CHAPTER 07

Quality Control, Safety Management and Legislations

7.1 Introduction

In all construction projects, proper inspection and quality control become very important so that the construction is carried out in accordance with the plans and specifications. This will result in good quality construction at a reasonable cost. In any construction project, quality control is an important function of the management so that, it is ensured that he project work is carried out in accordance with the specification and this quality control is cared out through proper inspection at various stages of the project.

7.2 Elements of Quality

There are three quality elements:

(i) Quality Characteristics (ii) Quality of Design (iii) Quality of Conformance

7.2.1 Quality Characteristics

Refer to the properties that define the nature of a product for quality control purpose. These include dimension, strength, colour, temperature, etc. Taking a common material such as concrete, compressive strength, slump, size of aggregate, water cement ratio, surface finish and sometimes colour are the important characteristics to be checked frequently for structural purpose.

7.2.2 Quality of Design

No design can produce absolutely perfect results. Hence, the desired standards for the characteristics that define a product such as dimension or strength and also the tolerances for acceptable variations from the standard are specified. If very high standards of quality and stiff tolerance limits are set, then this will increase the cost of the project.

7.2.3 Quality of Conformance

Whatever design quality has been specified, then the degree to which it is achieved in the actual construction work is the quality of conformance. As in the case of design quality, the degree to which the quality is to be enforced in the field has to be considered along with the cost necessary for quality control procedures.

7.3 Organisation for Quality Control

The responsibility for judging quality should be separated from those who are entrusted with the execution of the work. In fig. 7.1, the responsibility for quality control is taken by the resident engineer and his inspectors. The specifications stipulated in the design are enforced by the resident engineer and his inspection team during the construction. The resident engineer also interacts with the project engineer and his team who are carrying out the construction for complying with the standards.

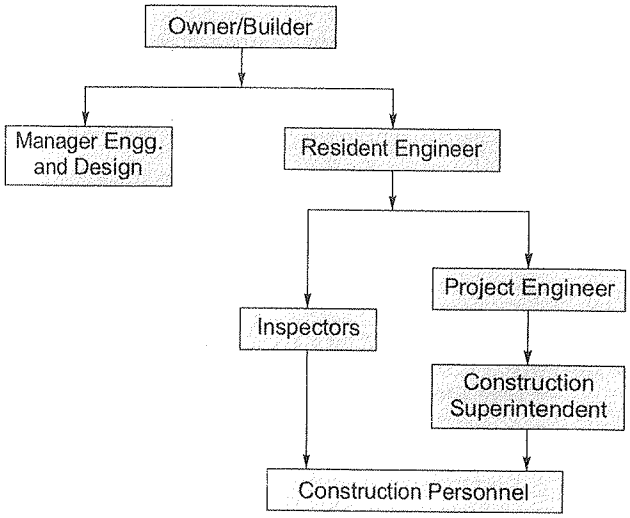

Fig. 7.1 Quality Control Organisation

7.4 Quality Assurance Techniques

The major quality control methods are:

7.4.1 Inspection

This consists of receiving inspection, in-process inspection and the final inspection before accepting the constructed structure. First of all, inspection is to be carried out for the materials of construction about their quality and acceptability. Then comes the inspection during the process of construction. For doing this, a check list has to be prepared.

7.4.2 Testing

This means the examination of a material or product to check its conformance to the specified performance standards. Testing can be destructive or non-destructive. It may take place on the site or in the special laboratories. In destructive testing, the element is tested intentionally to failure as in the case of concrete cube testing.

7.4.3 Sampling

This is the process of determining the quality of a large group by examining a part of the group that will be statistically representative of the whole group. The reliability of the information obtained increases with the size of sample used. If the size of the sample is reduced, then the cost of inspection is reduced, but this will also reduce the reliability. This will result in acceptance of substandard work. Reliability is expressed as a percentage as follows:

$$\text{Reliability Number} = 100 - \left[\frac{\text{No. of defective units}}{\text{No. of units tested}} \times 100\right]$$

Statistical analysis is a statistical tool used to measure the degree of accuracy with each, for example, a particular batch of concrete is made and to provide a means of assessing the most economical use of material. In the case of concrete, the compressive strengths of the concrete cubes made out of the particular batch of concrete are first found out. Let the total number of cubes tested by N and let the compressive strengths of the individual cubes be X_1, X_2, X_3, ... X_n. From these values, the mean, standard deviation and coefficient of variation are calculated.

