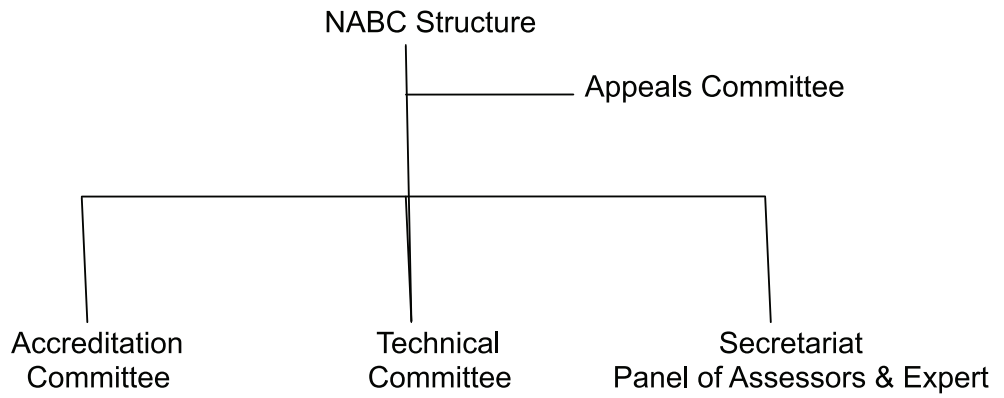
(a) Quality Management System (QMS), (b) Quality for Medical devices (c) QMS for Aerospace Industry (d) Environmental Management System (e) Occupational Health and Safety Management System (OHSMS) (f) Fire Safety Management Systems (FSMS) (g) Inspection (h) Product Certification (i) Energy Management System (j) Information Security Management Systems (k) Information Technology Services Management System (ITSMS) (l) Personnel Certification and (m) Road Traffic Safety Management Systems (RTSMS)

(v) NABCB Accreditation Process

(a) Applicant Body – Application for accreditation (b)Secretarial Review (c) Document Review (d) Office Assessment (e) Witness Assessment (f) Recommendation to Accreditation Committee (g) Decision by Accreditation Committee (h) Issue of Accreditation Certificate (i) Surveillance and Reassessment

Note – At any stage it can be sent to applicant body for Review/Feedback

(vi) NABC Structure



VI. THE DEMING ROUTE TO QUALITY AND PRODUCTIVITY – ROAD MAPS AND ROAD BLOCKS by William W. Scherkenbach- Foreword by W. Edwords Deming

Kiva Books Private Ltd. 4327/3 Ansari Road, Daryaganj, New Delhi -110002.

This book presents Demings fourteen points in the order that makes logical sense to the author.

1. Create Constancy of Purpose

(i) Point No. 1-create constancy of purpose toward improvement of product and services, with the aim to become competitive, stay in business, and provide jobs.

(ii) Most important requirement is how to conduct survey from customers. Four steps in manufacturing are (i) Design the products (ii) Test it in production line and lab (iii) cut it on the market and (iv) Test it in senses –through market research find out (a) what user think about it and (b) why a non user has not brought it.

(iii) If customer driven, team-fueled and even best approach to business that forms constancy of Deming. Team work spirit between marketing and sales and designs, product planning and engineering, is necessary.

(iv) Only top management can establish the constancy of purpose. They make policy, set case values and set the long term course.

(v) Short term measures have long term impacts. They irrevocably make the future. Constancy of purpose affects the opportunities of tomorrow but course needs to be set today. Deming said, doing your best is not good enough, you have to know what to do, then do your best.

(vi) Constancy of purpose (i) Set the course today to be in business tomorrow, and (ii) strive to reduce the spread ….around the course.

Joseph A. Schunpater fett, the questions are always more important than the answers.

2. Adopt the New Philosophy

(i) Point No. 2- Adopt the new philosophy. We are in a new economic age, created by Japan. Western management must awaken to the challenge, must learn their responsibilities, and take on leadership for change.

(ii) As per new philosophy the manager's role is changing. Industry was preoccupied with what their competitors are doing and not what was needed by customer. To look after needs of customer is now philosophy.

(iii) Old believe was, productivity goes down if quality is to be improved. In real sense productivity increases with improvement in quality. It is process improved which increases uniformity of products. In turn market improves and moral of work force. Substantial improvement must come from system – responsibility of management.

(iv) It is to be understood – what kind of work is understood and what is not.

(v) Adoption of anything new is defective, anything that calls for you to give up some of the precepts that you held as dogma is extremely difficult.

(vi) Mr. Petersen realized that meaningful change can only take place from within – Must meet the customer not just the competition; you must changes, not the competition.

3. Cease Dependence on Mass Inspection

(i) Point No. 3-cease dependence on inspection to achieve quality. Eliminate the need for inspection on a mass basis by building quality into the product in the first place.

(ii) Every one of us in business manages process. Every one of us has customers and supplier, and every one of us is both a customer and supplier. We affect the quality of what the ultimate customer purchase. A process is a blending or a transformation of inputs such as people, materials, equipment, methods and environment into outcomes. Some of inputs do the transforming and some of them are transferred. In a organization many processes are interrelated and are process's product is another's input.

(iii) The old, expensive way is managing outcome by defect detection. Good product is sent to customer and bad product is reworked or scraped.

(iv) (i) Teaching adult is more difficult compared to teaching children (ii)Inspite of what is learnt, attempting to detect defects through mass inspections is not good enough.

(v) With input similar/same, outcome will be different all the time.

(vi) Prevention of defects is an improvement over the detection of defects, it is still an attributes – type system. The lack of a negative does not mean that there is strong positive.

