Positive Influences of Nuclear Construction

By ASCE Construction Division Committee on Construction of Nuclear and Power Generation Facilities

Abstract: Construction on the first commercial nuclear power plant began in the early 1950s. Since that time, over 100 commercial nuclear generating units have been constructed and licensed to operate by the Atomic Energy Commission/Nuclear Regulatory Commission. This massive construction program over the last three and a half decades has generated many lessons to be learned by the civil engineering profession. This paper discusses the positive influences that nuclear construction continues to have on the construction industry.

Introduction

Over the last thirty-five years, the construction industry has evolved from a fairly basic industry that built dams, bridges, roads, office buildings, and industrial plants, to a complex industry that has built multi-billion dollar megaprojects which include nuclear facilities. Construction became even more complicated during this period with the ever-increasing amount of government regulation imposed on the industry.

In the 1950s, only one nuclear plant was put into commercial operation. During the 1960s several smaller nuclear units were completed. In the 1970s, construction was started on dozens of units. The growth in size (rated capacity) as well as regulatory effects increased the complexity of nuclear power plant construction. By the 1980s, the construction of nuclear plants drastically diminished. No new plants were started in the 1980s and work on those projects under construction was either completed or terminated. However, the 1980s have seen a new phase in the industry. There has been a major move to modifications of existing units to improve performance and safety as well as replace deteriorated systems.

Many factors influenced the construction industry in the 1970s and 1980s. Nuclear power plant construction, the space program, the Occupational Safety and Health Act, the Interstate Highway System, the Alaska pipeline, the formation of the Environmental Protection Agency, and the accident at Three Mile Island are just a few of the major factors. Because of the complexities and special performance requirements placed on nuclear plants, the nuclear industry had a significant influence on techniques, safety, quality, equipment, and management of construction. Some specific examples of the positive influences on the construction industry are examined in this paper.

Quality

As the popular automobile commercial says, "Quality is job one." Quality in construction made more gains in the nuclear era than any other aspect of construction. The mandatory planning and training of individuals performing nuclear safety related work, as well as efforts to make individuals respon-

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sible for their own performance through checklists and sign-offs, has had a significant impact on the construction industry.

In the inspection area, Title 10, Appendix B of the Code of Federal Regulations established an 18 point criteria for quality assurance at nuclear power plants. Using this criteria as a basis, the construction industry developed extensive quality assurance programs that are still being used on non-nuclear construction projects. Detailed written inspection procedures, formal inspector training, improved document control, better material control, and independent inspection agencies are but a few areas where quality has improved throughout the construction industry as a result of nuclear construction.

A study called "Construction Industry Cost Effectiveness" by the Business Roundtable points out other benefits and improvements in quality assurance such as:

1. Application of QA/QC principles results in cost effective design and construction.
2. A total QA program, effectively implemented, can help open communications feedback among project team members.
3. QA/QC can help identify areas for operation improvement, thereby increasing competitiveness with a greater return on investment realized.

Some other far-reaching developments include:

1. ASCE and other organizations are developing guidelines to incorporate QA/QC principles into the civil engineering curricula of major universities and colleges.
2. The construction industry as a whole has recognized that QA is a vital and necessary element of the total project engineering-management process.
3. Several code/standard issuing bodies have voiced a strong indication hat they will endorse and invoke the QA/QC programs under development. Some of these include: (1) ASCE's "Manual of Professional Practice for Quality in the Constructed Project"; (2) ACI's Report ACI 121-R-85, "Quality Assurance Systems for Concrete Construction"; and (3) ASQC's "Construction Quality Program Manual."

Safety

In the early 1970s, the Occupational Safety and Health Act was passed by Congress, and the construction industry immediately began placing a greater emphasis on safety in the work place. The nuclear construction industry, with thousands of workers working on massive and congested projects, became a leader in developing new techniques to comply with the OSHA regulations.

Better shoring in deep trenches, improved scaffolds, emphasis on air quality in confined spaces, ear protection to protect from excessive construction noises, and testing requirements for cranes are a few of the areas in which the nuclear construction industry improved safety on the job. The use of new and/or hazardous materials such as solvents, epoxy coatings, and special processes have created an awareness of the need to communicate the hazards and to train workers in the precautions to be used with these materials.

The emphasis on safety has been very effective. Some projects were able to record over a million consecutive work hours without a lost time accident several times during the construction of these large projects. At least one, two-unit project was built without a single construction fatality even though it took over 55,000,000 construction work hours to build the project.

Design

Many improvements were made in the design processes that are being utilized by the entire construction industry. Some of these include:

1. Development and use of computer-aided drafting (CAD) systems.
2. Improved interference analysis programs.
3. Engineering design programs to analyze pipe stress and support locations.
4. Engineering design programs to analyze building seismic design requirements.
5. Improved use of load monitoring for structures.
6. Programs for developing electrical circuit and raceway design.
7. Development of standardized (generic) technical specifications and plant design.
8. Programs to improve records retention and as-built design drawings.
9. Use of plant models in design to analyze constructability in complex areas.
10. Use of constructability review teams which facilitated design and lead to such innovations as prefabrication and modularization of components.
11. Heightened awareness of value engineering and risk analysis associated with building capital intensive projects.
12. Heightened awareness of the management control/decision process due to prudence hearings commissioned by state public utility commissions.