Mean $\bar{X}$ = the average of the series of compressive strength values

$$= \frac{X_1 + X_2 + X_3 + ... + X_n}{N}$$

Standard deviation, $$\sigma = \sqrt{\frac{\Sigma(X-\bar{X})^2}{N-1}}$$

Coefficient of variation, $$V = \frac{\sigma}{\bar{X}} \times 100$$

A small value of standard deviation, σ gives the idea that the concrete of that particular batch has a high degree of uniformity of observations and the homogeneity of quality of the concrete.

7.5 Introduction of Safety Management

The social concern of the safety of construction workers and their protection against injury arising out of their employment has been quite evident for a long term. However, the measures taken to translate this social concern into concrete programmes of action are legislative, administrative or educational.

7.5.1 Importance of Safety

The construction industry, employing the largest labour force in country has accounted for about 11% of all occupational injuries and 20% of all deaths resulting from occupational accidents. The cost of accidents is expensive. However, economic cost is not the only reason for which a contractor should be conscious of construction safety. The reasons for considering safety include:

1. **Humanitarian Concern:** When the accident happens, the resulting suffering of the injured workers and their families is difficult to quantify in economic terms. The contractor should never ignore this even if he has insurance against accidents.
2. **Economic Reasons:** Even if a contractor has insurance, he will find out that the cost of accidents will come out of his own pocket through an increase in insurance premiums. In addition, there are other indirect costs that result from accidents.

   Direct Cost:

   - Medical care expenses for injured.
   - Workmen's compensation costs.
   - Insurance premium increases.
   - Replacement cost of equipment and material damaged in accident.
   - Facility repair and cleanup.
   - Fees for legal counsel.

   Indirect Cost:

   - Slowdown in operation.
   - Decreases in morale which affects productivity.
   - Productive time lost in injured worker and fellow workers.
   - Administrative work associated with accident.
   - Loss of clients' confidence.
   - Overtime necessitated by work slowdown.
3. **Laws and Regulations:** As per different acts and laws, the employer should look after the safety of the employees. Violation of these laws will be subject to punishment.
4. **Organisation Image:** A good safety record can produce higher morale and productivity and stronger employee loyalty. It will also improve the company's public image and therefore, make it easier to acquire negotiated jobs.

7.5.2 Causes of Accidents

There are as many possible causes of accidents as there are occasions. Among these are : technical defects in equipment and methods of work, defects in organisation and dangerous acts by workers. Ti these have to be added those causes that come from the nature of construction operations themselves, defects in planning and construction, constant changes in workplace and task, and the friction oftea found when workers from different trades are working in close proximity to each other. In the followiij list, the causes of accidents have been grouped according to their nature.

1. Planning and Organisation
   - Defects in technical planning
   - Fixing unsuitable time-limits
   - Assignment of work to incompetent contractors
   - Insufficient or defective supervision of the work
   - Lack of co-operation between different trades.
2. Execution of Work
   - Constructional defects
   - Use of unsuitable materials
   - Defective processing of materials
3. Equipment
   - Lack of equipment;
   - Unsuitable equipment;
   - Defects in equipment;
   - Lack of safety devices or measures
4. Management and conduct of work
   - Inadequate preparation of work
   - Inadequate examination of equipment
   - Imprecise or inadequate instructions from supervisor
   - Unskilled or untrained operatives
   - Inadequate supervision
5. Worker's Behaviour
   - Irresponsible acts
   - Unauthorised acts
   - Carelessness

The Important elements for maintaining safety in construction are given in the Fig. 7.2.