(vii) Identify needs and expectation and meeting them consistency is required. Look ahead to outguess the customer; to provide years from now what will appeal to the customer. Through the process of continuous improvement.

4. Constantly and Forever Improve the System

(i) Point No. 5 – improve constantly the system of production and service, to improve quality and productivity, and thus constantly decrease costs.

(ii) Deming Cycle – Recognise the opportunity-Test the theory to achieve the opportunity – observe the test result-Act on the opportunity – and continue cycle.

(iii) Opportunity for improvement is customer – driven process and can be thought as a gap between customer's needs and process performance. So customer and supplier both are to be involved.

(iv) Earlier it was thought that mastering engineering specification was the best one could do.

(v) If the process of continuous improvement will get people to praise your product, what is preventing you from undertaking it (roadblocks on continuous improvement)

5. Remove Barriers of Pride of Workmanship

(i) Point No. 12 – Remove barriers that deprives worker of his right to pride of workmanship. The responsibility of supervisors must be changed from stressing sheer numbers to quality. Remove barriers that deprives management and engineering of their right to pride of workmanship. This means, interalia, abolition of the annual merit relating and management by objectives.

(ii) Performance appraisal system – Major inhibitor (i) It destroys team work (II) it fosters mediocrity (III) it increases variability (iv) It confounds the people with their other input resources and (v) it focuses on the short term.

(iii) The proposal that fosters team work is evolved by looking at three main parts of process, the outcome, the proposal itself and the inputs. For group objective development, (i) Identify your customer's needs and operationally define their critical characteristics, these needs (iii) Determine who can help to accomplish the improvement.

(iv) Instead of focusing on outcome, focus on managing process variable and specify range of outcome. To fast consistency, you have to understand variability. Rating method should recognize the fact that most of the people should be performing within the system. So they can be outside low or outside high as well.

(v) Daily production reports – They put undue pressure on quantity. Waste can be eliminated by giving leaveway to plant managers. Reporting to upper management has to be average out. Most wanted resource in the industry is management.

(vi) In financial management system too much of compartmentation and information are not desirable.

(vii) Quality is to be enhanced by reducing costs. Cost is composed of both visible and invisible figures. The process or procedures is what is carried out and not what is written. Financial tools are just tools and not answers.

6. Drive out Fear

(i) Point No. 8 – Drive out fear, so that everyone may work effectively for the company

(ii) Fear should be removed first. Without an atmosphere of mutual respect, no statically based system will work nor will any other system. Fear aids to wrong type of communication. The fear of knowledge is pervasive in many levels of management.

(iii) You must continue to improve, you must never stop learning. You are never too smart or too old or too important. Anyone who stops learning is old, whether at twenty or eighty. Anyone who keeps learning stays young. The greatest thing in life is to keep your mind young.

7. Break Down Barriers between Departments

(i) Point No. 9 Break down barriers between departments. People in research, design, sales and production must work as a team to foresee problems of production and in use that may be encountered with the product or service.

(ii) Japanese have developed the process as 'Quality Functions Deployment'. Voice of Customer is deployed to, all concerned by K.K. Fables (Koe- means voice and kaker means planning) primary customer requirements are subdivided into secondary ones.

(iii) There is no substitute for knowledge. There is no substitute for knowing your processes and improve them. The true challenge is to get everyone involved in the innovation, everyone recognizing that they each have something to contribute and they can do so in an atmosphere of mutual respect. Only by involvement barriers will break.

8. Eliminate Slogans

(i) Point No. 10 –Eliminate slogans, exhortations, and targets for the work force that ask for zero defects and new levels of productivity.

(ii) 'O.God, I beg! Guide my step/So I do not fall' –written on an extremely risky staircase. 'safety is your responsibility' written on stairs without rating. It is individuals responsibility ? certainty no.

(iii) Slogans may limit variability but are no substitute for knowledge of the process. They are no substitute to tools and methods necessary to help manage the process.

(iv) Electronic updating information stages give greater variability and frustration.

9. Eliminate Work Standards

(i) Point No. 11- Eliminate work standards (quotas) on the factory floor. Substitute leadership. Eliminate management by objectives. Eliminate management by numbers, numerical goals. Substitute leadership

(ii) Start slowly and stress on training. Only then resource will be fully built. At time targets of work standards may be not but not objective.

(iii) Anytime you focus on the outcome and not on the upstream process, you limit your ability to meet your customers at a price they are willing to pay. If the data from the process feedback shows that the target is a part of the system, then the people on the job at least have a chance to resist.

10. Institute Modern Methods of Supervision

(i) Point No. 7 – Institute leadership. The aim of leadership should be to help people, machines and gadgets to do a better job. Supervision of management is overall, as well as supervision of production workers.

(ii) Instead of follow me, managers should state I am behind you all the way. First line of supervisors have toughest job in any organization. They are neither part of management nor part of work force. They do paper work or manage things –they have to manage people. They have to take part in processes so that they can guide. New learning requires learning, training, experimentation and integration.

11. Institute Modern Methods of Training

(i) Point No. 6 – Institute Training on the job

(ii) Japanese provide one year training before any responsibility is given. Training deepens knowledge of subject but it remains untapped if barriers in using knowledge are not removed.

(iii) Inhibitors to training – (i) It is for my people, not for me (ii) It is for manufacturing not for me (iii) Our problems are different here (iv) We rely on our experience (v) Hope for instant pudding and (vi) People learn in different ways.

