A Case Study in STEM Education: Construction Management Capstone Case Study: Museum at Five Points

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ABSTRACT

This paper places students in a role playing situation that revolves around the Museum at Five Points, a project which is already under construction. As the case develops the students, in the role of the project manager, must through a series of questions be able to make a decision on the extent of the problem, who was responsible, what questions must be answered to solve the problem, what work must be performed to remedy the situation, what costs are involved, how will the problem(s) affect the schedule, and what trades will be involved. They are required to make a decision that will be agreeable to all parties involved and at the same time resolve the problem in the most efficient and timely manner. The teacher/facilitator initially provides the following information: setting and initial statement of problem, time frame and conditions of site, job site description and personnel on the project, and description of conversation of problem presentation. The teacher/facilitator starts off the case with a statement from the assistant to the project manager notifying them of a potential problem. The students must then take over the role, ask questions and proceed through the project's resolution.

Keywords: Case Study, Construction Management, Capstone, Role Play, Critical Thinking Skills.

1. INTRODUCTION

The construction management (CM) profession covers an extremely broad and diverse industry ranging from small remodel projects for a few hundred dollars to multi-year duration projects with costs exceeding $9 billion. In order to prepare students and future leaders of the industry, it is necessary to educate them not only in technical and business skills, but also in the intricacies of every aspect of construction.

The capstone class combines subjects the students have taken as separate courses: business, estimating, scheduling, surveying, writing, presentation skills, safety, contracts and construction forms, risk management, finances, and 3-D modeling. The CM goals are not only to be able to know these topics individually but to be able to merge them together and through the use of critical thinking assimilate them and make them second nature. The primary goal is to prepare them for a leadership role in the construction management industry.

A method that has proven effective is using case studies. Through the use of specific case studies students can be placed in the role of decision maker. In this setting they are required to use the skills learned in the CM program to not only determine if a problem exists but to solve the problem in the most effective and efficient manner.

This is case study of a project that the author was involved with while acting in the role of project manager for the construction of a new $3 million museum in a semi-rural setting. A thorough written history of the events surrounding the case and its outcome are provided for anyone using the case as a teaching tool.

The instructor should read and be familiar with all aspects of this case prior to teaching it. The narrative and all events and individuals involved in the case are provided. It is the instructor's position to act as a facilitator and assist the students in using their critical thinking skills to ascertain the extent of the problem and work their way through it to final resolution.

The students are to take the position of the project manager. No other limitations are placed on the students and the students are allowed to utilize any tools they deem necessary to assist them in solving the case.

2. OBJECTIVES

The objectives of this case study are testing the students' ability to:

- Develop critical thinking skills through application of concepts and principles already learned to solve a new problem.
- Develop the ability to analyze the situation by visualizing interrelationships of all parties involved in the case.
- Develop the skills necessary to make a sound judgment based on criteria they have acquired by information gathering skills gained in the first two objectives.

3. FACILITATE DISCUSSION SETTING

Arrange seating that encourages eye contact and sets stage for interaction among students. Students may be arranged in small groups to discuss possible responses or left as a single group.

4. QUESTIONS AND NARRATIVE

The instructor should use questions/probes that are:

- thought provoking (e.g., open-ended) and explore the issues
- clarify various perspectives
- encourage analysis of contributing factors
- generate and critique options
- project possible outcomes
- elicit evidence to support opinions

Provide adequate wait time (5-20 seconds) for participants to respond to questions. Provide narratives as needed during the case study to assist the students in thinking through the problem

resolution.

Maintain an appropriate level of leader involvement:

- listen carefully
- allow students to carry the discussion
- maintain a non-judgmental stance
- challenge assumptions
- discourage premature solutions

The instructor should provide visuals for a better understanding of the location, site, and building specifics.

Summarize the discussion at critical points so students will reflect on the course of action they have taken so far.