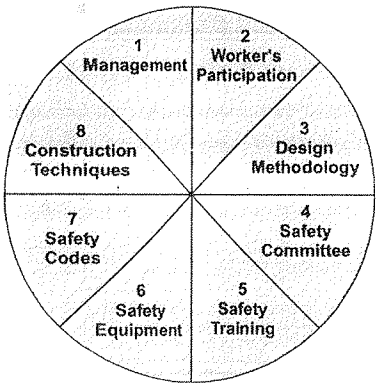

Fig. 7.2 Important elements for maintaining safety in construction

7.5.3 Responsibility for Safety

The responsibility of safety in construction is mainly that of the management. Management is the contractor who undertakes the execution of the work or the builder who promotes a project or the construction department/ agency for whom the construction work has been undertaken. The overall management for all construction activities however vests with the government. Although one single individual or agency has to shoulder the primary responsibility of ensuring safety in construction, the close co-operation of all those engaged in construction is a matter of vital significance.

7.5.4 Safety Measures

Safety during the construction of a project is also influenced in large part by decisions made during the planning and design process. Some designs or construction plans are inherently difficult and dangerous to implement, whereas, other comparable plans may considerably reduce the possibility of accidents. Safety largely depends upon education and training, vigilance and cooperation during construction.

Choice of technology can also be critical in determining the safety of a job site. Safeguards built into machinery can notify operators of problems or prevent injuries. Educating workers and managers in proper procedures and hazards can have a direct impact on job site safety. The realization of the large costs involved in construction injuries and illness provides a considerable motivation for awareness and education. Prequalification of contractors and sub-contractors with regard to safety is another important avenue for safety improvement.

7.5.5 Safety Benefits to Employers, Employees and Customers

There is no lack of humanitarian concern if we view safety from a profit stand point, provided, we recognize that it is profitable not only to the employer but to the worker as well. The construction worker who is injured, suffers financial loss as well as pain and discomfort. The construction employer who disregards safety suffers an indirect cost which could ultimately affect his survival also. With atleast half of construction cost consisting of labour, any constructive type of safety program will result in economics and be of great importance to the worker, to the contractor, and to the public as a whole.

Uninsured costs are approximately nine times greater than insured cost. Thus, for every one rupee in direct loss or cost of an accident, nine additional rupees are spent indirect.

A. Injuries

- Compensation for lost earnings
- Medical and hospital costs
- Awards for permanent disabilities
- Rehabilitation costs
- Funeral charges
- Pensions for dependants

B. Property Damage

- Insurance premiums or charge
- Fire
- Loss and damage
- Use and occupancy
- Public liability

Uninsured cost which result in indirect losses are as follows:

1. Associated Costs

- Difference between actual losses and amount recovered
- Rental of equipment to replace damaged equipments
- Surplus workers for replacement of injured workers
- Wages or other benefits paid to disable workers
- Overhead cost while production is stopped
- Loss of bonus or payment of forfeiture for delays

Safety is also an important public relations tool, a great potential for building goodwill. Good public relations have important financial and business implications for the employer.

2. **Safety Benefits to Employees :** Any accident that results in reducing a worker's physical power, creates serious challenges to that worker's projected manhood. Special care must be afforded to the injured worker in both physical and mental rehabilitation. By safety, all these can be eliminated.
3. **Safety Benefits to Employers :** As the expenses of industrial accidents are to be considered as cost of operation, and as such, are to be transferred from the worker and employer to the customer, eventually, the customer will bear the cost of poor accident presentation programmes. It is very possible that the immediate cost will not affect the customer, particularly in the case of fixed bid contract construction, but the effect that losses due to injury creates within the cost of providing workmen's compensation insurance will eventually be felt.

   The cost of a project as viewed by the customer includes not only the price for construction but also the cost of non-productive capital. Accidents create time losses - the time for which a project is delayed while another piece of equipment is brought in to replace the damaged one, the time spent replacing an injured worker, and the training time to bring that worker to full production. Serious accidents can create delays that may never be overcome.