(iv) Statistical Methods are strong tools, to be used. They help in evaluating specified frames. (i) Control Chart-Actual to be recorded between control limits. It is an economic tool (ii)Flow Diagram-can lead to improvement and understanding of process

(iii) Clause and effect diagrams – They force people to think explicitly about the specifics of their process

(iv) Histograms – Gives graphic information about distribution of individual out come.

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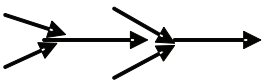
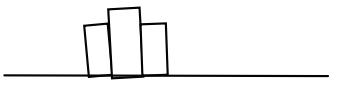
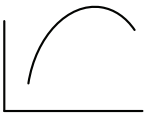


(iv) Histograms – Gives graphic information about distribution of individual out come.



(v) Scatter Diagram – To examine possible relationship between data



(vi) Graphs – To see information and trends on graphs for decision making or otherwise.

(v) Once a process is in central, the real improvement can begins, because of our ability to plan (Deming 1) and then analyze (Deming 3)

(vi) Faguchi defines quality, as the less imparted to the society from the time a product is shipped. He recognises that there is an incremental economic loss for any deviation from a customer – specified target.

12. Institute a Programme of Education and Retraining

(i) Pont No. 13 –Institute a vigorous programme of education and self – improvement.

(ii) Management will recognize the need for education and retaining when they realize that people are an asset and not an expense. Many Japanese companies invest in their people through the commitment to life time employment. In their pyramidal organization structure, their actual staffing exceeds the companies of pyramid at middle and upper management level.

(iii) The 'excess' managers are busy visiting customers, training younger employees, provide social memory needed to sustain the company. What has Japan? Nothing except people and good management. No iron or no oil, no copper, no manganese. Not even wood for commercial purposes.

(iv) One possible approach to work is a stronger industry- university partnership through development of quality and productivity institutes. Areas to be covered may include development of statistical thinking and development of real world perspective.

13. End the Practice of Awarding Business on Price Tag

(i) Point No. 4 – End the practice of awarding business on the basis of price tag. Instead, minimize total cost. Move toward a single supplier for any item on a long-term relationship of loyalty and trust.

(ii) By long term relation, suppliers can invest in future so that nobody replaces them.

(iii) No improvement could be made until management changed the system, specifically the method or procedure that guided other people's action.

14. Put Everybody to Work to Accomplish the Transformation

(i) Point No. 14- Put every in the organization to work to accomplish the transformation. The transformation is everybody's job.

(ii) Stastician has important role to play; he must have (i) Master level Qualification (ii) Five Year Experience (iii) Burning desire to be effective(iii) Ability to communicate at all levels, learn and teach (iv) Ability to teach-Demings.

(iii) Quality is online responsibility and not a staff responsibility. Large staff is not required. Quality is meeting customer's need. There can be other visions, but what is important-they must carry out.

(iv) Middle managers can block the information. The delegation to accomplish task does not emphasize on quality. You can improve some quality only by focusing on process. Without system change, long term improvement are not possible.

(v) Three pronged approach, to implement Deming philosophy (i) training for continually improving (ii) Improve or remove inhibiting management systems which stand in the way of continuing improvements and (iii) Identify opportunities to improve at all levels. Training senior management is extremely difficult because of their superstitious learning. Training is for all levels.

(vi) Training skills are to be used within a few weeks of learning. Time to be split between training and consulting.

(vii) Check list for Demings price is as follows (i) Policy(ii) Organisation and Management(iii)Education and dissemination(iv) Information accumulation and utilization system (v) Analysis (vi)Standardization (vii) Control(viii)Quality assurance (ix) Effectiveness and (x) Future planning. Priority is conveyed by asking questions on different point of Deming.

(viii) It is necessary to work out strategy to involve top mass.

VII. QUALITY ASSURANCE IN CONSTRUCTION by J. M. Duncan, Brain Fhospe and Peter Summer. Gower publishing House Gower House, Craft Road, Aldershot, Horts GU Il 3HL England.

This book is a practical guide for preparation of documents and implementation of TQM.

Preface

The book is meant for real understanding of the requirements and benefits of quality assurance within construction. The requirement of client, design team and construction contractors has been considered in the book.

1. Introduction

1. Quality assurance is a very good management system, company has to demonstrate through audit process that its working practices are applied in thorough manner. Motivation of workforce has to be got around the system. QA will avoid reduced profits, delay, loose of reputation etc.

2. There are failures and cost related errors in construction activity. Reasons being (i) inadequate training of design staff (ii) inadequate or incorrect specification (iii) inadequate division of responsibility (Iv) poor communication (v) Inadequate training of workers and supervisors (vi) Inadequate verification routines.

3. In a project there is never (i) enough time, (ii) enough money and (iii) desire to undertake related activities in comprehensives manner. PQP is t be prepared so that everything move in satisfactory manner. Documentation is to be designed for project specific/ job specific.

2. The Meaning of Quality Assurance

(i) Quality – The best, value for money fitness for purpose complete meaning “the complete meeting of agreed specified requirements”.

(ii) Quality Assurance – Evolution from (i) 1930 – final inspection (ii) 1940-50- quality controls (ii) 1965- controls in engineering design phase (iv) generation of quality standards BS 5750/ISO 9000 – Quality to be achieved consistent in a cost effective manner. These standards recognize that (i) Business is a team work (ii) Management policy for quality (iii) Procedures are required (iv) system to be relevant to recount, QA is a structured approach to business management and control, which enhances the ability to consistently provide products and services to specification, programme and cost.

(iii) Business is judged on performance, the performance is enhanced when there are sound management and control disciplines and effective and efficient working method, implemented through a trained and committed management and work force. This is QA.