5. NARRATIVE SCENARIO

The day is November 21 and it is a beautiful day in the Smokey Mountains. You (the project manager) are in the process of moving to Cleveland, Tennessee from south Florida to take over managing the local office of Tennessee Construction Company (TCC), a general contracting company based out of Ohio but which has some strong ties in Cleveland. Cleveland is a small southeastern Tennessee town with a population of about 37,000 people. It has a small town feel and the people are fairly close knit to their community. The people are nice and they typically know everyone that works in the area. There are very few construction trades that work in the town and therefore the competition is restricted. The concrete subcontractor (sub) is the only one that can handle the size of project you are working on and some of the other trades are the only ones located in the town. To find other trades one would have to travel 45 minutes to an hour away to a larger town.

The Ocoee River is just to the east of town and is the location of the summer 1990 Kayak Olympics. The closest major city is Chattanooga to the south about 45 minutes. Lee College is the local four year college and the President of the school is the brother of the owner of TCC.

It's about 10:30 a.m. and you are sitting with the owner of Tennessee Construction Company in his Chevy Blazer just off site of the project. You are told that he doesn't want the present PM/superintendent to see him talking with you since he will be let go next week. He describes the project as a museum which is being built as a joint venture for the city of Cleveland and Bradley County. The project has been under construction for two months. There is also another project that must be started in three weeks that you will oversee as well. It is the construction of a three story dormitory for Lee College. The Museum Center at Five Points is the key to a downtown revitalization project for the city. It is critical to TCC's reputation to get this job done on time in order to secure more work from others in the area.

It has rained off and on and made the job site muddy with some standing pools of water. The owner wants you to start work Monday; today is Friday. You will be introduced to the superintendent on Monday and he will be around for only two days.

You have a 20 year old field engineer assistant. Over the weekend you visit the site to get familiar with it before Monday morning. You determine that the building has all of the footers poured and anchor bolts set, that the eastern wall is built and that the north wall on the eastern portion of the building is complete. The masons are working on two other areas according to the partial walls that are in place. The site is not clean and there are several safety violations that need to be addressed.

Monday morning arrives and you show up on the site and meet the superintendent and your new field engineer, who has no formal construction education or experience.

You discuss the project until the owner of TCC arrives and makes the announcement that you are the new project manager (PM). You spend the rest of the day checking out the job site and reading the construction plans to get familiar with the project and some of the subs. There is a schedule on the wall but you don't know if it is realistic or has been updated since the project started. You spend the next two days finding out all you can from the superintendent before he leaves. The only trade on site is the masons. Several other subcontracts have not been bought out yet and awarding those contracts will be a part of your job.

It is now two days later and you are starting to get a handle on the job. It was early in the day when the field engineer, Richard, came and reported a potential problem where a crew of masons was working. They had been on site for about 2 weeks and had completed about 75% of the tall far eastern wall and the tall north wall on the east portion of the museum. They also had another crew starting on the western part of the building where a north wall joined an eastern wall. This wall faced onto a future courtyard and the roof structure was supported by several columns which were aligned with window openings to the south in a conference room and a work room as well an entrance walkway with a 35 feet-tall vaulted barrel ceiling. As we left the job trailer he told me the potential problem was with the masons working on the shorter north wall facing out into the courtyard. They have stopped working and are waiting for you to check out the situation and tell them what to do.

The museum building is approximately 17,000 square feet in size. A footprint and layout of the construction site is provided.

6. DISCUSSION QUESTIONS

The question is now posed to the students, "What steps do you take from here?"

Discussion questions are listed that may be used by the teacher/facilitator to prompt students to develop an acceptable solution. If the students hesitate to respond they are reminded that they have a crew of five masons that are costing them money and time.

- Is there a problem?
- What is extent of problem?
- What materials are needed?
- Cost of materials and labor
- Who was responsible for the incorrect work?
- Who performed the work?
- Who is responsible for design of repair work?
- What design was agreed upon to fix the problem?
- What parties should be contacted to resolve the problem?
- Was the schedule affected?
- How will you communicate this problem to the

owner, architect and GC?
- Will the owner have any liability?
- What budget issues affect your decision?