On future nuclear plants, there will be a strong emphasis on either basing the design on a reference plant or having essentially all design completed before construction begins. Past experience has shown that there are tremendous benefits to using a standardized design along with either fixed price or lump sum contracts.

Construction Management

Many nuclear projects required large and complex management organizations because the construction of projects lasted 10 to 15 years and involved thousands of personnel to design and build them. This gave many young engineers the opportunity to assume management roles and to learn the techniques for managing large construction projects. Planning, estimating, budgeting, progress reporting, working with contractors and subcontractors, negotiating labor disputes, working with financial and legal matters, and dealing with government regulation and inspection are some of the experiences to which these young managers were exposed while working on nuclear plants. This valuable management training for many young engineers will have a very positive effect on the construction industry for years to come, and will help improve contract development and administration throughout the industry.

In the area of labor management, the nuclear construction industry initi-

ated the Nuclear Power Stabilization Agreement with the AFL-CIO Building Trades Council. This was the first national attempt to allow contractors the flexibility in establishing work weeks and overtime pay, and eliminated many nonproductive practices. It was a signal to the construction industry which opened the door for many innovative agreements with the unionized building trades.

Another factor that will aid construction management is the growth and enhancement of the computer industry during the nuclear construction era. Nuclear construction required the development of larger data bases that are now available on smaller, less expensive computers. Scheduling and cost control software has been developed that can be run on personal computers at remote construction sites to monitor the schedule and budget performance. Data covering records control, records retention, and change control are available almost instantaneously using modern computer programs. Material status and inventory, design status, construction progress, and overall project expenditures can be continuously tracked using modern high speed computers. Much of this computer technology was developed to support the needs and demands of the nuclear construction industry.

Materials and Equipment

Construction materials and equipment have improved in the last 20 years due greatly to the requirements of the nuclear industry.

The transportation routes required for large nuclear vessels have generated port facilities, rail routes, special lifting and hauling equipment, and technology that can now be used for other heavy transportation needs. For example, a rail line between Charleston, South Carolina and Charlotte, North Carolina was upgraded to be able to handle four Reactor Vessels and sixteen Steam Generators being shipped to the McGuire and Catawba Nuclear Stations. Clearances and maximum load restrictions had to be increased all along this route to allow for the oversized and extremely heavy loads.

There is now a higher awareness for not using corrosive materials in construction; i.e., scaffold boards, cleaning and marking agents, chlorides, etc. Also, the use of fireproof lumber for construction of formwork and scaffolding arose from the need to reduce risks and insurance costs on these large nuclear projects.

In the welding area, much of the welding equipment in use today was developed to meet the needs of the nuclear industry in order to produce high quality welds efficiently. Portable, lightweight pipe cutting and beveling equipment arose from the need to be able to quickly cut and bevel pipe for both new and modification construction at nuclear plants.

There is an improved effort throughout the construction industry to control and protect material and equipment in storage.

The testing and development of concrete anchors that can withstand seismic loads was enhanced during the nuclear construction era.

The development of robotics has been accelerated because of the needs and applications of nuclear construction doing modifications in radioactive areas.

Techniques

The nuclear construction industry has in general raised the skill levels of the individual craftsman. Craftsmen have been exposed to new techniques

and equipment which will make them more valuable to other segments of the construction industry. Additionally, they have become more aware of quality as a responsibility of the individual craftsman.

Some specific construction techniques are:

1. The requirement to place large numbers of concrete anchors in heavily reinforced concrete walls encouraged the development of improved NDE techniques and equipment to avoid damage to reinforcing steel: (1) A radiography technique was developed which could identify the depth, location and size of reinforcing steel to within an eighth of an inch in very thick walls; (2) an induction/infrared sensing method to locate reinforcing steel in walls is now available; (3) a radar (very low frequency ultrasonic) method to locate reinforcing steel in concrete walls was also developed; and (4) a ground fault switch for concrete anchor drills which automatically shuts power off when the drill bit touches reinforcing steel is now in use.
2. Research and testing required to meet the needs of nuclear construction have brought about many changes to the construction industry: (1) Visual weld acceptance criteria for structural welds was revised to permit non-critical defects within expanded limits established by destructive testing. Savings will be significant without compromising integrity; and (2) new regulations for nuclear plant security required highly sophisticated and effective systems. To develop and implement these security systems for over 100 nuclear units required the creation of several new companies, the development of new products, the publication of a great deal of security related information, and the development of security engineering capabilities within many leading A/E firms. The knowledge gained from providing security systems for nuclear plants is now being used in other areas. For example, the Department of State has recently required the services of the security engineering community to support the upgrading of our embassies worldwide.

Conclusions

The examples given in this paper are but a few of the areas in which nuclear construction has had a positive influence on the entire construction industry. Through increased quality awareness, research and development of construction equipment and techniques, project management training, and the experiences learned on massive construction projects, the entire construction industry has benefited from the nuclear construction era.

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Appendix. Reference

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