(iv) Quality systems is documented expression of management quality policy. Quality system has to be right for the organisation and has to satisfy requirements of quality standards such as IS : 5750. Advice to set up quality systems is (i) Always start from the top (ii) Good working practice to get priority over standards (iii) systems has to be right for you (iv) in value many people for developing system (v) Train all levels (vi) Don't rush for third party accreditation. Be aware of developments in the sector.

3. Quality Assurance Standards

(i) 1979-BS-5750 in 1987-ISO-9000. Status as recorded (which was changed in 2000) is (i) BS – 5750 part 1: 1987 and ISO -9001-1987 – Specification for design/ development, production, installation and servicing (ii) BS – 5750 Part 2: 1987 and ISO – 9002 – 1987 – Specifications for production and installation and (iii) BS – 5750- part 3: 1987 and ISO 9003 – specification for final inspection and test [ISO 9000 and 9004 are guideline documents]

(ii) (i) BS – 5750 Part 1: Covers design – its applicability is for contractors who carry out designs, design consultants, architects etc. (ii) BS 5750-Part 2: documents process control so it is applicable for construction contractors where evidence of interstate inspection is to be given to clients and (iii) BS – 5750 – Part 3 is for organisations setting up management system to control their activity and demonstrate in a client the adequacy of product and service. It is applicable to manufacturing and construction both.

(iii) Analysis of BS 5750 part 1 -1987 – (a) Management responsibility (4:1) (i) for establishing and formally defining the quality policy (ii) organisation (4:1:2) – responsibility and authority (4:1:2:2), verification resources and personal (4:1:2:2) and management representatives (4:1:2:3) (iii) management review (4:1:3) at appropriate level.

(b) Quality systems (4:2) – Organisations documented system to ensure that to make paper work (c) contract reviews (4:3) – to have a formal system (d) design control (4:4) (i) General (4.4.1), (ii) design and development planning (4.4.4), (v) design verification (.4.5) (vi) design change(4.4.6), (e) document control (4.5) – besides drawings and specifications, procedures and

instructions are covered. (f) Purchasing (4.6) – clear specification and capability of supplier. (g) Purchaser supplied products (4.7)– Full control and system of return. (h) Product identification and traceability (4.8) (i) Process control (4.9) (i) general (4.9.1), (ii) special processor (4.9.2) – integrity of measuring desire (j) Inspection and testing (4.10) – (i) in process inspection and testing (4.10.2), (ii) final inspection and testing (4.10.3) and (iii) inspection and test records (4.10.4) (k) Inspection measure and test equipment (4.11) (l) Inspection and test status (4.12) (m) control of non-confirming products (4.13) – feed back (n) Corrective action (4.14) – Responsibility and reference. (o) Handling, Storage, packing and delivery (4.15) – forward planning (p) quality records (4.16) – records to prove application of system at (i) contract offices (ii) design office (iii) inspection and test (iv) quality assurance (q) internal quality audits (4.17)– for adequacy and effectives. (r) Training (1.18) – training and at times necessity t have valid certificates (s) servicing (4.19) – service manuals and schedules (t) statical techniques (4.20) – to verify process or product characteristics.

4. Developing and Implementing a QA system

(i) Establishing awareness – Top of company to agree for the system. Necessary for competition. It can being improvement in business performances. It should be done whole heartedly, giving priority to system development and by committing resources.

(ii) Widening the awareness – support of senior and middle management is necessary. A one day awareness programme is necessary to address (i) what is QA, (ii) How it help (iii) significance of BS 5750 (iv) Preparation of a system with management role (v) widening commitment (vi) cost effective use of QA, (vii) review and audit techniques and (viii) ongoing improvement.

(iii) Quality manuals – can have a multi-tier hierarchy of manuals such as

(a) Policy manual – (i) index (ii) company profile (iii) amendment record (iv) policy statement (v) statement of compliance of chosen quality standards (vi) company organisation structure figures are descriptive test (vii) index of manual (b) Departmental / descriptive manual – (i) index (ii) amendment record (iii) supporting instruction (vi) specimen of documents (c) Can further have support instruction and standards documents.

(iv) Company profile, amendment history sheet, policy statement and compliance are detailed separately. Besides organisation and responsibility information to be given describing interface of departments. Thereafter each department should have further details of its control chart.

(v) Procedures – write down what you do. Then ask why, how, alternative etc. Then see relevance with BS 5750. Adopt common document formats for front and continuation pages. Also formats should contain (i) title (ii) unique reference number (iii) page no (iv) issue status (v) the status. The front page to include signature of authorisation and signature of QA acceptance. There has to be consistant style for presentation. Procedure is a higher tier document compared to instructions.

(vi) compilation of information is to be done after all data is checked, authorised and incorporated in draft manual.

(vii) Introduction of system is not to be imposed. If should be introduced progressively. Draft information should be put to practice on trial basis only. Participation will encourage commitment. Introduction should be through proper source.

(viii) System review is necessary after installation. Review has to be by management and there has to be internal audit. Managers to review as per their own system to understand as to how change is working.

(ix) The internal audit is of two types (i) internal systems audit and (ii) project audit. Audit to ensure that there is (i) management system, (ii) understand by those who perform and (ii) really put up practice. Audit should be an aid to management, should be carried out by trained person. Task includes, audit schedules, audit reports, auditor performances, conveying and recognizing the audit message and corrective action follow up.

(x) The selective use of the system is necessary as it has to bring about cost effective performance. Gradually it is necessary to ascertain, the extent to which requirements of BS 5750 are being fulfilled. Decision should be recorded on suitable performa showing questions, answers, those involved, determination level, date of evaluation, signature etc.

