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Construction Quality Assurance and Control Practices in the USA

Assurance et conrôle de la qualité dans la construction aux USA

Qualitätssicherung und -Kontrolle in der Baupraxis der USA

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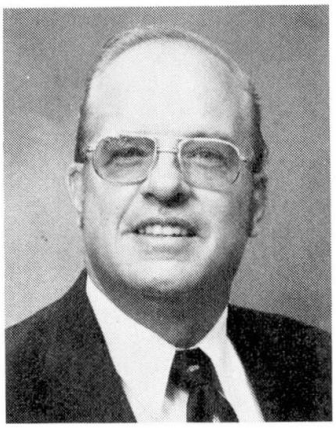

SUMMARY

An analysis of the construction industry in the United States which compares the Quality Assurance/ Quality Control systems adopted in the Highway, Nuclear Power Plant and U.S.Navy construction areas with the "traditional" quality control approach used in Building Construction is presented in this paper. Each sector of the industry is examined with regard to Background, Planning, Procedures and Organization and Management. This consolidation of existing concepts and practices should provide a direction for establishing an improved conceptual approach to quality assurance.

RESUME

L'industrie conventionnelle de la construction aux Etats-Unis est comparée du point de vue de l'assurance de la qualité et du contrôle de la qualité, avec les domaines de la construction des routes, des centrales nucléaires, et de la marine américaine. Chaque domaine est étudié de façon systématique: base, planification, procédure, relatives à l'assurance et au contrôle de la qualité. L'amélioration des concepts et des méthodes actuels aidera à trouver une meilleure base en vue d'améliorer l'assurance de la qualité.

ZUSAMMENFASSUNG

Die konventionelle Bauindustrie der USA wird in bezug auf Qualitätssicherung und Qualitätskontrolle verglichen mit den Bereichen Autobahnbau, Kernkraftwerkbau und Schiffsbau. Jeder Bereich wird dabei untersucht nach Hintergrund, Planung von Qualitätssicherung und -Kontrolle, Verfahren und Organisation und Management. Die Darstellung bestehender Konzepte und Verfahren soll helfen, einen grundsätzlich besseren Ansatzpunkt für Qualitätssicherung zu finden.

1. QA/QC IN HIGHWAY CONSTRUCTION

1.1 Background

In the early 1970's, a new "statistically based quality assurance/quality control" approach began to emerge on highway construction projects. The variability, as well as the central tendency, of material characteristics were considered. In addition: (1) the contractor or material supplier had to submit a "Process Control Plan" for approval prior to the start of the project, (2) the highway agency was held responsible for Monitoring the contractor's activity and the Final Acceptance of the material and (3) The highway agency was also held responsible for "Quality Assurance" auditing to ensure that the total quality system operated satisfactorily [1].

1.2 QA/QC Planning

State highway agencies carried out extensive testing programs on construction projects to collect sufficient statistical data about selected material properties. A variance analysis (to establish the sources of variability) was performed prior to establishing the tolerances that appear in the highway agency's "Acceptance Plans" and that govern the contractor's "Process Control" activities. Data from these testing programs also influenced the development of the "Adjustment of Bid Price Schedules" which were included in the Acceptance Plans [2].

1.3 QA/QC Procedures

With regard to process control, many contractors graphically document their measurements and test results in a "Statistical Control Chart" format. With regard to the acceptance function, the Acceptance Plan becomes the basis for a decision to accept the inspected "LOT" of material at full price, to accept it at a reduced price, or to reject it.

1.4 QA/QC Organization and Management

The organization and management of highway construction QA/QC is best portrayed as a combined effort. This effort, although managed by the state highway agency, allows the highway contractor complete managerial and organizational flexibility as long as the specification requirements and the process control plan commitments are met.

2. QA/QC IN NUCLEAR CONSTRUCTION [3],[4],[5]

2.1 Background

Public concern for nuclear safety has made quality more important than cost and schedule on nuclear projects. Failure to meet the QA/QC requirements established by the U.S. Nuclear Regulatory Commission (NRC) can result in either very large financial penalties or the denial of an operating license. Quality Assurance on nuclear power plant construction had its formal beginnings with the publication of the 18 Criteria of Appendix B of 10 CFR 50 (CFR = Code of Federal Regulations) in 1969. These criteria, together with the numerous interpretive documents and standards which have since been published, constitute a highly restrictive set of regulatory requirements which govern all quality activities related to a nuclear project. The NRC holds the owner (i.e., the electric utility) responsible for all QA/QC activities. As a result, the owner must develop an extensive QA/QC program for each project. Each firm involved in the project must also develop its own written QA/QC program.