7.5.6 Approaches to Improve Safety in Construction

1. **Organisational Approach :** A sefety progarmme cannot be successful without an appropriate organisation setup. A compnay safety program should be a part of the contractor's businesss, just as scheduling and cost accounting. Several guidelines can be drawn.
   - (i) **Safety Departments :** A formal safety department is essential in a company. This department should be incharge of the safety staff and jobsite representatives, recording and analyzing safety and other accident prevention programmes.
   - (ii) **Committee :** A safety committee should be set up to guide the operation of safety programs. The members of the committee should include all levels of workers and management to reflect opinions on safety from all levels.
   - (iii) **Field Procedures :** A system must be designed to process safety suggestions from workers, the people who carry out the daily construction process, since they are in the best position to detect any possible accidents.
   - (vi) **Incentives :** Field management and supervisors should be evaluated for promotions and salary increase in terms of safety record as well as productivity and cost.
   - (v) **Safety Cost :** The cost accounting system should be adjusted to encourage safety by allocating safety costs to company account and allocating accident costs to project accounts.
2. **Physical Approach :** In physical aspects, a contractor can improve safety performance using the following guidelines :
   - New workers should be given a safety orientation.
   - For every project, the contractor must study in advance the possible accidents that the proposed construction methods, procedures and equipment may create. Then an accident prevention programme should be devised to take care of those accident.
   - The contractor should enforce the use of approved equipment for personal protection such as hard hats (helmets), safety belts, safety glasses, goggles, hearing aids, gloves etc.
   - The contractor should integrate safety programs with other programs such as scheduling and budgeting during preplanning procedures.
   - Periodic checking of tools and equipment is necessary in order to make sure that they are well maintained.

- Conduct periodic safety meetings, such as tool box meetings, to provide safety education on the job.
- Seek and obtain full cooperation from all subcontractors on the project. Many accidents occur just because of lack of coordination. These kinds of accidents can be avoided easily by administrative effort.

3. **Behavioural Approach :** Studies conducted disclose that more than 80% of all accidents result from worker's unsafe acts, while only about 10% result from failure of equipment or improper procedures. Apparently, this is the are with the most potential for improving safety performance. Also, the behaviour of managers on every level has significant influence on worker's, safety performance. The following guidelines will be found useful :
   - Top management, while visiting job sites or meeting in the main office, should talk about safety in the same way as they talk about schedules and costs, this will make the subordinates understand that safety is an important as cost and schedules, so that the importance of safety will not be ignored.
   - The project manager and the superintendents should not place unnecessary pressure on foremen, such as over emphasising the importance of meeting the estimated budget and schedule.
   - Crafts foremen are the key persons in, behavioural approach as to better safety, because they are the persons who have daily contact with workers. They are also the person in the best position to detect the workers abnormal behaviour.
   - The foremen along with project managers and superintendents should try to create and maintain good relationship between members of craft crews. If workers have pleasant relationships with each other, they tend to be more concerned about their co-workers safety.
4. **Economic Incentives :** Owners as well as contractors should always bear in mind and take into consideration the economic benefits due to safety at the worksite. If a complete estimate should be taken into account for the cost of their safety programme as percentage of direct field labour costs, their estimate would result in some positive return for the amount spent on safety programme.

7.5.7 Measuring of Safety

1. **Injury Frequency Rate :** The term injury frequency rate is defined as the number of disabling injuries per one lakh of man-hours worked. It is expressed by the following equation :

$$\text{Injury frequency rate} = \frac{\text{No. of disabling injuries} \times 1{,}00{,}000}{\text{Total no. of man-hours worked}}$$

The disabling injury means an injury which causes a loss of working time beyond the turn, shift or day during which the injury occurred. Thus, injury-frequency rate denotes how frequently accidents occurred. But it does not take into account the time lost because of an injury.