(xi) Quality programme and quality plans indicate effect of quality system specific to a project or major contract. Detail quality plan is used to control activities on discrete packages.

5. Quality Assurance and the Client

(i) Client, consultant and contractor must play their part and they should be know what their part is. It should be understood that customer is the one who receives output. It is necessary that definitive specification is applied from the very beginning. If a client is a large organisation and sets up a project team, the QA is to be applied in specified manner.

(ii) Project team to have a nominated quality engineer and his duties are to be agreed. He has to undertake all connected issues with system and interface also. It is to be established as to how (i) project is to be managed with responsibility (ii) procedures to carry out tasks and (ii) compilation of O & R information, procedures, manual etc. Thereafter work packages are to be assessed and consultants/contractors invited. They have also to submit their QA capabilities. These are to be assessed. During implementation, number of functions are to be assured by QA engineer. This includes proper application, audits, works, review, finish, final hand over records etc.

(iii) Clients not having QA to ask internal question on How, What, Why on their capabilities. QA training is called for, for proper understanding. It is profitable to follow QA

6. Quality Assurance and the Design Team

(i) Procedures most appropriate for a company are those which are tailor made after accounting for specific need of a company. Other documents like BSI schedule are to be referred.

(ii) A system development team is to be formed with those who will be responsible for the implantation. Team to understand provision of BS 5750 to be implemented.

(iii) Establish the system structure. This team should record chronological stages by which a project is received and dealt. All stages, steps to implementation are recorded. Thereafter the structure of the system is designed to accommodate all steps. Important points are (i) a formal contract (ii) procedure of site surveys (iii) procedure on concept designs (iv) individual activities to be seen during execution. For this propose PQP is necessary. Procedure to be developed for (i) flow of data (ii) design calculation drawings (iii) bill of quantities (iv) control of contact. The typical menu to cover substantial proportion.

(iv) A sample system structure is to be worked out from policy statement to contract completion stage. Items covered are as follows (i) company

organisation and responsibilities (1-2) – Quality assurance manager (ii) training (1.3) (iii) Contract review and concept designs (2.1) (iv) Preparation of PQP (2.2) – scope of work, project organisation and responsibility, project management, client project review, verification and approval, project quality procedure, design basis and programme, project phasing, project review schedules, records and retention period.

(v) Control of data records (2.3) – all type of data (vi) control of design base information (2.4) , (vii) design control (2.5) – scheme prepared preparation, design calculation, verification and approval, document issue, charge control and feedback (concessions and corrective action (viii) preparation of detail drawing (2.6) (ix) contract cost measurement (2.7) (x) control of records (2.8) (xi) preparation of specifications (2.9) (xii) concessions and corrective action (2.11), (xiii) review of QA system (2.12).

(vi) (xiv) Placing contracts (2.13), (xv) writing and controlling work instructions (xvi) control of sub contract (xvii) equipment calliberation (2.16), (xviii) document issues (2.17), (xix) the use of computers (2.18), (xx) contract management (2.20).

(vii) Using the quality system – company promotion, tendering, project management.

7. Quality Assurance and the Construction Contractor

(i) Three main type of contractors having interface with the client. These are (a) Turnkey contractor client employs, projects manager and he is having construction contractor i/c subcontractors (ii) design team and (iii) architect, (b) independent contractors – client employs a team of project manager/architect/consultant engineer and this team employs contractors A,B,C,D..... (c) Construction management – contractor and consultant are independently employed by the client.

(ii) The contractors responsibilities as usual as per contract and also has operation capability of QA system. His QA activities are to be identified at tender stage.

(iii) Receive enquiry – Besides technical specification, QA conditions are also received. These QA conditions request contractor to provide documentary evidence of management capabilities in QA. The first contract review will also include QA requirements.

(iv) Contract review is carried out after award and in setting up of contract team, QA engineer is provided to report directly to project manager.

He has responsibilities for QA plans, programmes, monitoring subcontracts etc.

(v) Preparing a Quality programme (PQP) project related quality assurance manual. It has to include from policy statement to audit schedules (all stages). it has to be approved by the client.

(vi) Placing subcontractors on the basis of list available, with known history. Subcontractors are to be contracted. Detailed quality plan (PQP) are required to control sub package. There have to be system for goods inwards inpection and on site control of sub contractors.

(vii) Use of the Quality programme as on site is necessary for control. It includes the organisation and responsibilities as also procedures, introduction/ method statements covering the important construction and installation activities number of other instructions as per BS 5750 -2 are also covered, from 4.5 to 4.18 subheads.

(viii) Preparation of quality records – As per PQP all records are required. It can be pre decided as to how records are to be kept like (i) hard copies (ii) micro films (iii) combination of two.

(ix) A sample specification for precast concrete block is given including performa to control all the activities.

8. QA Interfaces (Summary)

Flow chart is given which identifies activities to be undertaken for QA system by client, Design consultant and contractors. Their interface is also described.

VIII. TOTAL QUALITY IN CONSTRUCTION PROJECT :- Achieving Project Ability with Customer Satisfaction – Ron Badan Hellard - Thomes Jelford London 1993

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"When you can measure what you are speaking of, and express it in numbers, you know that on which you are discovering. But if you cannot measure it, and express it in numbers, your knowledge is of a very meager and unsatisfactory kind."

Lord Kelvin

Introduction

1. First quality assurance standard of U.K. is Quality System (B.S.5750)

2. Overriding philosophy for success is improvement of overall performance of an organization

3. Quality assurance is not synonymous with paper work systems – Paper Work Systems are not synonymous with B.S.5750 –B.S.5750 is not synonymous with certification.