2.2 QA/QC Planning

QA/QC planning in nuclear construction is an activity that occurs throughout the life of a project. The establishment of required quality levels for the various construction materials is not considered to be a QA function, it is viewed as an engineering design responsibility. There is generally no attempt made to perform an extensive testing program to set particular tolerances beyond those which are promulgated in the accepted industry codes and standards of practice.

2.3 QA/QC Procedures

Virtually every aspect of construction must be supported by documentation. Construction Procedures (CP's) prepared by the contractor's construction group represent the first level of documentation. They specify in great detail how a particular construction operation will be performed. The next level of documentation is typically generated by the contractor's QC group in the form of Quality Control Procedures (QCP's). These procedures are based on the commitments defined in the above mentioned Construction Procedures (CP's) and are written to provide the QC inspectors with a guide for judging the acceptability of the construction activities. A third level of documentation is represented by the Quality Assurance Procedures (QAP's). The owner and each contractor maintain their own Quality Assurance organizations. The contractor's QA group is primarily involved in an"auditing" role. The owner's QA group has essentially the same role with the additional responsibilities of overseeing the constructor's QA group and serving as the primary point of contact with the NRC. At any time the NRC may perform random unannounced inspections and audits to verify the total quality system. The extreme influence of a governmental agency such as the NRC has no parallel in other types of construction. Although the NRC does not have a direct contractual relationship with either the owner or the contractor it "controls" the QA/QC phase of each project.

2.4 QA/QC Organization and Management

The concept of organizational freedom for QA/QC personnel is an important aspect of the nuclear programs. On a nuclear project it is required that the QA and QC engineers report directly to their counterparts in the home office, not to the job site construction manager or project manager. This allows the QA/QC personnel to accomplish their tasks without undue cost and schedule pressure from the construction or project manager.

3. QA/QC IN U.S. NAVY CONSTRUCTION

3.1 Background

The U.S. Naval Facilities Engineering Command (NAVFAC) administers all construction work which support Navy ship and shore facilities. Nearly all work is accomplished by civilian contractors. A Navy Contractor Quality Control (CQC) Program was adopted in 1970 because many people felt that contractors were relying too heavily on Navy inspectors for control of quality and workmanship. The basic premise of CQC is that the individual contractor is completely responsible for the quality of his work.

3.2 QA/QC Planning

Contractor Quality Control (CQC) planning in Navy construction begins during the design phase and continues through the bidding and preconstruction phases.

The most significant contractor planning occurs between the time of contract award and the commencement of work. In this period of time the contractor must establish a quality control organization, develop procedures for processing submittals, provide an inspection and testing schedule, and develop documentation procedures. Each of these items, as a minimum, must be included in the mandatory CQC Plan, which must be approved by the Navy prior to commencement of construction. The contractor must designate a CQC representative in his firm who will insure that the CQC plan commitments are properly implemented.

3.3 QA/QC Procedures

QA/QC procedures in the CQC program can be divided into contractor related procedures and government related procedures. A major objective of both is the prevention of defects rather than the discovery of them after they occur. The contractor is responsible for testing and usually hires an independent testing agency that is satisfactory to the Navy. Documentation requirements in the contract stipulate that a daily report be prepared by the contractor. The report documents all quality control activities. Navy procedures govern enforcement, inspection and surveillance. Enforcement involves steps to correct a contractor's problems and deficiencies in carrying out his CQC tasks. Navy Inspection is an independent examination of construction for the purpose of insuring that all work complies with the plans and specifications. Surveillance is defined as "a close watch or observation kept over a contractor's inspection system to ensure that it is functioning properly..." It is accomplished by the assigned Navy inspector. It differs from nuclear QA in that it is not accomplished according to formal procedures. It is highly judgmental, and conducted at the discretion of the inspector.

3.4 QA/QC Organization and Management

The most important member of the contractor's QC organization is the CQC representative on the construction project. It is his duty to execute the "CQC Plan." The requirements state that the CQC representative must not be subordinate to the project superintendent, but rather must report directly to an officer of the firm. This parallels the concept of organizational freedom which is so important to nuclear QA. In addition to authority and organizational freedom, the contract requires that the CQC representative's duties be limited to those which involve quality control. This ensures that this individual gives adequate attention to his QC responsibility.

4. QA/QC IN BULDING CONSTRUCTION

4.1 Background

Building construction is accomplished in the United States for both private as well as public owners under many different types of contractual relationships. The "traditional" QA/QC framework is often established by American Institute of Architect's (AIA) documents. During the preliminary design phase the owner, in conjunction with the architect, establishes the quality, budgeting and time constraints which will govern the project. The attitude of the owner at this point in the process is crucial. If he insists that "time is of the essence" or if the competively bid contract approach is used in order to achieve a minimum cost situation then these factors, rather than QA/QC, will naturally receive the highest priority. The drawings and specifications which the architect develops typically reference industry codes and standards in order to define the desired quality levels of the various phases of the project. The contractor is very rarely required to submit a quality control plan for

approval by the architect or owner, perhaps because such a requirement would tend to increase the apparent cost of construction.

