



Model Answer

Question (1): Define the following: (20 Marks) [ILO's: a1, a2, a3, a6, b1, b3, c1, c2, d2, d4, d6, d8]

- (1) **Quality assurance:** (*QA*)—A management tool for all planned and systematic actions necessary to ensure that the final product meets the requirements of the design drawings and specifications.
- (2) **Quality control:** (*QC*)—A production tool for those actions related to the physical characteristics of the materials, processes, and services that provide a means to measure and control the characteristics within predetermined quantitative criteria.
- (3) **Owner:** The individual or organization having financial and legal responsibility for construction of a project, as well as bearing the ultimate responsibility for the public health, welfare, and safety related to the project. For many purposes in this report, the term “owner” includes those organizations or individuals acting as agent for the owner.
Owner's representative: The person or management organization that becomes the owner-engineer team in a system that varies from the traditional design-bid-build system. Their role is to coordinate and communicate the entire project process to minimize project construction time and price.
- (4) **Architect engineer:** (*A/E*)—The architectural or engineering organization with responsibility to the owner to perform the structural design, produce design drawings, define construction requirements, implement inspection and testing programs, and prepare project specifications for the project
- (5) **Contractor:** The organization responsible for constructing a project according to the project specifications and design drawings.
- (6) **Inspection:** The term “inspection,” as used herein, includes not only visual observations and field measurements but also laboratory testing and the assembly and evaluation of test data.
- (7) **Inspection organization:** The organization/agency that may also be a testing laboratory, and is responsible for providing acceptance inspection and testing for the owner, or providing quality-control inspection and testing for the contractor or producer.
- (8) **Inspection test report:** A document signed by a certified inspector or individual assigned to do the task, and used to demonstrate and provide evidence of the verified attributes plus the results of the inspection/test activity performed.
- (9) **Testing laboratory:** An independent commercial organization that provides testing services and, when required, inspection personnel to owners, governmental agencies, architects, engineers, contractors, and material or product manufacturers.

(10) Material supplier: The organization responsible for producing or manufacturing a product or material used in the process of construction, or for supplying products or materials to a project, with or without performing additional operations on the product or material.

Question (2) Discuss the following items: (40 Marks) [ILO's: a1, a2, a3, a6, b1, b3, c1, c2, d2, d4, d6, d8]

(1) Functional classification of inspection:

Inspection activities and organizations are mainly concerned with the following four functions:

1. Acceptance inspection—A series of formalized activities and procedures that provide the owner of the structure being built, with an acceptable degree of assurance that the contractor has satisfied his or her obligations to construct in accordance with the contract documents. The evaluation of tests performed and of the observation of procedures and practices used in the construction should permit the determination of conformance to prescribed acceptance standards.

2. Quality-control inspection—contractor—Quality-control inspection by the contractor is a series of formalized activities and procedures that are part of the contractor's operation, providing in-process evaluation of the quality of construction. This helps to ensure the contractor that the finished construction will meet all requirements of the project plans, drawings, and specifications, and will be accepted by the owner's representative.

3. Quality-control inspection—producer—Quality-control inspection by the producer is a series of formalized activities and procedures. They are part of the fabricating or manufacturing operation of a producer of concrete materials, reinforcement producer/fabricators, or products, who furnishes to the construction industry rather than only to a specific project. Examples are operations of cement and aggregate producers, ready-mixed concrete producers, pre-casters, pre-stressing concrete fabricators, and reinforcing steel mills and fabricators. Production inspection personnel operate essentially the same way as those described for the contractor. They aid in ensuring that finished products will meet general specifications or those specifications relative to a specific project.

4. Regulatory inspection—A series of formalized activities and procedures used by governmental bodies (such as licensing boards and building permit boards), charged with responsibility for enforcing building codes and other regulations. In this case, the inspectors have responsibility for ensuring that the finished structure conforms to the requirements of the codes or regulations. The organization and activities of these inspectors are governed almost entirely by legal regulations.

(2) Inspection Items:

Regardless of classification, an inspection team or group may consist of a number of individuals or, for very small projects, a single individual. Inspection, including testing, may be performed by a variety of groups such as:

1. Owner's inspection personnel—Qualified inspection personnel maintained by the owner. Examples would be permanent or semi-permanent personnel of governmental agencies, or large industries with continuing building programs.

2. Architect/engineer's inspection personnel—Inspectors trained, certified, and maintained by a firm for work on projects designed by the firm.

3. Laboratory's inspection force—Inspection and testing personnel trained, certified, and maintained by a testing laboratory to provide contractual testing and inspection services.

4. Contractor's inspection force—Inspection personnel trained, certified, and maintained by a contractor to provide quality-control (in-process) inspection on projects it constructs.

5. Material manufacturers and suppliers inspection force—Inspection (and testing) force trained, certified, and maintained by a concrete material and product manufacturing and fabricating firm for its own in-house use in quality-control (in-process) inspection and testing.