It is best to prompt students and cause them to start thinking about how to handle the situation by making them ask questions in a logical manner. What do they need to know and who would they need to speak with in order to get a correct answer?

7. FACILLITATOR CASE INFORMATION

As the facilitator, it is your responsibility to keep the discussion moving by understanding the particulars of the case and by prompting at certain times throughout the case study as needed. The teacher/facilitator will play the role of any individual on the project with whom the students need to interact. The first interaction is the student's role, as the PM, speaking to the masons.

Prompt students at this point: Students should act as if they are having a conversation with the masons' crew leader. Based on this, they should be able to determine that the masons' crew leader said that according to his plans the anchor bolts in the footer wall he was building were supposed to line up with the wall and window sections on the wall they were building just to the south about six feet. Based on his measurements they were off by as much as 2 inches.

Prompt students at this point: Students should be prompted to ask the question, "Do I believe that he measured correctly?" Rather than accept his measurements they should decide that they would measure the bolts' layout and see if they come up with the same error he found. The answer is yes the measurements are the same.

Prompt students at this point: Students should question if his plans are the most up-to-date and correct plans. Not knowing if his plans were correct, they should get their plans from the job trailer and compare them with his to make sure he had updated plans.

They will then find that after checking their plans they determine that the drawings were correct and that at least two sets of anchor bolts were placed in the wrong location. The bolts were off from 1-2 inches and not aligned properly with the direction of the footers. In reviewing the plans, it was obvious that the location of the columns was critical to the construction and architectural design of the museum. The conclusion they should come to is the bolts would have to be removed and new ones installed.

Prompt students at this point: Students should be prompted to resolve the issue of where the masons could work now rather that leave the project. The immediate concern was where to have the masons work to avoid the anchor bolt problem and the time factor and method required to correct the problem. They should determine that the crew should work somewhere on site with no anchor bolts. Show them the site layout and they can visualize where this would be possible.

Prompt students at this point: Prompt students to determine their next step in resolving the issue**.** First thing is to determine was who was responsible for setting the bolts in the wrong location and the extent of the problem. They should be prompted to consider that eight bolts had been found in the wrong location; therefore, it is probable there might be more incorrectly set.

Once they reach this conclusion then explain more narrative as follows. "I asked my project field engineer to measure the bolts and count how many were wrong but he said he did not have any construction experience and wouldn't know what to do. As a result I spent the better part of two days measuring all 200 anchor bolts to determine which ones were correct and which would need to be redone. In all, 150 of the 200 anchor bolts were far enough off that they would have to be removed."

Prompt students at this point: Students should question the layout of the entire building site at this point.

Continue the narrative as this point is raised. "In order to measure the locations, I wanted to make sure the building had been surveyed correctly since the former superintendent had also laid out the building location. I re-surveyed the site and found two locations on the site plan designating the top of a fire hydrant in front of the site and a nail set in a power pole at the rear of the site as benchmarks from which to measure. It was determined that the building site was laid out correctly."

Prompt students at this point: The students should be prompted to consider the site conditions as laid out in the beginning.

They should conclude that since the site had several days of rain the footings were mostly under water or covered in mud. Ask for possible resolutions to the problem and then continue the narrative. "I hired a laborer (my field engineer's room mate) at $7 pre hour for two days to help dig out the anchor bolts. To get the water away from the site and prevent the footings from getting covered up again I showed the field engineer how to operate a small track backhoe we borrowed from the masons.

He was instructed to dig three trenches from the footings in the rear of the building to the north sloping away from the building. This allowed the footings to drain away from the site. He also dug a four foot deep hole in front of the building near the east end of the building to allow the water to drain from nearby footings into the hole. We rented a 2-inch trash pump for three days to pump the water out of the hole. He dug another trench on the southwest corner of the building to allow the footings in that area to drain away from the site. With the water removed, we could then shovel the mud off of the bolts and clean the area so we could mark the correct locations, drill new holes and set the new bolts."