4. TQS must start at the top – in construction industry it must start with building clients.

5. Auditing has a major role to play in effective and continuous improvement of projects

6. Third party certification is inappropriate and not cost –effective for most of the construction projects.

Definitions

Assignment register (DTI-QA register) – certification-QMS or product confirmity or Product approval, certifying body, defect, Non confirmity, product or service such as a service computer programme a design direction of use – provisions of service or executions of a product, Quality, Quality Assurance, Quality Audit, Quality Control, Quality Loop, Quality Spiral, Quality Management, Quality Management System, Quality Plan, Quality Policy, Quality Systems Review, Registered firm, Reliability, Traceability.

1. Evolution of Total Quality Management

(i) Customer satisfaction is inseparateable from business goals.

(ii) TQM is third industrial revolution –two main streams are scientific management and that of quality.

(iii) Taylor and Gilbgeth at the end of 19th century applied their mind on methods, machines and materials.

(iv) Quality stream – inspection of finished goods – Quality Control during and at start of production –Quality assurance needs systematic examination of documentation – Work of Design, Cross by Juran and Feigenbaum, they emphasized importance of monitoring, through audits to never ending process of improvements.

(v) Designing Contribution – Red bead exercise and tunnel experiment and chain satisfaction. 14 points- consistency of purpose, outlaw mistakes and have team work, Quality by process improvement, purchase best quality, improve system, institute training, institute leadership, drive out fears, break barriers eliminate slogans, eliminate numerical quotes, remove barriers to pride of workmenship, vigorous education and training and action to accomplish change, Also Demings seven deadly diseases.

(vi) By Philip Graspy –Quality is goodness, prevention, zero defeat, quality to be measured by non conformance.

(vii) J.M. Juran – handbooks, Juran biology, Quality planning, Quality Control and Quality Improvement

(viii) Others include Kaqru Ishikawa

(ix) Common Philosophy – Analytical evaluation of work process, development of quality culture and empowerment of employees cultural changes needed – There is Boeting modal for process improvements.

(x) People participation and teamwork –Quality Vocabulary ISO 8402, defines a way of managing an organization which aims at the continuous participations and cooperation of all its members in the improvement of the following –Quality of product and services –Quality of its activities –Quality of its goods.

2. Applications of Quality as a Management Process in the Construction Industry

(i) Evolution of functional relationship and operational grouping in firms engaged in quality, client, engineer, supplier, architect, contractor etc.

(ii) Conflicting elements of construction project are function, aesthetics, cost and time.

(iii) Project requirements - firmness of tender and need of cultural changes.

(iv) Management to combine mathematics and physical sciences with the human sciences of people and their relationship.

(v) Functions of manager, clients role management responsibility pyramid.

(vi) Process of accepting Instructions.

(vii) Management and Motivations- Maslow's Hierarchy of human need – physiological, safety, Social, Ego and self realization.

(viii) Cultural and group influence on individuals by family, workmates, church, state, employer, unions, friends.

(ix) ISO 9000 to construct –uniqueness, time difficulty, unique people relationship, Feedback, costs conflicts, lack of client experience, Nature of Contract.

(x) Audit first party the contractor –second party the owner (client).

(xi) Bench marking for TQM – of construction commitment, planning, Action and Evaluation.

3. Contractual Options and Integration with Quality Systems

(i) Two specific applications in construction projects – (i) Second party audit on a pre-contract but project-specific basis for all organizations involved and (ii) adjudication by third party assessment to make an interim award on claims to keep teamwork spirit.

(ii) Third party certification is misleading

(iii) Different types of contract forms.

4. General Application of Total Quality Management to Construct Projects

(i) Client has to establish an organization frame work and project quality system

(ii) Quality standards to be specified in project documents and reference to ISO 9000 can be confusing.

(iii) International Council for Building Research Studied and Documentation (CIB W.88) developed relevant guidelines for Quality in Construction and not ISO 9000 CIB quality loop is more relevant.

(iv) ISO 9004 - 2 Quality Management and Quality System elements guidelines for services is excellent for respective jobs but still relevant to TQM. Key elements for quality system in buildings contracting firms can be correlated to ISO 9004-2.

5. Total Quality Management

Its philosophy and principles for the building clients at the project inception stage.

(i) Building client to be involved in total QM.

(ii) Building construction project is very complex. It needs clients functional, ecstatic, cost and time requirements to frame quality plan. It is also necessary to know human motivation and behaviour according to contract condition

(iii) To judge costs on consideration of technical failures and dissatisfaction –so aim is quality

(iv) Client to know roles of other members of the team and importance of second party auditing skill a pre-employment audit is required for firms to be involved in project.

(v) Harmonization of objective is necessary

6. Total Quality Management and the Design team through the Project Design Phase

(i) Project specific audits are necessary for organizations that will make project team.

(ii) Nature of authorities which control the project without responsibility, to be reorganized.

(iii) Client to participate for total quality.

(iv) Questionnaire to be developed by design team for contracting firms as per Appendix.

7. Total Quality Management and the Contractor Pre Contract and Post Contract

(i) The contractor to be presented with project management plan and manuals. The contractor after referring his corporate quality plan will develop his own plan and management system. Work procedure can have sections (i) Preparation of tender (ii) Award of Contract (iii)

General procedures for control of contract document (iv) Procurement (v) Construction phase. This is departure from ISO 9004-2.

(ii) Subcontractor assessment system should be developed. It has to be ISO 9000 plus TQM. Subcontractor having TQM can be even listed by owners.

8. Project Quality Management for the Specialist Subcontractor

(i) Subcontractor having ISO for product may be available but erection is also to be included in certification.

