UNIT 14 QUALITY CONTROL DURING CONSTRUCTION

Structure

14.1 INTRODUCTION

In any construction activity, it is expected that tlie end product will function as expected by the designer. This necessitates that some sort of check is maintained at each stage of the work so that any shortcoming may be removed as the work proceeds. The quality of the work needs to be checked.

In this unit, you will learn about the various aspects of quality control during construction of a facility.

Objectives

Alter studying this unit, you should be able to

- define quality control and discuss the economic objectives of quality control,
- describe field quality control and explain the ways and means of achieving field quality control,
- explain the advantages and disadvantages of contractor quality control,
- appreciate the importance of incentives and penalties clauses in specifications, and
- workmanship as a mark of quality.

14.2 QUALITY CONTROL

The actual quality of construction depends upon the control of the construction itself. Construction quality control includes quality of workmanship, inspection, material testing, surveying, contractor drawing approval and other similar functions.

14.2.1 Advantages and Disadvantages of Quality Control

Advantages **of Quality Control**

The advantages of quality control are as follows :

(a) improved understanding of the construction process by the supervisor charged with the control of quality,

(b) greater effort by contractors to seek more qualified men – and also contractors are encouraged to deal with good and more capable suppliers, and

(c) windfall savings through the availability of technical information – less delay in testing; ability to fit the inspection process to productidn needs.

Disadvantages of Quality Control

The disadvantages of quality control are as follows :

(a) resistance to change on the part of both parties – tlie designer and the constructor, and

(b) duplication of effort – both manpower and equipment.

After the level of quality has been established by the planner and designer, it is defined in tlie contract documents. These ideas are converted into reality during tlie construction process. This always involves testing of materials and equipment plus inspection of procedures and workmanship by someone and to some degree.

If tlie desire of both the owner-engineer and the contractor is to work together to build a quality structure, then it is likely that quality will result.

14.2.2 Communication

An essential part of maintaining quality in tlie actual construction is good communication. It is essential both to properly convey technical matter and to foster positive attitudes. Communication in its best form is a dialogue : engineer and contractor talking and listening to each other. Another valuable source of communication is in the discussion, in prebid meetings, of the work to be perforined.

The question of the division of responsibility for quality control in construction is a basic one. Engineers and contractors feel that quality can be achieved more effectively and more economically if the contractor is given more quality control responsibility.

14.2.3 Quality Control and Quality Assurance

Both the terms : quality control and quality assurance are used. For instance, checking reinforcement placement in a concrete structure may be characterised as quality control if the contractor does it or quality assurance if tlie owner does it and yet tlie physical act of checking is exactly the same. While the contractor's inspector would check the bar locations as they are being placed, the owner's inspector would only check random bars after the placement of a group of bars was complete.

14.2.4 Internal Quality Control Program

To monitor ongoing construction projects, many corporate owners and public organisations establish their own internal quality control programs. In case of continuous construction programs or very large and complex projects, the owner may have, within his organisation, a functional department that employs trained personnel and develops standards for the application of quality control in the field.

14.25 Consultants for Quality Control

Specialised consultants may sometimes be hired by owners to provide field quality control service. The consultant, in this context, is a technical firm such as a testing laboratory, specialised consulting engineer other than the designer, or construction management firm that renders quality control services.

On extremely complex construction or on projects that have specialised and highly technical, stringent quality control requirements, such consultants are frequently engaged. These firms-are absolutely independent of the engineer and tlie contractor and are usually hired before the design is completed to provide advance quality assurance input and advice.

SAQ 1

(a) What factors are included in construction quality control ? What are the advantages and disadvantages of quality control ?

(b) What is meant by communication and why is it essential in construction ?

(c) What is the difference between quality control and quality assurance ?

(d) What do you understand by internal quality control program ?

(e) Why are consultants employed for quality control ?

14.3 ECONOMIC OBJECTIVES OF QUALITY CONTROL

The objective of any manufacturing process or construction is to obtain the item or structure at minimum cost while maintaining the quality of the product so tliat the life of the product is extended as much as possible. Economy lies in obtaining the maximum life; output or benefits at least expense to the owner.

