

## Engineering of Structural Modifications for Operating Nuclear Plants

T.J. Duffy, P.A. Gazda

*Structural Engineering Division, Sargent & Lundy Engineers, 55 East Monroe Street,  
Chicago, Illinois 60603, U.S.A.*

### ABSTRACT

The engineering of structural modifications for operating nuclear plants offers many challenges in the areas of scheduling of work, field adjustments, and engineering staff planning.

The scheduling of structural modification work for operating nuclear plants is normally closely tied to planned or unplanned outages of the plant. Coordination between the structural engineering effort, the operating plant staff, and the contractor who will be performing the modifications is essential to ensure that all work can be completed within the allotted time.

Due to the inaccessibility of areas in operating plants or the short time available to perform the structural engineering in the case of an unscheduled outage, field verification of a design is not always possible prior to initiating the construction of the modification. This requires the structural engineer to work closely with the contractor to promptly resolve problems due to unanticipated interferences or material procurement that may arise during the course of construction.

The engineering staff planning for structural modifications at an operating nuclear plant must be flexible enough to permit rapid response to the common "fire drills," but controlled enough to assure technically correct designs and minimize the expenditure of man-hours and resulting engineering cost.

## 1. Introduction

In these days of continuing regulatory requirement changes and high interest rates, the engineering of structural modifications for operating nuclear plants has taken on greater importance for most owners. The regulatory requirement changes requiring structural modifications must be incorporated in a timely manner to permit continued operation of the plant. Also, many owners now consider plant betterment projects as the most economical means of making existing plants more efficient and ensuring their continued licensability. This paper will discuss the general types of modification work, the reasons for these modifications, and will review some specific structural modifications and how they were accomplished.

There are three basic types of modifications: 1) Scheduled - Non-Outage Related, 2) Scheduled - Outage Related, and 3) Emergency.

Scheduled - non-outage related modifications are planned and scheduled by the owner and do not require the plant to be shut down in order for the work to be accomplished. Outage related work, however, does require that the plant be shut down in order to minimize or eliminate problems of exposure to high radiation and temperature and/or of ease of access. Emergency modifications are those modifications which are required immediately in order to maintain plant safety or continue the uninterrupted operation of the plant. Modifications of these types may be required for various reasons.

The owner may desire to improve his plant for the sake of plant betterment. Some examples of plant betterment are additional office space, maintenance shop space, changes or additions to the radwaste systems, and onsite storage facilities for low-level radwaste or spent fuel.

Revised regulatory requirements in the United States, such as those contained in the NRC's IE Bulletin 80-11, "Masonry Wall Design," may also dictate that modifications be performed. In the case of IE Bulletin 80-11, additional structural steel may need to be installed in order to allow previously designed masonry walls to meet the intent of the NRC Bulletin.

Malfunctions of equipment or systems during operation may require checking or redesign of existing structures for new or revised loadings. These types of modifications generally are the most challenging due to the tightness of the resulting schedule.

Case studies of modifications required due to plant betterment, revised regulatory requirements, and malfunctions are discussed in the next section.

## 2. Case Studies of Problems and Solutions

### 2.1 Standard Seismic Conduit Supports

Wiring systems in operating nuclear plants often require additions or modifications. New conduit required for fire protection, separation criteria, new security systems, and additional equipment for control and instrumentation are frequently being installed. A problem confronting most owners is the cost required to design seismic conduit support details for each modification.

A solution to this non-outage related modification is the generation of a standard seismic conduit support package which may be used by the station's own technical staff or

the installation contractor to support safety-related conduits for any modification. This package could contain 15 to 20 types of standard seismic conduit support details (see Figure 1 for typical details), along with the material requirements, location selection procedures, and installation requirements. The package would allow the station personnel to select the conduit routing and types of details for the support of the conduit. Also, conduit supports for modifications designed by several different engineering firms would be of the same type and would provide consistency for the installation crews.

The design of standard seismic conduit supports should, as a minimum, consider the required loads, original load combinations, and allowable stresses consistent with the plant's design basis. However, current regulatory requirements that are less stringent should be permitted to be used. The material types used for construction should be clearly defined to ensure that the required design properties, such as yield strength, are obtained. The use of in-place concrete strengths should be considered to minimize or eliminate potential reinforcement modifications.

In the initial design of the standard conduit supports, all reasonable construction tolerances which may be required to install the support must be considered. Such tolerances should include angularity in the installation of expansion anchors, relocation of expansion anchors due to potential reinforcing bar hits, support centerline attachment point to anchored plate, conduit location along the length of support, distance between supports, etc.