(ii) Sections 4 of ISO 9001 has 20 principal headings for the quality assurance system (i) Management responsibility (ii) Quality system (iii) Contract Review(iv) Design Control (v) Document control (vi) Purchasing (vii) Purchaser – supplied products (viii) Product identification and traceability (ix) Process control (x) Inspection and testing (xi) Inspection, measuring and test equipment (xii) Inspection and test statics (xiii) Control of non – confirming products (xiv) corrective action (xv) Handling storage, packing and delivery (xvi) Quality record (xvii) Internal Quality (xviii) Training (xix)Servicing and (xx) Standard techniques.

(iii) ISO 9002 has appropriate amendments and design is omitted.

(iv) ISO 9003 is limited to final test and summaries.

9. Total Quality Management during Commissioning and Maintenance

(i) For buildings with multiple services, time and cost of commissioning are under estimated. A commissioning engineer is necessary to coordinate. He should understand every detail in which plant is likely to work.

(ii) Quality Management to develop earlier attentions to this integration

(iii) At turning the plant stage 100% success is expected. It is not possible so commissioning engineer is required. All services are to be balanced, when commissioning is done. In ship and aircraft, this practice is prevailing .

(iv) Commissioning is easy, if at construction stage precaution are taken from (i) Resolution of design interface (ii) All drawings completions before installation (iii) Single plant reference on plant technology and (iv) Engineer for collaborative support in construction.

(v) During Commissioning Steps needed are :-

(i) Subcontractor's testing documentation and handling over to main contractor

(ii) General Contractor confirmation and documentation for handing over

(iii) Engineering consultant confirmation and documentation

(iv) Activities confirmation and documentation

(v) Acceptance by the clients facilities manager

(vi) Handing Over to include service and maintenance instructions for each service at the stage of practical completion. In all 500 set of documents needed.

10. First Party Auditing

(i) Activities of an organization are to be carried out through a management system. There has to be interface between departments and processes that should be controlled. A diagram for overall processes carried out by company is required. There has to be as usual review audit.

(ii) Every organization has four areas of activities, to be coordinated in overall system. These are, (i) marketing (ii) production-carry outwork (iii) administration and (iv) strategy – the principal concern of directors. These instructions and interfaces are to be listed in diagrams. Diagrams illustrated are necessary and part of QMS.

(iii) Identification of activities and documentary recording of procedures through overall process is necessary through State-of-art-audit and identify, (i) gaps is system (ii) Linkage between sub systems and (iii) create procedure/forms to bridge the gap. Those who follows undocumented procedures should be asked to document, for developing forms.

(iv) First Party by one who is not responsible for activities- it has to monitor the conduct of the system. Audit can be done by one branch people on other branch, Effort should be made to avoid over documentation. Requirement is to create a system and net get ISO. The British Standards guide for quality systems audit is B.S.7227.

(v) Second Party audit to limit to the extent of involvement in the project, before award of contract.

(vi) Self Assessment is most important. TQM delegates responsibility to lowest levels following X and Y approach of Mcgyor.

11. Second Party Auditing Pre-Contract

(i) It aims at conveying to all that TQM has been developed and followed and will have affirmed from those firms who will be involved. This is to be undertaken, as per system provided, for firms who will make up project team.

(ii) Philosophy, commitment, attitudes, practices and procedures must start from top –the client so it is second party for design team, contractors, subcontractors, Client to have designated Project Manager.

(iii) At inception Stage, the client has to appoint a project management team. The terms of reference are brief for this team. Only thereafter the design – process can begin.

(iv) Briefing to design team by Client, at times represented by several people, is difficult task. Relative importance of technical, aesthetic, cost and time should be accessed. Thereafter feasibility study and brief document are made. Organization structure –Combination of professional and commercial relationship for optimum results. All the problem of communication, motivation, competences and skills, quality standards and availability of resources to be additional.

(v) At conceptual stage, briefing of document is necessary. It should also give salient information to auditors. Second party to describe scope of the projects , Model document to carry out second party audit is developed. For first visit of auditors, questionnaire has been developed.

12. Auditing Works in Progress

(i) TQM should be exercised from the conception of the project and not to be instigated by contractor. The issue of line management authority or policing by a quality manager will have to be resolved.

(ii) QMS of contractors and subcontractors are subjected to precontract audit. Subcontractor audit should be for TQM and ISO certification is not enough.

(iii) The first audit on site should be conducted to see that all planning work is consolidated with the site manager. The checklist is given in Table. Quality has to be management responsibility for general contractor and subcontractors. Traditional monitoring by Architects, Surveyors and Consulting Engineer should provide external monitoring and to go for third party adjudication.

13. Contact Management Adjudication : The Final Step in Project Management

(i) It is important to continue harmony between parties in conflict situation when these problems arise. The cost of adjudication is to retain harmony without prejudice to any of the party's ultimate legal rights of redress. It will add value and reduce cost of quality by subsequently reducing cost of disputes and subtracting the negative value of legal fees.

(ii) Project quality philosophy, principles and procedure to start from top and at beginning of project to develop confidence and team spirit. Objective to client requirement to be achieved in terms of functions, according to cost and time to achieve objective, changes are necessary which give rise to 'claims', which leads to disputes. So philosophy of TQM and arbitration evolve control management adjudication, of course TQM avoid all the problems of dispute.

(iii) Dispute, arbitration, court cases cost is heavy. Value of construction claims 7% of value of project. If all other is added it is very high. TQM will avoid heavy costs. It is preventive medicine.