A very important feature of a good quality control program is that better quality and lower costs go hand in hand. Why this is possible is clearly seen as soon as the lrue character of these categories of quality control is considered. These categories are as follows :

(a) Failure **costs,** which are caused by defective materials and products that do not meet the owner's quality specifications. They include such loss elements as re-work scrap, field complaints due to non-performance as per requirement, and spoilage.

(b) Appraisal costs, which include **the** expenses for maintaining quality levels by means of formal evaluation of product quality, This involves such cost elements as inspection, testing, oulside certification and quality audits.

(c) **Prevention costs,** which are for the purpose of keeping defects from occurring in the first place. Included here are such elements as cluality control engineering, employee cluality training, and the quality maintenance of products and plants.

The economic objectives of cluality control by the contractor are as follows :

(a) savings through the reduction of rejects,

(b) savings through a closer approach to design standards rather than greatly surpassing them, and

(c) savings Io the owner and user through the creation of a better product at no added cost.

Savings will result when

(a) the traditional views of the men on the project gradually with the passage of time,

(b) contractors meet the challenge with better trained supervisors,

(c) specifications are improved through trial and error, and

(d) contractors find that effeclive control of quality improves profit.

SAQ 2

What are the economic objectives of quality control and how are they achieved ?

14.4 FIELD QUALITY CONTROL

Tlie basic instruments, equipment and facilities required for a field quality control program will depend on the mission and services expected from the quality control team or laboratory. The problems facing most laboratory managers are those of justifying tlie necessity for equipment to satisfy the occasional need, evaluation of its projected utilisation, and its availability in other sections of the project. In addition, they must consider the effects of non-performing a specific test and the floor space and other services required for operating the equipment or tool.

Projecting the total manpower requirements for a field quality laboratory poses a difficult problem. As a service organisation, manpower requirements are subject to wide fluctuations, because of the impact and priority of other constructional activities. The normal support efforts required of a field quality laboratory for product control can usually be well planned and managed with a minimum of effort after the initial planning stage when occasional peaks occur in tlie total work load, management by priority is a necessity. Each job must be evaluated and assigned a priority rating to ensure that the most important jobs are given precedence.

Field quality control involves

(a) the desire to do well all of those things which must be done,

(b) seeking out new and better ways to accomplish a given task,

(c) the intelligent application of experience,

(d) pride in one's effort,

(e) favourable consideration for future business to the contractor, and

(f) happiness and satisfaction to the owner in knowing that he is getting what he is paying for.

SAQ 3

What are the features of field quality control ?

14.5 ACHIEVING FIELD QUALITY CONTROL

Planning for achieving quality control in the field is a must to deliver satisfactory quality at minimum quality cost,

Many different pieces of work must be performed by many people and in a certain time-phased sequence. Different techniques are used in accomplishing the work. Therefore, the development of a quality control plan is based on using the results of the techniques of analysis progressively to the answers of the following questions :

(a) What specific elements of a quality work need to be done ?

(b) When, during the construction, does each element of structure need to be done ?

(c) How is it to be done; by what method, procedure or equipment ?

(d) Who does it and what is his position in the organisation ?

(e) Where is to be done; at what location – whether in the workshop, on the structure, in the laboratory, in the field whether the supplier does it or the owner's representative does it ?

(f) What tools, equipment or instruments are to be used ?

(g) What are the inputs to the work ? What is needed by way of information and material inputs to get the structure completed ?

(h) What are the products to be obtained to do the testing ? Do any decisions have to be made ? What are they, and what criteria should be used for making them ? Does any material have to be identified and routed ?

(i) Is any record of the action to be made ? If so, what is the form of the data ? What kind of analysis is required ? To whom is it sent ? What form of feedback is to be used ?

(j) Are there alternative procedures to be taken, depending on certain differences in the product quality encountered ?

(k) Is any time limit imposed on the work ? If so, what is it ?

Many more such questions are developed as the planning assumes a finer degree of detailing. Finding answers to these questions and following them in the field will help in achieving the desired quality control in the field.