4.2 QA/QC Planning

The plans and specifications prepared by the architect, in addition to establishing quality levels and specifying the material and methods which should be used to achieve these levels are the primary planning documents of the QA/QC programs. This traditional approach to QC planning has been criticized because unreasonable, unrealistic, and poorly worded specifications are often used as the frame of reference.

4.3 QA/QC Procedures

A well defined set of procedures for building construction field inspection or quality control are typically not developed for building construction projects. Contracts between Owners and A/E's may specify the frequency of inspections (periodic or continuous), but they usually do not tell the inspector how or what to inspect. These matters are left to the discretion of the inspector, and although he may be guided by industry inspection codes and standards, his own judgment and experience often dictate his procedures.

4.4 QA/QC Organization and Management

Formal QA/QC programs, such as the Highway, Nuclear and Navy examples, do not exist on most Building Construction projects. As a rule, building contractors do not have a separate quality control staff in their project or home office organizations. The project manager and superintendent for a particular job is typically assigned the responsibility for all aspects of project control (cost, schedule, and quality, etc). Also they usually do not establish formal ongoing quality control programs. Project manuals, which provide field personnel with job control procedures covering timekeeping rules,administration of subcontractors, etc., are frequently prepared without ever mentioning anything about QA/QC procedures.

5. CONCLUSIONS AND RECOMMENDATIONS

The following conclusions and recommendations are considered to be of particular importance to the building construction industry:

1. A formal QA/QC system approach holds the greatest promise of achieving the goal of high quality construction because it encompasses an active quality effort over all phases of a project, and it requires the direct involvement of all participating organizations.
2. Implementation of a QA/QC system requires owner commitment prior to the selection of the architect and the construction firm. The owner cannot assume that these organizations will automatically preform QA/QC functions, particularly if each is under pressure to reduce costs and construction time. Specific requirements emphasizing QA/QC responsibilities must be included in the contractual documents.
3. The contractor should be required to develop some type of a "Quality Control Plan" which describes his inspection, testing, documentation and management procedures. The plan should be approved by the owner prior to job site mobilization and should be monitored by the owner during the construction phase.
4. Within their organizations, the contractor or the architect should maintain a Quality Control, and in addition, perhaps a Quality Assurance

group. These groups should have the necessary authority and organizational freedom to effectively perform their responsibilities.

5. The architect should be committed to writing clear and realistic specifications. To be realistic, quality levels should include tolerances based on the natural variability of the material characteristics being considered. The building construction industry should seriously consider the adoption of statistically based price adjustment schedules where appropriate. Such schedules, fairly applied, may provide the proper incentive for a greater QA/QC emphasis.

6. The architect should include in the specifications a description of the quality control and acceptance criteria for each work item. It is essential in a QA/QC system that each participating organization understand, in advance, the responsibilities and activities of all parties.

7. The QA/QC system which is adopted should be consistent with the type of project being built. It is totally inappropriate to directly transfer the QA/QC complexity required on a nuclear power plant project to a more conventional type of building project. Selective adoption of aspects of the system cited above, should, however, improve the level of quality which is currently being achieved.

REFERENCES

1. WILLENBROCK, J. H., "A Manual for Statistical Quality Control of Highway Construction: Vol. I and II," The Federal Highway Administration, Washington, D.C., Jan. 1976.

2. WILLENBROCK, J. H., P. KOPAC, "A Methodology for the Development of a Price Adjustment System for Statistically Based Restricted Performance Specifications," (Report for PennDOT), The Pennsylvania State University, University Park, PA, Oct. 1976, 160 pgs.

3. WILLENBROCK, J. H., H. R. THOMAS, J. BURATI, "A Comparative Analysis of Structural Concrete Quality Assurance Practices on Nine Nuclear Power Plant Construction Projects," (Report for the United States Department of Energy), The Pennsylvania State University, University Park, PA, June 1978, 835 pgs.

4. WILLENBROCK, J. H., H. R. THOMAS, (editors) Planning, Engineering and Construction of Electric Generation Facilities, John Wiley & Sons, Inc., New York, May 1980, 869 pgs.

5. WILLENBROCK, J. H. (editor) Construction of Power Generation Facilities: Experience with the Implementation of Construction Practices, Codes, Standards and Regulations, A.S.C.E., New York, May 1982, 613 pgs.