(iv) Third party adjudication is operating technical part of arbitration and giving adjudicator, greater freedom to intervene. This roles is like a cricket empire. Normally to intervene only when asked. He has to observe 'no balls' and offences against rules that might go unobserved or cause dispute. It applies to supplies as also indemnifying insurance campaign. By adjudication most important resource i.e. management time is not wasted much. It is cheaper.

(v) Arbitration/Litigation have disadvantages (i) time lag (ii) expert opinion at later date (iii) documentation is time consuming (iv) solicitors, advocates and experts cost (v) Legal views prevail over technical views. Adjudication has further been evolved and 'mini trial' /'pre trial' review are held by legal experts on informal basis. Outline procedure evolved by polices – outline given in sketch.

(vi) Purpose and Procedure are clearly understood and defined. Gaps are identified. Brief is to be maintained by adjudicators.

(vii) Model Clause:- TQM and CMA do not need major changes in contract form, Besides normal Clause, the appointment of company for adjudicator can be mentioned.

14. Conclusions and Action Plan for Quality Projects

(i) TQM- the third industrial revolution apply to construction projects.

(ii) Philosophy of team work and co-operation are due competition has to continue

(iii) Gradual improvement is necessary

(iv) Education and Training in team work are necessary. Management is a discipline

(v) Monitoring of performance by quality auditing. First party auditing and second party auditing for project specific.

(vi) Third party auditing to be for project defined standards.

(vii) Third party auditing not by involvement

(viii) Progress by management and leadership, business goal is inseparable from Costumer satisfaction.

(ix) Companies to document procedure and system

(x) Produce continuous improvement - “Joy of Work’ has to arrive-Deming.

IX. ROLE OF BIS IN MANAGEMENT SYSTEMS CERTIFICATION

1. Only BIS Operates its Management Systems Certification under an Act of Parliament, with BIS Act 1986 and BIS (Certification) Regulations 1988. Besides, for it is accredited by NABCB, QCI Management Systems certification scheme are operated by BIS for several IS/ISO standards, which includes, Quality Management System(ISO 9001), Environmental Management Systems (ISO 9001), Environmental Management Systems (ISO 190001), Hazard Analysis and critical control point (IS 15000) etc. as also Integrated Management System to different IS/ISO.

2. Management Systems Certification Policy (MSCP) – It offers certification services to all organizations according to ISO/ISC 17021. These services are provided to all sections of private and Government. It is committee be continually improve quality, services, protect environment, occupational health and safety of employees including food safety. Each activity of operation leads to excellence thereby enhancing the credibility and image of BIS.

3. Policy for operation of the scheme as per MSCP is made by Management Systems Certification Department (MSCD). The certification is done by regional offices. DDGs are granting and renewal authorities. Coordination is done by Regional offices. Certification to foreign organizations to be done by MSCD.

4. Auditing Personal – There are BIS Auditors, BIS Experts, Registered External Auditor, Registered External Experts. Designated Personal and Training Officer at MSCD carries out selection, registration, maintenance and up-grading auditing personnel.

5. MSD Documentation – The quality manual is approved by DG. Guidelines, procedures and forms are approved by DDG in charge. The certification system conforms to requirements of ISO 17021.

6. Road Map for ISO 9001 Certification – (i) Understand the philosophy and requirements of IS/ISO 9001 (ii) Interpret the requirement with reference to functioning of organization, (iii) Organize training - BIS training wing can this job (iv) Appoint Management Representative which can do this job (v) Appoint Management Representative with responsibility and authority (vi) Develop document such as Quality Manual, Procedures, Work Instruction, Formats as applicable to organization (vii) Implement the system and make connections in the document as required (viii) Monitor the Implementation through internal audit for which Auditors are to be developed by training (ix) Corrective actions are required based on internal audit report/observations (x) Management Review (xi) Complete the actions as a result of Management review and (xii) Apply to BIS.

7. Process of Management Systems Certification – (i) Submission of application (ii) Scrutiny by BIS - can be rejected or returned for correction and resubmission, thereafter submitted for (iii) Adequacy audit (iv) Preliminary visit and corrective action if required (v) Audit Team appointment (vi) Audit (vii) Audit Report – If unsatisfactory take corrective action and submit audit team to reprocess (viii) Recommendations for Award of License (ix) Granting of Licenses (x) Surveillance and (xi) Renewal.

   Thereafter BIS's QMS logo is given for IS/ISO 9001 and EMS Logo is given for IS/ISO 14001.

8. Terms and Condition of Licenses - (i) Granted for Three Years, (ii) To be followed by annual surveillance audit (iii) The Third audit shall be the renewal (re certificate) audit and (iv) The Third surveillance audit may be clubbed with renewal audit, if required.

9. Privileges of Licensee – (i) Multiple certification system through one audit (ii) Display of Original Management System Certification (iii) Use of standard mark on letter heads, advertisement brochures etc. Not to be applied on product or its packaging, to avoid the impression that product is certified by BIS (iv) Each Licensee to be in register of Licenses maintained by BIS.

10. Strength of BIS MSC Activities – (i) National standards body (ii) Backed by Act of Parliament (iii) Founder member of ISO (iv) Offices in important cities (v) Qualified Auditors and they have exposure to industry.

11. QMS in Construction Industry – (i) Quality Manual for entire construction activities covered by industry is to be prepared and (ii) Quality procedures for different activities to be prepared like foundations, excavation, basement, plumbing, electrical connection, sewerage, flooring, walls, ceiling, roofing etc. (iii) Quality Guidelines to be prepared for ensuring compliance of various procedures, activities and quantum required (iv) Quality formats required for recording maintaining of various activities/performance like, foundation, plumbing, electrical, sewerage etc. (v) Documentation may vary for different organization.