Quality control in the field can be achieved by

(a) developing within the owner's organisation the technical and practical expertise necessary to define the quality requirements for each facility, in terms that can be understood by the design organisation and field management,

(b) producing clear and accurate models, drawings, details, and specifications in the design office, with proper considerations for construction in the field,

(c) involving contractor's field management personnel in construction reviews, as the design progresses,

(d) insisting on the procurement of quality materials of construction,

(e) emphasising the need for careful protection of materials and equipment in the field, in storage and handling and after installation; and by providing the contractor with the information necessary to accomplish this,

(f) encouraging studies to determine the best methods of construction and the right tools and equipment for the job,

(g) keeping abreast of the latest developments in equipment and techniques for determining quality in the field and seeing that the contractor is aware of these where appropriate,

(h) insuring that the contractors recognise their responsibility for the quality control function and provide proper staff to make it happen,

(i) assisting contractors in establishing effective, on-site quality control programs,

(j) frequent visits to the field by technically competent and experienced personnel, to review the contractor's quality control records and procedures and to willingly assist in a team effort to solve problems when unusual conditions are encountered,

(k) providing competent residenl engineers who are prepared and authorised to exercise sound judgement when quality problems arise,

(1) requiring contractors to insure that every potential subcontractor thoroughly understands all of the quality requirements and objectives of his part of the work, before an award is made,

(m) establishing a feedback to the design organisation that will make it possible to benefit, on future projects, from difficulties encountered in the field, due Io particular design details, and

(n) involving the appropriate design representative in the solution of problems encountered by the field personnel.

Ensuring Quality Control in the Field

During field construction it should be ensured that the work accomplished is in accordance with the requirements specified in the contract. For tliis, quality control is a must. The quality control program checks whether the contractor coinplies with the standards which the engineer establishes as his criteria for the construction. The field quality control program includes inspection, testing and documentation for the control of the quality of the materials used, workmanship of the craftsman, and the methods employed by the contractor. The quality control program on any project may be administered by the engineer, owner, consultants, prime contractor, or construction manager. The quality control inspector is not authorised lo give directions, render interpretations, or change the contract requirements, The role of the inspector is not to manage the job, direct the work, or to relieve the contractor from any of his obligations. The inspector cannot tell the

contractor what to do or how to do a job, nor can he interfere in field operations except to prevent something from being done improperly. The inspector is required to observe the construction process and ensure that the contractor complies with the contract provisions.

SAQ 4

(a) How can you achieve quality control in the field'?

(b) How can you ensure quality control in the field?

14.6 PROMOTION OF QUALITY CONTROL IN THE FIELD

Promotion of quality control in the field is possible when the persons in charge of assessing tlie quality of work clone are different from those who are actually getting the work done. It is not possible for the person in charge of the construction to be ascertaining the quality at each stage of operation. Since the in-charge of the construction is set with some target or outputs to be achieved there will be a tendency for him to overlook tlie quality or he may comprise on the quality. Both the aspects are detrimental to the safety of the structure.

After completion, if the structure fails lo meet the requirements of the owner, either the defective portions have to be dismantled and re-laid or if that is not practicable, lower the capacity of tlie final structure. In eitlier case, there will be a loss to the owner. To overcome such a situation quality control should be exercised and promoted in the field during the execution stage.

Quality control in the field can be promoted by

(a) emphasising the potential cost savings, which accompany high-quality construction. The job that is done right the first time does not have to be redone. Work that does not meet quality requirements may have to be removed and replaced,

(b) placing special emphasis on the concept that quality control is a field management responsibility, along with cost, schedule, and safety,

(c) insuring that the contractor establishes a viable organisation in tlie field that enhances the opportunity to produce good cluality results,

(d) insuring that staff relationships are thoroughly understood and effectively utilised by the contractor's field organisation,

(e) assisting the contractor where necessary in establishing the position profile for his Quality Control Coordinator including areas of technical and practical competence, attributes leading to the ability to work effectively with others, and the ability to anticipate the consequences of what is being done today in, say 5-10 years time,

(f) including assistance in problem solving, in the responsibilities of quality control personnel,