The use of standard seismic conduit supports requires close interaction between the structural engineer and the owner's plant engineers in order to assure that the standard details fit the station's needs. The engineering firm should also have the structural engineers on call to support the field when the engineering of non-standard seismic conduit supports is necessary.

## 2.2 IE Bulletin 79-14 - "Seismic Analysis for As Built Safety Related Piping Systems"

Regulatory requirements such as those defined in IE Bulletin 79-14 present many challenging problems to the structural engineer. In some cases, an owner will hire an engineering firm not responsible for the original plant design to do the as-built piping analysis. An interface between the two engineering firms results in order to exchange information such as existing drawings, design criteria, hanger details, piping analysis results, hanger loads, etc. Procedures are required in order to ensure that each organization has a well-defined scope and understands interface requirements and schedules. Monitoring of the progress of these interfacing activities must be performed by the owner to ensure successful completion of the modification.

In the case of 79-14, many existing pipe hangers needed to be field verified for location, size, etc. Frequently, field verification must take place during outage situations due to high radiation exposure or other access problems. This dictates that careful planning and scheduling be followed in order to ensure a timely and orderly collection of field data consistent with the scheduled release of any required modifications during the outage. Security clearances should be obtained and all required

personnel should receive radiation training in advance of the outage so that the field team is ready for work at the beginning of the outage.

### 2.3 Boron Injection Tank Replacement

During a recent outage at an operating PWR nuclear plant, a routine equipment inspection detected a major leak in a boron injection tank (Figure 2). Because the problem was found late in the outage, time was of the essence in rectifying the problem. Due to the severity of the leak, the owner decided that the replacement of the tank would be the best solution.

Structural engineers were immediately sent to the station at the owner's request. These engineers were from a group who were familiar with the plant, its original design basis, and had the appropriate security clearances and radiation training.

In order to remove the existing tank, structural steel bracing acting as an upper lateral support had to be removed. Care was taken in choosing the field cut locations to allow the easy splicing of the replacement steel. Also, a temporary opening was required in a 12-inch thick reinforced concrete slab in order to remove the tank (Figure 2). An evaluation of the effect of this opening on the structure was performed by close coordination between the structural engineers in the field and in the office. Temporary lifting beams were designed and fabricated on site in order to expedite the modification. The complete replacement of the tank including all related piping took just 3 weeks.

This modification required expertise in the areas of structural analysis, reinforced concrete design, and steel design. The original design calculations and design drawings were reviewed to determine the existing structure's dead load, live load, and seismic load. The presence and magnitude of hanger loads were field verified. The capacity of the 12-inch slab that required a 6-foot by 6-foot field cut opening for the tank removal was reviewed and found to require additional supporting members. All the replacement steel and connections were designed and detailed using materials that had been verified as being easily available to the site to ensure rapid procurement. All modifications were field verified and accordingly modified by the structural engineering team.

### 3. Summary

The basic requirements for successful structural modifications at operating nuclear power plants can be summarized as follows:

- (a) As with any successful project, there must be a detailed scope and schedule of work. Interfaces between organizations must be well defined and their progress and support of interfacing organizations must be monitored by the owner.
- (b) A team of engineers who are familiar with engineering modifications at existing plants must be available to perform the work. The latest analytical capabilities should be available to minimize the extent of any required modification. The engineering firm should have the flexibility to increase the structural modification staff and add engineers in the specialized areas of materials, geotechnical, civil, etc., if the situation warrants it.

- (c) Designs for structural modifications should be field verified during the preliminary stages of design to ensure the reasonableness of the design and then again, prior to their release for fabrication or construction, to reduce potential constructibility problems.
- (d) Engineers familiar with the modification should be available to assist the contractor with the solution to unforeseen field problems. Quite often, one of these engineers will be required to be on site for the duration of a modification to expedite the resolution of minor detail changes the contractor may wish to make in order to facilitate construction and to maintain schedule. The value of this interaction cannot be understated when working within tight outage related schedules.
- (e) All modifications in their as-built condition should be documented on the original plant design drawings. This will ensure the existence of an accurate set of plant drawings which will be useful for future modifications. When multiple engineering firms are involved with modifications at a single plant, the owner should ensure that all as-built information is incorporated into the initial plant drawings and that the combined effect of these modifications does not violate the design basis of the plant.