Prompt students at this point: Students should question who legally, per the contract, might have been responsible for setting the anchor bolts.

After the students discuss their responses, continue the narrative. "In order to determine who was responsible, I had asked Richard, my field engineer if he knew who set them. He had only been there a week before me so he didn't know who set them. In order to determine who did, I reviewed the sub-contracts in the office.

"At this time we had bought out the work for the masons, electricians, plumbers, steel erectors, concrete work and preliminary site work. Since the concrete was the obvious sub to check, I looked up his scope of work. The contract stated

that the concrete sub was responsible for laying out the footers, forming and pouring them, furnishing anchor bolts and installing them and completing all flat work and curb work to complete the project."

Prompt students at this point: Students should conclude that they need to talk to the concrete subcontractor. When they reach this conclusion, have them portray the actual phone call with the instructor acting as the sub on the phone. The following narrative will help set the stage for this conversation. Listen to their attempts first at having a conversation with John Sandlin and correct as needed. The students should realize they must handle the situation tactfully and not with blame. After they have made an attempt at the phone conversation, read the narrative of how the situation might have been handled.

"When the owner, John Sandlin, of the company supplying the concrete work answered the phone I told him who I was and that I was new to the area and was now running the museum project. I explained my problem with the misplaced anchor bolts and told him that when I checked his contract, it indicated the anchor bolt placement was in his scope of work. I asked him if he was familiar with the project. He said "yes" and I asked if he could visit the job site and schedule some labor to come out and remove the old anchor bolts and set new ones. He informed me that even though the contract read that way he didn't set the bolts and had told the former PM that he never set bolts. He didn't have anyone that could set them and therefore he never set them and had never set them on any job. He really didn't care what the contract said and he wasn't liable for any problems with them because he didn't set them. He told me that he had talked it over with my boss, Bob Johnson, the owner of Tennessee Construction Company (TCC), and that they had agreed that he wouldn't have to place the bolts. I asked him if he knew who set the bolts. He checked with one of his project managers and he said that the previous superintendent, Ralph, had set the anchor bolts but that they had furnished them."

Prompt students at this point: Prompt the students to question whether they should believe the sub's story and why.

After this discussion, the narrative of actual events can now be given. "I had now resolved who had set them but I felt it would be best to check the validity of the story so I called my boss, Bob, and related what I had been told by John Sandlin, the concrete sub. He said he recalled the conversation and confirmed that Ralph, the former superintendent, had set the bolts. I told him that 150 of the bolts would have to be cut off and replaced. He said he didn't have money in the budget to pay for the repair and told me to negotiate with John Sandlin and see if he would help out some way. I asked how much we had in the budget for extra help, etc. and he said $200.00.

Bob further explained that John's company was the only concrete company in the area that could handle this size of project and that the dormitory project was coming up soon so I should not upset him. His brother also owned the concrete batch plant where we bought our concrete. We still had about 17,000 square feet of flat work to pour."

Discuss the ramifications of your boss's decision to ignore the contract documents.

Prompt students at this point: Ask the students what is their next step. Who should they contact and what type of documentation should they receive before proceeding?

The narrative can then proceed. "My next step was to determine what the proper method was for cutting and replacing the bolts. I contacted the architect and he told me to call JS Barkley, the structural engineer. Mr. Barkley and I discussed the situation. He asked if the distance of offset was small enough that we might be able to slot the column plates. They were too far off to slot and it was determined that fortunately the bolts were placed far enough off that we could cut the existing bolts and drill new holes and set new bolts. If they had been in between it would have been a problem trying to cut new holes with the old bolts in the way. He said he would send me some drawing documents and specifications on materials to use."

The drawings are shown on slides to the students. "We were to get ¾" x 14" hardened anchor bolts and set them in 1 ¼" holes and leave three inches protruding above the footing surface. They would be anchored with Dural Crete gel grout. The engineer stated that the holes should be clean and dust- and water-free. That would be a challenge since some of the bolt locations were under water and mud."