(g) avoiding the use of the term "Inspector" with its policeman connotation. Upgrade the image of field quality control personnel through the use of such titles as "Quality Control Engineer", "Coordinator" etc. and provide personnel who are deserving of such titles because of their capabilities,

(h) promoting team-building concepts within the field organisation, which include quality control personnel as team members,

(i) emphasising the importance of including quality control consideralions in the planning of all field work,

(j) emphasising the importance of including quality control personnel to include "why" in their explanations of quality requirements to supervisory personnel,

(k) encouraging design alternative thinking in the field, with the involvement of both quality control personnel and line supervision, and by effecting design changes suggested by the field where it is to the advantage of the project,

(l) relating quality control to safety,

(m) using on-site promotional material, e.g., posters, slogans, quality control training for supervision, competitions, awards, etc., and

(n) a continuous expression of interest and concern for quality, on the part of the owner, and recognition of quality achievements.

SAQ 5

How can quality control be promoted in the field ?

14.7 CONTRACTOR QUALITY CONTROL

Good contractor quality control results in owner confidence in contractor, gives the contractor flexibility, and is the contractor's commitment by top management to provide the proper quality. Discussions should be held with the contractor before the job starts in order to get an understanding of the quality level required. The control plan required from the contractor is not to try into his affairs but rather to assure total involvement by everyone on both the owner and the contractor teams. There are both advantages and disadvantages with contractor quality control.

14.7.1 Advantages of Contractor Quality Control

Some of the advantages of contractor quality conlrol are follows :

(a) Tesling and inspection is a necessary cost, and the money can be more efficiently managed by the contractor who directly controls production.

(b) The contractor is the only one who is in a position to anticipate and order the necessary adjustments in production to assure proper quality.

(c) Quality is built into a product and not inspected into it. The best that an owner can do is to conduct an effective quality assurance program. Testing, inspection, evaluation, and appropriate action by the contractor is a means of building quality into the product.

(d) If the contractor does his own testing, he is forced to know his product better, which in itself could result in an improved product, perhaps at a reduced cost.

(e) Statistical specifications can be used more efficiently if integrated into the contractor's effort. By maintaining a quality control chart mounted or displayed so that everyone can see and evaluate the degree of conlrol the contractor will encourage and simplify quality control as well as establish an easy means of communication concerning his quality control,

(f) The department contracts directly with a general contractor. The contractor may purchase from a supplier and do his own hauling, spreading, and compaction, or some other combinations of work items. Controversies may arise as to responsibility when material handled by more than one organisation does not meet the specifications. With the contractor responsible for quality control, tlie department no longer would need to arbitrate such controversies.

(g) The owner's inspecting and testing forces would have more time to devote to broader construction problems, which should insure a better overall project.

14.7.2 Disadvantages of Contractor Quality Control

Some of the disadvantages of contractor quality control are follows :

(a) Small contractors may not have the necessary facilities to do their own quality control, This will necessitate the hiring of an outside agency, In remote areas, this may be a problem and add to the cost of the project.

(b) From the user's point of view, quality control by the contractor would seem more effective when an endpoint specification is available. Not all products have adequate endpoint specifications.

(c) Satisfactory quality control by the conlractor will only be achieved if it is handled by personnel trained in quality assurance procedures with sufficient authority to actually control the quality of the contractor's product. Such experienced persons are not many.

But several points appear fundamental to the effective implementation of contractor quality control. These include the following :

(a) The most important ingredient is that of attitude. If a contractor is concientious, it is more likely that contractor quality control will work.

(b) The calibre of quality control personnel. Where quality control personnel are experienced and capable, the quality of work is good. Men who have previously worked for public agencies are found to he most effective. College graduates are also found to be effective in supervising materials testing.

(c) The owner must be clear what he expects of the contractor's quality control. The owner must spell out tlie quality control requirements. He must also specify the qualifications and number of quality control personnel the contractor must hire. These measures help assure an effective program and also put all bidders on an equal footing.

(d) The need to separate quality control and production. In tlie contractor's organisational setup, the quality control function must report directly to the project manager. If quality control reports to tlie construction supervisor instead of tlie project manager, production may prevail but at the expense of quality.