2. **Injury Severity Rate :** The term injury severity is defined as the number of days of lost time due injuries for 1000 man-hours worked. It is expressed by the following equations:

$$\text{Injury severity rate} = \frac{\text{No. of days lost} \times 1000}{\text{No. of man-hours worked}}$$

3. **Injury Index :** It is expressed by the following equation :

$$\text{Injury index} = \frac{\text{Injury frequency rate} \times \text{Injury} \times \text{Severity rate}}{1000}$$

4. **Equivalent time charge :** The term equivalent time charge is used to indicate the number of days lost for partial or total disability of permanent nature. The equivalent time charge with respect to the importance of function of the member of the body can be framed and the members of the body are described as hand, thumb, arms, legs, combination of thumb and fingers, toes, eyes, ears etc.

7.5.8 Ergonomics applied to the Construction Industry

Ergonomics is the application of the human biological sciences along with engineering sciences for achieving the optimum level of adjustment between man and his work. Ergonomics helps in achieving human efficiency and well being. It reduces stress, lightens the work load, increases safety and thereby, the productivity. It has been successfully applied for improving various tasks in the manufacturing industries. Construction industry has been slow in adopting this technique and deriving the benefits. Considering the fact that productivity can be enhanced by proper planning and adoption of safety techniques, the application of ergonomics appears to be more important to the construction industry than to any other field of activity.

7.6 Need for Legislation

Next only to agriculture, the construction industry provides maximum employment. In every five-year plant almost 50% of the outlay is spent on construction and related activities. This expenditure will further increase in the coming years due to huge investments that will be necessary in improving the infrastructure facilities. The construction personnel as compared to their counterparts in the manufacturing industries enjoy lesser facilities and privileges. There is no job security and the workers are hired when required and fired when the work is over. Workers have to migrate from one project location to another project location in search of jobs. The work of the construction industry is hazardous in nature.

Child labour is also prevalent to a considerable extent in this industry. Hence, legislation is important atleast to safeguard some important provisions like daily hours of work, rest periods, adequate sanitary facilities, protection against hazardous operation, protection for vital organs of the workers and other factors.

In general, legislation is necessary for the following reasons :

1. To fix the terms of employment.
2. To provide proper working conditions.
3. To provide social security.
4. To maintain a cordial relationship between the employer and employees.

7.6.1 Fixing the terms of Employment

This is regulated by the payment of wages Act (1936, amended - 1982) and minimum wages Act (1948, amended 1986).

7.6.1.1 Payment of Wages Act

This Act was introduce to regulate the payment of wages, imposition of fines, etc. The term 'wages' includes all remuneration including all allowances, bonus, notice pay, etc., but does not include house rent, water and electricity charges, travel allowance, medical allowance, pension, gratuity etc. According to this Act, wages are to be paid promptly on a monthly basis and if any person is terminated from service, his wages should be settled within two days of the termination. This Act is applicable to employees having a salary less than ₹ 1600 p.m.

7.6.1.2 Minimum Wages Act

This Act prevents the exploitation of the unorganised labour in the construction industry by the employers. According to this Act, provision is made for the statutory fixation of minimum rate of wages in the establishment. According to this Act, different minimum rates can be fixed depending on the class of work, type of personnel employed - adults, children or apprentice and depending on the location of work. An advisory committee is usually set up to collect all the relevant data and then arriving at the minimum rate. These rates could be revised at every five year intervals. There is a provision for a weekly holiday, with pay. Overtime payment is at double the minimum rate.

7.6.2 Providing proper working conditions

This is regulated by the Factories Act, 1948 and the Contract Labour Act, (1970, amended 1986).

7.6.2.1 Factories Act

Under the Act, the health, safety, welfare, working hours, annual leave, accidents and any penalties are taken care of. Regarding health, arrangements for proper cleanliness of the premises, disposal of waste, ventilation and comfortable working temperature are to be maintained. Fist aid equipment and ambulances, canteens, rest sheds, proper washing areas are to be provided. Where 500 or more workers are employed, welfare officers are to be appointed. Normally, the working hours are restricted to 8 hours/day with a lunch break of 1/2 hour and a total of not more than 48 hours/week. If the worker is engaged on holidays, compensation leaves is to be given. Overtime wages are at twice the ordinary rate of wages. Women mazdoor should be employed only from 6 a.m. to 7 p.m.