Prompt students at this point: Ask students how they would maintain the $200 budget for extras, clean up the water on the site and still purchase and replace the anchor bolts. After their response, discuss the case as it was handled explaining there are other options that could have taken place.

Continue the narrative: "I then called John (the concrete sub) and tactfully stated that I appreciated his position but that I could really use his help. I was new to the town and didn't know where to buy materials and was wondering if there was any way he could help. I asked if he could supply the materials of bolts and anchoring grout and that I would supply the labor. He asked how much we needed and I told him what our engineer had specified and how much I calculated we would need. He finally agreed and said he could have some all-thread to the site by the next morning but not all of it since he couldn't get it locally. I asked when he thought I would get it and he said by 10 am tomorrow. I offered to drive to get it myself and he stated that it wouldn't be a problem and he would have it for me the next day.

"The next day we were expecting to get a partial delivery of the 150 -14 inch anchor bolts and some of the Dural Crete cartridges the engineer had specified. The delivery time arrived and passed and by 2 pm I decided to call the concrete sub to make sure of the delivery location and time. He said he forgot to order it but we would get it the next day. I again offered to pick them and up and he declined the offer but promised they would be delivered.

"In order to expedite the resolution of the problem I had my field engineer start cleaning off the anchor bolt locations in preparation for the bolts the next day. We were anticipating precut bolts that were 14" long; however, we received 8' long all-thread rods. It would now be necessary to cut the bolts to the proper length. We found a Sawzall in the job trailer tool box but no blades. We went to the local hardware store and bought 10 new blades and started cutting the bolts. We used three blades without making a dent in the hardened steel bolts

and decided that this method would not work. We had a torch so I showed the field engineer how to thread a nut onto the rod past the point we would cut the rod and then use the torch to cut the rod into the correct lengths. After the rod was cut, we would back the nut off and this would clean the end of the threaded bolt and make it useable. This had to be repeated until all of the rods were cut. Since they came in 8 ft. lengths we had some waste. The rest of the rods and epoxy showed up three days later."

Prompt students at this point: Students should be questioned about where to start the process and check the schedule to determine the events that would occur next.

The narrative continues: "The next problem I had to solve was where to start cutting bolts off and drilling new holes to fix the problem. I had moved the masons so they were continuing down the west side. In reviewing the site and the schedule, I determined that the steel erection would start in about 2 weeks. I called Mike Gordon, the erector and introduced myself as the new project manager working for TCC on the museum and asked him if he showed the steel erection starting in about 2 weeks. He said yes but that they might be a couple of days late. I asked if he could come out to the site and help me determine where they would be starting and where they would need a spot to store their beams and columns. When he arrived, I told him I would like for him to start on the west side in the large open room area. I did not mention to him the anchor bolt location problem. He indicated that would be good and we set up a lay down area for his materials. The starting location would allow me the opportunity to cut and replace the lowest number of bolts in a large area and would keep the steel erectors busy for several weeks. This would give me time to keep ahead of them in cutting and replacing bolts."

Prompt students at this point: Students should be prompted to consider the points as laid out in the following narrative.

"Now that I had determined where to start and the time frame required for completing the task, I could set things in motion and stay ahead. Richard and I measured and marked the correct locations of the new anchors and started cutting and setting new bolts. Part of the problem in doing so was that the entire site was pretty muddy. The area I wanted the steel workers to start was the worst so after Richard drained the footings in this location (eastern part of the building) I called the concrete sub. I asked him if he was still supplying the base material for the site slabs. He said yes so I asked him if he could start early on the east part of the building with his base since it was needed to enable worked to get around in the building site. He said he could deliver the base gravel but didn't have someone to spread it. I told him if he could provide the materials we would supply the labor to spread the base. He delivered about 10 tons of base and we borrowed the masons' bobcat loader and spread the gravel over the inside of the building site on the east side. This gave the field engineer a dry spot to drag electric cords and the torch and hammer drill around to cut off bolts and drill new holes. In searching for the company's hammer drill we found an old one that would not work. My boss Bob Johnson agreed to purchase a new drill and 8 - 1 ¼" drill bits. I also had to teach the field engineer how to drive the bobcat and spread gravel. He was learning lots of new skills.