Some public organisations insist tliat the prime contractor take a more active role in project quality control by making him develop and manage his owl1 quality control programs. The owners of such construction contracts require the prime contractor to maintain a job surveillance system of liis own and lo carry out such inspections which ensure that tlie work performed conforms to the requirements laid down in the coiitract. The contractor is required lo maintain and make available adequate records of such inspections. During the construction process owner's representatives monitor tlie contractor's quality control program and make on the spot check inspections. Under such contracts, the contractor is required to provide significant and specific inspection and documentation to satisfy himself and the owner that the work being performed meets the requirements **of** the contract. Usually, the contractor is required to report on a daily basis the progress on the construction, problems encountered and corrective measures taken, and to certify tliat the completed work conforms to tlie drawings and specifications. The owner is responsible for inspecting at any time deemed necessary and for carrying out the final inspection to ensure that the contract requirements have been strictly ensured.

SAQ 6

(a) What are tlie advantages and disadvantages of contractor quality control'?

(b) How can contractor quality control be implemented effectively'?

14.8 IMPORTANCE OF SPECIFICATIONS

Specifications are necessary to explain to tlie contractor the quality of workmanship which will be required of the contractor wlio is to build a construction project. Workmanship is meant to denote the contractor's operations in the shop or field ratlier than the materials used by him in tlie performance of the contract.

The conventional specification generally controls quality by setting a series of absolute max-min limits on the physical properties for the materials, processes and performance of the item. Such limits many times do not adequately recognise the variability of materials and processes, The acceptance of materials under this method is based upon the

assumption that representative samples provide a satisfactory picture of the characteristics of the inaterial provided. If any test indicates the material or component is outside the specified limit, the material represented by tlie sample should be rejected.

The "representative sample" often leads the construction inspector to select the sample from a lot or batch which itself is representative of the component being evaluated. For example, in portland cemenl concrele, the batch typically picked for sampling is one which appears to be within the specification limits – say with respect to slump. Results from samples thus selected do not correlate well with samples sclectcd on a purely statistically based random process. Comparison between results from random samples analysed by probability statistics (recognising the variability of the materials) and those from single-level tests on samples from the same lot of materials show marked difference in the apparent quality of the lot.

Another important factor, in evaluating the quality of construction components, is the number of samples used for the evaluation. The application of statistics will permit determination of the probability of accepting a lot or componenl which does not in fact meet the specification requirements. Conversely, the probability of rejecting a lot or component which actually does meet the requirement can also be determined. Thus, realistic specifications can be developed; however, it is necessary that the designer decide exactly what physical properties and characteristics are required and what cannot be toleraled.

SAQ 7

Why are specifications important ?

14.9 INCENTIVES AND PENALTIES IN SPECIFICATIONS

Quality control is necessary for the owner to see that the structure or product fulfills his requirements during its lifetime. Quality control measures impose restrictions on the contractor in hastening the work. Left to him, the contractor would like to complete the work as early as possible so that he is not penalised for delay in completion of the project. This calls for some strictures on the contractor when he is doing work. Where the contractor does not follow the specification laid down for different items of work, some sort of a penalty is introduced for repealed lapses on the part of liis workmen. The penalty may be a small amount for the first few lapses. These sliould be sufficient for the workmen to correct themselves and avoid such mistakes in later operations. However, if the specifications are repeatedly violated, stronger penalties may have to be imposed on the workmen. Such penalty clauses are often included in contracts. On the other hand, when there is systematic following,of procedures and methods the quality may improve. To acknowledge such conscientious working some incentive is given to the contractor.

Incentives and penalties do not serve the same purpose in specifications. From a psychological point of view, they have definitely different effects on people. If we desire to bring about equitable specifications and eliminate the adversary owner-contractor relationship, incentives should be used and penalties avoided.

14.9.1 Incentives

Incentives are for motivating lo bring about a desired action. In incentive specifications, there is no thought of accepting below the required level of quality (with its tolerances), and the incentive is to motivate the contractor to control his process in such a manner so as to reduce his variability in attaining the desired quality. Incentives work in motivating 100 per cent of the time. Incentives usually bring about positive and desirable reactions in a person.

