Management Guidelines

Preventing/Mitigating Field Construction Problems

By James Lefter, P.E., M. ASCE

When teaching in the area of Construction Engineering and Management, the author presented "Guidelines" to help graduate students learn how to prevent or mitigate field construction problems. The Guidelines complemented the essential technical and management skills taught in the core curriculum.

Because errors at any stage of design and construction may cause field problems, the Guidelines encompass the entire process. Experienced construction managers and engineers know these Guidelines, but enforcement is often lax. Students found the Guidelines deceptively easy to understand, with little new technical expertise needed for implementation. But, as a former student wrote in a plaintive letter to the author, they are very difficult to enforce. The author believes that many field problems would be avoided or mitigated if the Guidelines were applied assiduously.

In the review of individual Guidelines below, illustrative examples in italics demonstrate how vulnerable any project is to field construction problems. Examples from the author's experience are prefaced by an asterisk and/or by reference to Veterans Administration Board of Contract Appeals (VABCA) Decisions in which the author served as the VA Contracting Officer.

Guideline 1

Promote the Worker's Innate Desire to Do a Good Job

Workers want to do a good job and take pride in their work. Sadly, many workers believe they have to choose between honesty and their own immediate interests. Mutual confidence is developed through successful interaction. Managers should set an example; assign clear duties and responsibilities; offer timely guidance; provide environmental and physical safety, appropriate tools, and equipment; and, listen to and respond to worker concerns. Whistle-blowers are often among the best, most conscientious workers, but are often frustrated by their inability to draw attention to their concerns.

Two measures that encourage worker honesty directly are: 1) an honor code type certification on important project documents, and 2) a system that assures high probability that transgressors will be caught. High probability of detection is a greater deterrent than the severity of punishment for the transgression (Mazar and Ariely 2006).

Guideline 2

Follow Building Code Requirements

The building code is mandated by law. Failure to follow the governing building code in design or construction may be considered as proof of negligence.

For many years, California structural engineers and contractors routinely used Type V (sulfate-resisting) cement for residential foundation concrete, with a specified f 'c of 2000-3000 psi (13.6-20.5 mpa). The water-cementitious materials ratio was generally in the range of 0.8 – 0.6. There were no reports of sulfate deterioration of the foundation concrete. However, an ACI 318 revision required the use of Type V cement and a maximum water-cementitious materials ratio of 0.45 for foundation concrete exposed to sulfates. This requirement was included in the 1985 Uniform Building Code and considered applicable to residential construction in California. After construction of a large housing development that did not conform to the new requirement, lawsuits amounting to billions of dollars were filed alleging deficiencies in foundation construction due to code violations, even though there was no evidence of foundation concrete deterioration due to sulfate exposure (Bondy 1999).

Guideline 3

Require Independent Review of Plans and Specifications

Poor quality construction documents cause many problems, although details are rare in the literature (Lefter 2005). Two main categories of defective documents are: 1) those poorly coordinated, and 2) those with too many details of construction left up to the contractor.

Independent Review should address the basic question: Is the project buildable? The author strongly encourages Peer Design and Constructability Reviews, through which many potential problems are discovered and corrected at a relatively low cost (Elwin 2000).

The collapse of the Sleipner Offshore Platform in the North Sea on August 23, 1991 was reviewed by Collins, Vecchio, Selby and Gupta (1997). The article was based on extensive laboratory testing and analysis. A principal cause of the collapse was attributed to a computer program that underestimated the applied shear stress.

Figure 1.

An independent review would have caught and corrected this error.

Guideline 4

Build it Right the First Time

There are estimates that over 10% of all new construction has to be reworked, much of it due to recurring types of problems. Lists of "most frequently encountered field construction problems" usually include low strength concrete, premature removal of forms, omission or misplacement of reinforcing steel, improper flashing, weld defects, inadequate soil compaction, unbraced masonry walls and unbraced structural steel erection. These types of problems are generally preventable.

Column and slab concrete strength specified for a reinforced concrete high rise building was f 'c=5000 psi (35 mpa). The compressive strength of the concrete in place, based on field cores, ranged from 950 psi to 3900 psi (6.5-27 mpa). Compared to the approved design mix, the field concrete had lower cement content, a higher water-cementitious ratio, and unapproved lightweight aggregate (Szypula and Grossman 1990).

Many constructors seem to consider not knowing how to build something a personal weakness. Encourage craftsmen and field superintendents to seek help if they don't know how to build "it."

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Guideline 5

Provide Continuous Field Inspection from the First Day

Competent and continuing field inspection is a fundamental need for any quality assurance/quality control program. Most construction contracts hold the contractor responsible for quality control and require a documentation program. The author advocates that contractor's quality-control be augmented by independent inspectors who know the work well enough to judge if it is being done in accordance with contract documents and good practice.