(3) Owner's responsibilities:

1. The owner is responsible for acceptance inspection and testing. A/Es should provide owners with alternatives and information enabling the owner to recognize and evaluate the quality/price/maintenance relationships involved in the construction. Owners should understand that field inspection and testing need to be provided to ensure conformance to codes and quality requirements. The owner should review the inspection plan with the A/E and, where appropriate, select the level of acceptance inspection required, consistent with the size, quality, complexity, and needs of the project.

2. The acceptance inspection personnel are responsible for, and can only be involved with, determining that inspected materials, procedures, and end products conform to the requirements of the design drawings and project specifications. The contractor is obligated to meet all requirements of the project specifications. For the inspector to accept less than required deprives the owner of full value, whereas requiring more than called for in the design drawings and project specifications places an unacceptable burden on the contractor. Either action is a contract violation.

3. The inspectors personnel representing the owner have no responsibility or authority to manage the contractor's personnel. Inspection requirements on projects supervised by a construction manager should be detailed by the A/E and should be carried out by the owner.

4. The owner should be responsible, in conjunction with the A/E, for arranging a preconstruction conference including all parties involved in the construction project. The conference should establish lines of communication and identify responsibilities to achieve quality. To be effective, the inspection personnel should have the acknowledged support of the owner.

5. The fee for acceptance inspection should be a separate and distinct item and should be paid by the owner directly to the inspection organization or to the A/E (unless the A/E is also the contractor) who will in turn pay the inspection organization. The owner or A/E should avoid the undesirable practice of arranging payment for acceptance inspection and testing services through the contractor. Such a practice is not in the owner's interest. Impartial service is difficult under such circumstances, and the price is eventually paid by the owner in any case.

(4) Architect engineer's laboratory responsibilities:

1. For the protection of the owner and the public, the responsibility for planning and detailing acceptance inspection should be vested in the A/E as a continuing function of the design responsibility. The responsibility of the engineer for this inspection may be discharged directly or may be delegated to an independent inspection organization responsible to the A/E.

2. If the A/E is also responsible for construction, an independent inspection organization should be retained by the owner. In those cases in which the owner provides the A/E service, the owner should also provide acceptance inspection, or retain an independent inspection organization.

(5) Contractor's responsibilities:

1. Coordination and scheduling of acceptance inspection should be made a responsibility of the contractor. This will provide timely inspections and avoid owner-caused construction delays.

2. Quality-control inspection, or in-process inspection, is performed by contractor personnel or others specially hired by the contractor. These inspectors are most effective when they report directly to the contractor's management. It is important that these activities be actively supported by management. Inspection and testing by or for the contractor, subcontractors, or concrete suppliers is separate and distinct from acceptance inspection for the owner.

3. In some construction contracts, the contractor is required to provide a specified amount of inspection and testing as part of a formal quality-control program. When not contractually required, many contractors still maintain a quality-control program that includes inspection and testing forces separate from the line of supervision, reporting directly to management. The price is often returned many times over through reduction of rejections, and savings in replacements and repairs. Sometimes this inspection work is an informal and automatic part of the contractor's operations performed by regular production supervisors.

4. Inspection performed by, or for, the contractor, particularly when contractually required, will often be much more detailed than is the usual practice for acceptance inspection. The contractor's personnel should make a much more detailed inspection of form alignment, reinforcing bar positioning, cleanup of forms, and other concrete placement. Even if not required by the project specifications, the contractor should use quality-control inspection to ensure against later rejection of a complex placement. If such items are not covered by a formal quality-control inspection team, they should be covered by the contractor's supervisory personnel.

5. When the project specifications require extensive quality-control inspection and testing by the contractor, the owner should not reduce or eliminate acceptance inspection. If the contractor's quality-control inspection program becomes the owner's acceptance inspection program, the system is nullified. The objections are exactly as stated previously against the practice of having the contractor hire and pay an inspector to perform acceptance testing for the owner. When the owner requires the contractor to have a quality-control inspection program, the owner should still accept responsibility for acceptance inspection to provide assurance that the contractor's quality-control program achieves its objectives.

6. Quality-control inspection, other than, or in addition to, that required by the project specifications, will be as directed by the contractor's management. These inspection details and criteria will be based on management's judgment as to items and criteria necessary to ensure that all aspects of workmanship and the finished product will meet the requirements of the project plans and specifications and will thus be accepted by the owner.

(6) Manufacture's of fabricator's responsibilities:

Quality-control inspection by the manufacturer or fabricator should parallel the contractor's programs. Program content depends on contractual requirements and on the manufacturer's quality-control process.

(7) Written inspection plan:

Even the smallest project can benefit from a written inspection plan. A small project may require only a list of items to be inspected and tests to be conducted for acceptance purposes, but it becomes invaluable in developing adequate communication and understanding between the owner, A/E, contractor, and inspection and testing organization. It is recommended that all projects use some form of written plan or checklist. On complex projects, a written plan detailing responsibilities for acceptance inspection and testing, procedures for documentation of inspections and tests, scheduling and frequency of testing, reporting of results, handling of non-conformances and changes, record retention, and auditing the progress of the work is a necessity.