"About two weeks later the steel arrived and the steel erectors showed up two days later. By this time we had reset enough new anchor bolts that the erectors could set columns, beams and bar joists in the eastern portion of the building. This would keep them busy for enough time to allow us to cut and set new bolts in areas ahead of where they would work. It took about three and one half weeks to clean off the anchor bolt sites, drill new holes, cut bolts and set them in Dural Crete while working on other aspects of the building and managing the project. Other subcontractors had to still be bought out and the schedule had to be updated since it was unclear if it was accurate."

Prompt students at this point: Prompt students to consider other issues that might develop with the steel erection.

After discussing issues, continue narrative of actual issues on the site. "When the steel erectors started they wanted a benchmark to determine where they should set the elevation of the top of their column base plates. I told them where I had shot the building from and they said they didn't have any equipment and someone else usually did it for them. I used our equipment and shot the correct elevation for the finish floor (FFE) so they would have a guide point from which to set their columns. By the time we had all of the bolts set the masons could return to the original location and complete their work."

8. SUMMARY

In summary, the problem was solved without affecting the schedule due to proper scheduling and placement of subs and setting the bolts in the locations that would work the best to expedite the correction and keep everyone busy. It was a very involved and thoughtful process to ensure all aspects of the project continue without interruption. It required constant communication with all parties involved and some negotiations in order to meet time and budget constraints.

The better the instructor understands the case and the possible questions that the students might ask the better the discussions will be and the more the students will interact. It is suggested that the instructor write down any questions that should be asked and any questions that might be asked to help facilitate the class discussion.

9. STUDENT PARTICPATION

The instructor should have the students check on the internet or with suppliers to determine the cost of the equipment and materials that were purchased and have the students each write a company memo explaining the project problem and the resolution and costs involved. This will allow the instructor to better determine the comprehension level of the students.

10. MUSEUM PROBLEM REVIEW AND RESOLUTION

The following is a narrative summary of the project and how it was resolved to an acceptable conclusion by all parties.

"It was early in the day when my field engineer, Richard, came and reported a potential problem where a crew of masons was working. They had been on site for about 2 weeks and had completed about 75% of the tall east wall and the tall north wall on the east portion of the museum. They also had another crew starting on the western part of the building where a north wall joined an eastern wall. This wall faced onto a future courtyard and the roof structure was supported by several columns which

were aligned with window openings to the south in a conference room and a work room as well an entrance walkway with a 35' tall vaulted barrel ceiling. As we left the job trailer he told me the potential problem was with the masons working on the shorter north wall facing out into the courtyard.

"When I arrived at the site, the crew lead told me that according to his plans, the anchor bolts in the stem wall he was building were supposed to line up with wall and window sections on the wall they were building just to the south about six feet. Based on his measurements, they were off by as much as 2 inches. I measured the bolts distance from the north-south wall joining this area and came up with the same error he found. I told him that I would get my plans from the job trailer and compare them with his to make sure he had updated plans and would be back in a minute. After checking the plans I determined that we were using the same drawings and that at least two sets of anchor bolts were placed in the wrong location. The bolts were off from 1-2 inches and not aligned properly with the direction of the footers. In reviewing the plans it was obvious that the location of the columns was critical to the construction and architectural design of the museum. The bolts would have to be removed and new ones installed. My immediate concern was the time factor and method required to correct the problem.