**Column reinforcing bar cages had been erected. The carpenter foreman measured the cages and found them too large for the column sizes shown on the drawings. He cut off the last row of column bars to fit the column sizes shown. Fortunately, the error was discovered by independent inspectors and corrected before the concrete was placed.*

- How To See What Is There and Not There: Develop, Maintain, Update and Enforce "Check Lists." Each inspector performs differently, based on personal experience and interest, and may neglect some areas while over-emphasizing others. Check Lists can help bring uniformity and consistency to almost any process, including inspection. Textbooks and publications on quality-control and construction inspection by suppliers, manufacturers, and professional societies often include "Check Lists."

Check lists are vital when coordinating the work of several crews. For example, placing wall concrete in hot weather requires a mix that flows smoothly and without segregation while extending the time for placing. The method of placing the concrete (pumping or crane and bucket) impacts the mix ingredients (air entrainment, use of retarder and superplasticizer, aggregate size, etc.), lift heights, crew size, location and number of vibrators, placement monitoring, and locations of control joints and construction joints. Overlooking any of these factors can result in unacceptable construction. Figures 1, 2 and 3, from one of the author's projects, show that the concrete placement did not meet important ACI-318 Code Requirements, including that the that top surfaces of lifts be level (Figure 1, page 45), concrete flow readily into spaces between reinforcement (Figure 2), and be placed continuously until completed (Figure 3). Using check lists would have helped prevent this embarrassing and costly fiasco.

- Inspection Should Be Geared to Prevention Not Rejection.
- Do Not Rely on Self Inspection: Monitor the Performance of Every Level of Field, Office Staff, Including Inspectors.

The Alaska Pipeline was almost half finished in 1975. Sections of 80-foot pipe lengths had been field welded to the pipeline already in place. Strict weld quality control procedures in force began with visual inspection and were followed by radiography to detect hidden flaws. Metal tags identified each weld, each weld was x-rayed, and a computer uniquely identified each weld. Then an Inspector claimed that he was fired for refusing to falsify radiographs. He testified that x-ray equipment could not keep up with the welders, who were under pressure to maintain the construction pace. Reinspection of 30,800 field welds showed that 3,955 were questionable. A Congressional Committee later reported that the quality control system had broken down because on-site inspectors felt they had little support from their organization or federal officials (Ross 1984).

- Trust but Verify. Contract enforcement should not be a matter of trust, it should be a matter of record and procedure.

A testing company was accused of falsifying concrete strength test results on many city, commercial, and industrial projects in New York (Rashbaum 2008).

Guideline 6

The Construction Schedule Should be a Tool Not the Master

The Project Schedule is the primary control system for a project. Updating the schedule as the project progresses is a priority responsibility of the project manager, requiring comprehensive review and coordination of all concurrent and planned future activities.

The author was a Member of the National Academy of Engineering Committee that evaluated the management of Boston's "Big Dig," the Central Artery/Tunnel (CA/T) project (NAE 2003). Although the project mangers were highly qualified and experienced, the project was very complex, and difficult to plan and coordinate. It was plagued by cost and schedule overruns. The Committee Report discussed several methods used to enforce the overall project schedule that often led to extensive modifications and change orders during construction. Excerpts from the NAE Report follow:

"…the risks of highly technical engineering design and construction, unknown soil conditions, existing underground utilities, and other factors that increase costs and delay schedules should and could have been anticipated and addressed through additional planning and design, site analysis and cost and schedule contingencies." (p. 15).

"The project used a fast track design and delivery method to reduce overall project time… The CA/T work packages had complete civil design, but they frequently required modifications to accommodate project-wide systems that were designed in later packages. The result has been a high rate of claims and changes…" (p.16).

Figure 2.

"The project had large cost increases resulting from changes in scope, design, and project limits, as well as from deficiencies in coordinating contracts. … All contract modifications should be comprehensively reviewed – prior to execution – for impacts on scope, design details, interfaces, and contract duration." (p.18).

"Construction acceleration (extended periods of overtime and longer workweeks), with accompanying premium costs, could lead to problems with work quality and a bigger-than-expected list of items to be reworked or completed prior to acceptance." (p.18.)

The Committee advised that strict adherence to the schedule, if it means sacrificing project coordination, may result in time and money wasted.

If a project is behind schedule, the project manger should review the remaining schedule to find opportunities for recovery. Most schedules are planned and sequenced on a preferential rather than need basis, and it may be possible to recoup time by resequencing activities. This was accomplished on the "Big Dig" project.

"The project management consultant developed a "Milestone Manager" to provide real time performance data and develop new work sequences to work around delays." (p. 16).