14.9.2 Penalties

Penalties are for punishment for having failed to achieve the desired end, or for doing something undesirable. In penalty based specifications, the contractor knows that he can have below quality levels accepted by paying a penalty, and he can add into his price this

anticipated penalty, thus costing the owner more than the incentive bid price, and the owner may land up with a lower quality than specified. Penalties are paid for by the owner 100 per cent of the time. Penalties have always resulted in negative and undesirable reactions.

SAQ 8

What are incentives and penalties in specifications ?

14.10 WORKMANSHIP AS A MARK OF QUALITY

It is better to, and advisable to include in tlie specifications a statement to the effect that all workmanship is to be of first class, or of tlie best quality. This may not be specific but the intention is clear. Persons engaged in any particular activity, whether in the shop or in the field, will generally know what is meant. Third parties, too, can judge fairly well whether or not a given performance meets this standard.

A description of or specifications for all the procedures and work that will be required in supplying the materials and in the performance of various items of work on a large construction project cannot be included in tlie contract documents. However, a general statement requiring first class workmanship sliould not be used as an excuse for inadequate preparation of the drawings and the specifications.

SAQ 9

What is meant by "workmanship as a mark of quality" ?

14.11 FINAL INSPECTION

Sampling, testing, and inspection by the contractor for product control occurs during the construction before the structure is complete is a part of quality control. At this stage the testing is usually not the standard type of testing on the finished structure, but it is more elementary and responsive to the process in order to provide guides before it is too late.

The last aspect of quality control is the final inspection followed by field acceptance testing and start up of the facility. Testing at the end of any process or construction work is for record purposes as far as the contractor or producer is concerned, and it is at this stage that the owner makes tests for acceptance purposes. If the tests at the end of the construction are done as planned, honestly, fairly, and properly, as agreed upon, there is no reason why the parameters that result from the tests would provide different conclusions. While the owner checks all controls and instrument operation, the prime contractor, subcontractors, and the facility manufacturer's representatives start up tlie project equipment and systems. Simulation of operating and emergency conditions are also included. The facility together with a complete set of job files, shop drawings, maintenance, and operating manuals, and as built drawings is handed over to tlie owner.

In recent years, there has*been some increasing neglect of construction quality control. Modem construction involves so many teams that responsibility of the end product has become splintered 'and diffused. The engineer has been withdrawn. Inspection by the contractor is criticised because it is argued that contractors with profit-oriented objective cannot be expected to rigorously inspect their own work. There is an increasing feeling that construction quality control should be allocated some funds out of the total construction cost, and the responsibility should bc contracted out to third party professional firms.

14.12 SUMMARY

In this unit, you have learnt about the necessity of quality control on any project. You have been told about the economic objeclives of quality control, and methods of achieving field quality control. Wow should quality control be promoted in the field and the advantages and disadvantages of contractor exercising quality control have been explained to you. You have been told how specifications are important in executing a project and what are the incentives and penalties provided in the contract to deal with adherence to or breach of the specifications by the contractor. What are the last aspects of accepting the work have been discussed.

14.13 ANSWERS TO SAQs

Refer the relevant preceding text in the unit or other useful books on the topics listed in the section "Further Reading" given at the end of the block to get the answers of the sell-assessment questions.

FURTHER READING

Abbett, R. W. (1958), *Engineering Contracts and Specifications,* John Wiley & Sons, New York, Third Edition, pp 429.

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27	1604	fit's VG Vaze College, MUMBAI - 400 081
28	1614	Chandrapur Engineering College, CHANDRAPUR - 442 403
29	2117	College of Engg. and Tech., BHUBANESWAR - 751 003
30	2303	Kota Engineering College, KOTA - 324 010
31	2518 (P)	PSC College of Technology, COIMBATORE - 641 004
32	2519 (P)	Crescent Engineering College, CHENNAI - 600 048
33	2701	Jai Narain Degree College, LUCKNOW - 226 001
34	2703	Allahabad Degree College, ALLAHABAD - 211 003
35	2810	Maulana Azad College, CALCUTTA - 700 013
36	2818 (P)	Institute of Engineering & Management, CALCUTTA - 700 091