"First thing I needed to determine was who was responsible for setting the bolts in the wrong location and the extent of the problem. Since I had found eight bolts in the wrong location I assumed that there might be more incorrectly set. I spent the better part of two days measuring all 150 anchor bolts to determine which ones were correct and which would need to be redone. In all, 100 of the 150 anchor bolts were far enough off that they would have to be removed. In order to determine who was responsible, I had asked Richard if he knew who set them. He had only been there a week before me so he didn't know who set them. In order to determine who did, I reviewed the subcontracts in the office. At this time we had bought out the work for the masons, electricians, plumbers, steel erectors, concrete work and preliminary site work. Since the concrete was the obvious sub to check I looked up his scope of work. The contract stated that the concrete sub was responsible for laying out the footers, forming and pouring them, furnishing anchor bolts and installing them and completing all flat work and curb work to complete the project.

"When the owner of the company supplying the concrete work answered the phone I told him who I was and that I was now running the museum project. I explained my problem with the misplaced anchor bolts and told him that when I checked his contract, it indicated the anchor bolt placement was in his scope of work. I asked him when he could come out and remove the old anchor bolts and set new ones. He informed me that even though the contract read that way he didn't set the bolts and had told the former PM that he never set bolts. He didn't have anyone that could set them and therefore he never set them and never set them on any job. He really didn't care what the contract said and he wasn't liable for any problems with them because he didn't set them. I asked him who set the bolts if he didn't and he told me the superintendent that I had replaced set them, but that he had furnished the bolts.

"Since the former superintendent had left, I tried to contact him but was unable to since he had left the area and I couldn't locate his phone number. I contacted the architect and told him the problem and he contacted the structural engineer. They gave me a signed and stamped drawing of what to do to resolve the problem. They said to drill new 1 1/8" holes 12" deep. Make sure the holes were dry and dust free. Cut off the old anchor bolts and insert new anchor bolts 1" in diameter and 14" long into the new hole locations. He specified the type of steel for the anchor bolts and the type of epoxy to use.

"I talked to my boss, the owner of the general contracting company, and told him the problem I had uncovered. He told me that the concrete sub was the only really good one available in the area and that he really didn't want to upset him or force the issue very hard. He told me to try and negotiate with him and see what I could get. I called him and after a period of negotiating he said that he furnish the anchor bolts and epoxy if I would take responsibility for all of the labor and layout. I agreed and my field engineer spent the next three weeks cleaning out the footing trenches, cutting off the old anchor bolts, drilling holes in the correct location (we laid out), and placing epoxy and new anchor bolts in the holes.

"Since I knew steel was coming in about 9 days, I called the steel subcontractor and asked him what steel was being delivered first and where would it be set. I also wanted to know if he was still on schedule for his start date. He said he was on schedule and told me that they would start setting steel in the center of the building and work their way to the outside from north to south. Based on this information, I made sure we started placing the new anchor bolts in those areas first and we stayed ahead of his erection crew that way.

"In order to keep additional rain from refilling the footer trenches, we dug two holes next to the footer on the south side of the building to provide a drainage area. On the north side we cut a trench to allow any additional water to drain away from the footers. We rented a 2 inch trash pump for a week to suck out the mud and water from the footers. We also had to buy about six 1 ½ inch drill bits to drill the holes and a new hammer drill. The concrete sub provided eight foot pieces of ¾ inch all-thread which we cut into shorter pieces for anchor bolts. All total we spent about $550 for some extra labor and bits and saw blades. The concrete subcontractor provided all the other material per our agreement. The costs were minimal and by working ahead of the steel erectors and other trades we did not have to change the schedule.

"The project was completed on time and within the owner's budget."

11. OPEN DISCUSSION

At the conclusion of the case study, discuss what was learned and what thought processes were used to discover information required to solve the issues. Discuss how this case study might help prepare them for real life situations.

12. CONCLUSION

Student feedback has been very positive. One student contacted the author several months after graduation to tell him he had been placed in an almost identical situation in the field and as a result of the case study knew exactly what to do. Others have indicated that the case studies helped them develop their critical thinking skills. As a result, the students feel very comfortable moving into a management position upon graduation.