Finally, as reported by Kim and de la Garza (2003), the traditional CPM schedule is often not realistic; even resource-limited CPM schedules generally do not calculate float and critical paths correctly. Kim and de la Garza presented a direct solution to this problem.

Guideline 7

Address Field Problems When They Arise

Contracts usually assign responsibility for means, methods and sequence of operations to the Contractor. However, Owners can be held responsible for their own actions or lapses as well as those of their agents, including designers, project managers, and independent inspectors. Therefore, all parties should work together to resolve problems in the field when they arise.

**A $14 million construction contract required*

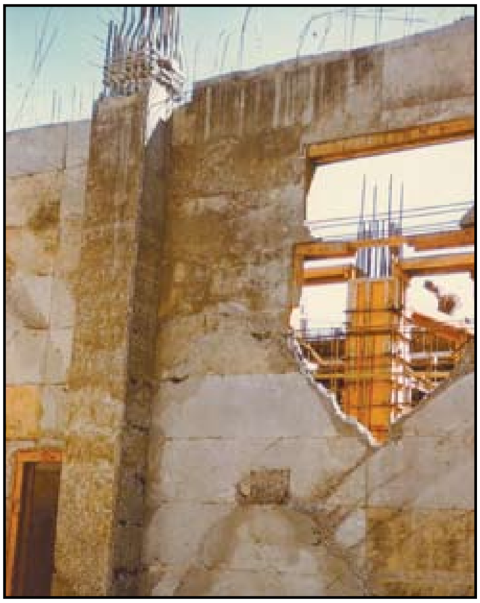

Figure 3.

pre-drilling through a layer of "cemented sands" for foundation pile installation. The contractor's equipment could not penetrate the layer. The Owner (Government) offered no direct help or advice, just pointed to the soil borings logs and insisted there was no differing site condition. The contractor completed the project nine months late. He then filed a "Differing Site Conditions" claim for direct costs of $1.5 million and prepared an additional claim for acceleration costs of $5.0 million. The Owner counter-claimed $2.7 million for liquidated damages. Total claims: $9.2 million. During the Board of Contract Appeals hearing, both sides learned that there were discrepancies in the field logs. Although the Owner "won" the case, there were no real winners, only losers. In retrospect, the Owner should have been more open to the possibility of a differing site condition and considered sharing the cost of more suitable equipment. This would have been a small fraction of the cost of litigation, preparation for the court hearing, schedule delays, and the claims themselves. (Murray Walter, Inc. 1987).

Courts generally recognize normal give and take between Owner and Contractor when both sides are jointly seeking a mutually agreeable solution to a problem. A notice of a claim is necessary to indicate when "…the battle lines of a dispute were clearly and irrevocably drawn." (Santa Fe, Inc. 1986).

Occasionally, design engineers are reluctant to help solve field problems because of concern of assuming additional responsibility. Review of a number of court decisions has persuaded the author that the courts generally recognize contractual responsibilities but, nonetheless, frequently assign to the Engineer-of Record authority and responsibility over construction operations involving worker safety.

Guideline 8

In Negotiations, Look for Common Interests: A Better Deal for Both Parties

In *Getting to Yes*, Fisher, Ury and Patton (1991) presented "principled negotiation." Principled negotiation is deciding issues on their merits rather than through haggling; looking for mutual gains wherever possible; and, where interests collide, looking for some fair standard, independent of either side.

Guideline 9

To Win In Court: Perform an Experiment to Enhance Expert Witness Testimony

Expert witnesses can be problematic in many ways: Judges and juries often do not understand technical presentations; there are questions as to how much weight should be given an expert witness's testimony; and, because each expert's testimony usually supports the sponsor, expert witnesses often cancel each other out.

An expert witness should perform an experiment or test to strengthen a presentation. A good experiment can impress both judge and jury.

**In a case discussed earlier* (Murray Walter, Inc. 1987), *the contractor testified that if the materials he was to predrill had been classified as "limestone" instead of "cemented sands," he would not have bid the project. Consequently, he suffered major losses. The Government's expert witness presented several limestone samples to the Board. Their compressive strengths ranged from 2000 psi to 10,000 psi (14-70 mpa). He encouraged the Judge to examine the samples and scratch them using his own pen knife. The Judge was persuaded that the word "limestone" would not have been a better description of the hardness of the material and based most of his decision on this experiment…*

Summary

Guidelines were presented to help graduate students learn how to prevent or mitigate field construction problems. The Guidelines complemented the essential technical and management skills taught in the core curriculum. Although experienced managers can readily expand on them, enforcement is often lax. The author believes that many field problems would be avoided or mitigated if the Guidelines were applied assiduously.▪

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