(8) Qualifications of personnel for inspection and testing duties:

1. The qualifications of personnel conducting inspections and tests are critical to attaining the desired level of quality, as erroneous results of tests and inspections can cause costly actions that are unwarranted.

2. The ACI certification program currently outlines training programs and certification of personnel in the following areas: CP 1—Concrete Field Testing Technician (Grade I); CP 16—Concrete Laboratory Testing Technician (Grades I and II); Concrete Construction Inspector has been replaced by the joint ACI/code committee's Reinforced Concrete Special Inspector; Concrete Transportation Construction Inspector, and Inspector In-Training; CP 8—Concrete Flatwork Finisher and Concrete Flatwork Technician; CP 19—Concrete Strength Testing Technician; and the newest program: Aggregate Testing Technician.

All personnel performing concrete inspection and testing work should be certified and demonstrate a knowledge and ability to perform the necessary test procedures equivalent to the minimum guidelines for certification in the appropriate category.

(9) Planning for inspection and testing:

1. General—Acceptance inspection should only be detailed enough to permit adequate evaluation of the product or process. The contractor and ready-mixed concrete producer should be encouraged to provide their own formalized quality-control programs.

Even if acceptance inspection becomes very detailed, contractors and concrete producers often rely on acceptance inspection and tests in lieu of their own quality control.

If there is concern by the owner or A/E about the adequacy of the quality-control function, project specifications can direct that the contractor provide specific testing and inspections as part of the quality-control program, with results disseminated to the owner and A/E. When this is done, acceptance inspection should not be eliminated, but it usually does not require the detail or emphasis that might otherwise be required to satisfy quality-assurance concerns.

During the course of the project, when a concern about the adequacy of quality control exists, acceptance inspection should necessarily be more rigorous until the contractor's quality-control activities remove reason for concern.

2. Acceptance inspection

2.1. The A/E should evaluate whether or not it is necessary to conduct prequalification tests of the materials to be used in the project. In the event materials with past service records are to be used, earlier qualification tests may be relied upon, or satisfactory performance in a similar

environment may be used as the basis for acceptance. If prequalification tests are to be conducted, the A/E should specify the tests and the acceptance criteria.

2.2 Approval of mixture proportions to be used in the project should be based on reliable criteria. It is recommended that the procedures and criteria established by ACI 301 be followed.

2.3 Based on the project's size and complexity, evaluate the need for certification of batch plants before concrete production and consider a qualification program for truck mixers, including mixer uniformity tests. National Ready Mixed Concrete Association certification procedures are recommended.

2.4 Sampling and testing concrete materials at established intervals during construction is usually required, and some properties will need to be monitored on a daily, weekly, or monthly basis. Generally, qualification tests will not need to be repeated during construction, but new qualification tests should be performed whenever there is a change in material or material source. Material test reports for cement, admixtures, and reinforcing steel can usually be relied upon for acceptance of these materials as delivered from the material manufacturer. To ensure more reliability, manufacturers' QA/QC programs should be formulated in accordance with ACI 121R.

2.5 Daily inspection of batching may be needed, depending on the level of plant automation, concrete strength, and quality level required. Regular checks for yield and aggregate moisture content are desirable.

2.6 Inspection of forming, pre-placement, placement, and post-placement of concrete activities should be part of the acceptance process for most projects, and special precautions should be considered during hot and cold weather concreting.

2.7 When form removal times are of importance to structural strength and stability, they may require monitoring by field curing of strength specimens or by using some form of nondestructive testing. Procedures and criteria established by ACI 305R and 306R are recommended.

2.8 Strength tests of concrete to correlate concrete production quality and design assumptions are almost always required.

(10) Inspection activities recommended for moderate projects:

	Inspection and testing Level B
Project examples	Industrial and commercial building construction; Low-rise construction; Small bridge construction; and Arterial streets or feeder route construction.
Scope of activities recommended for acceptance inspection programs	Sampling and testing of concrete materials before construction and at established intervals during construction.
	Use of proven materials and material test reports accepted for some required tests.
	Approval of concrete mixtures based on ACI 301 and ACI 318.
	Inspection of batch plant storage, production facilities, and delivery trucks before construction.
	Random inspection of batching operation during construction with checks for yields
	Preplacement, placement, and postplacement inspection of concreting activities (including curing). Special attention to mass concrete, hot weather concreting, and cold weather concreting.
	Sampling and testing of concrete in the field at established intervals by independent test laboratory or other qualified personnel acting as agents for the owner.
	Monitoring maturity of concrete before form removal or monitoring of other activities, such as post-tensioning, by means of a field-cured cylinder test program, or a nondestructive testing program.
Laboratory tests of concrete cylinders for acceptance of concrete strength.	

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