7.6.2.2 Contract Labour (Regulation and Abolition) Act (1970 amended 1986)

This Act contains the provisions for improving the condition of contract labour. Since, in the construction industry, many of the works are executed on contract basis, this Act is important.

7.6.3 Social Security

This is regulated by the following Acts:

Labour welfare Fund Act, 1965 and the workmen's Compensation Act, 1923 (amended 1984)

The provisions in the above Acts are now discussed.

7.6.3.1 Labour Welfare Fund Act, 1965

This Act provides for the constitution of a fund for the financing of activities to promote the welfare of labour. Establishment of State Labour Welfare Board, appointment of welfare commissioner and inspectors are all envisaged in this Act. The accumulations in the fund come from : all fines realised from employees, unpaid wages to workers including gratuity and bonus, grants and loans towards the fund, and any voluntary donations. The amount in this fund is spent for welfare of the workers such as : creating community and social education centres; games and sports, tours and excursions, recreation and entertainment. developing home industries for women and unemployed labour.

7.6.3.2 Workmen's Compensation Act, (1923, amended 1984)

This Act provides for social security to the workers. Compensation is to be paid to the workers in case of accidents sustained during the course of employment and the amount is decided upon its seriousness. The dependents are eligible to receive the compensation. This Act is applicable to all persons employed in construction, maintenance, prepairs or demoliation work. Under this Act, financial relief is given in the following cases:

1. In case of death.
2. On account of occupational diseases.

3. For permanent/partial disablement.
4. Half-monthly payments for temporary disablement.

7.6.4 Maintaining Cordial Relationship - The Trade Union Act

This is provided by the Trade Union Act, 1926.

Trade union is an association of persons formed mainly for the purpose of regulating the relations between employers and employees. A minimum of seven workers can join together and form a trade union. The union has to get itself registered with the Registrar of Trade unions. Normally, the objectives of a trade union are:

1. Evolving a wage formula for the workers linking the cost of living and the existing standards of living.
2. Improving the working condition of the workers by limiting the working hours, providing leave facilities, education and other welfare facilities. getting adequate bonus, protecting the workers against improper treatment, providing security of employment and getting justice in case of imposed punishment.

Objective Brain Teasers

Q.1 Construction safety is important because of
- (a) Economic reasons
- (b) Humanitarian concern
- (c) Medical expenses
- (d) Both (a) and (b)

Q.2 The responsibility for safety is to be exercised by
- (a) The designer
- (b) The employer
- (c) Workers and equipment manufacturers
- (d) All of these

Q.3 The major cause of fire hazards at construction site is due to
- (a) Portable heating equipment
- (b) Cutting/welding operations
- (c) Matches and smoking
- (d) Unsafe storage of materials

Q.4 Ergonomics is the application of
- (a) Chemistry and Physics
- (b) Mathematics and Biology
- (c) Biology and Engineering
- (d) Chemistry and Mathematics

Q.5 The major quality control methods are
- (a) Testing and sampling
- (b) Inspection and Testing
- (c) Inspection and sampling
- (d) Inspection, Testing and sampling

Q.6 The basic elements of quality are
- (a) Structural quality, design and conformance
- (b) Design and structural quality
- (c) Design and conformance
- (d) Quantity and design

Q.7 Sampling is the process of determining the quality of a
- (a) Large group from a small part
- (b) Small part from a large group
- (c) Small group from a small part
- (d) Small group at random.

Q.8 Reliability number is a measure of
- (a) The dimensions of a product
- (b) The quality of a sample
- (c) The accuracy of testing
- (d) None of these

Q.9 An arbitrator is one who mediates between
- (a) Two aggrieved parties
- (b) Public and workers
- (c) Engineer and architect
- (d) Public and the contractor

Q.10 A successful construction manager should have
- (a) Personality