TECH REPORT 3 SANTA ROSA JUNIOR COLLEGE STUDENT CENTER

Alternative Methods Analysis

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2009 SENIOR THESIS

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EXECUTIVE SUMMARY

The construction challenges, schedule acceleration scenarios, and value engineering topics of the Santa Rosa Junior College Student Center were shared through the help of the project manager, Dana Vallimont, for the further identification of problems and finally a technical analysis of the project. The SRJC student center had several constructability challenges that had to be dealt with throughout construction. Three of the biggest challenges that had to be dealt with were installing brick veneer accurately to minute tolerances, installing precast concrete that was prefabricated very early on in the project without first attaining proper field measurements, and installing roof tiles that were hindered by precast head pieces at the eaves of the roof.

As far as schedule acceleration scenarios for the SRJC project, four different areas were looked investigated. These areas include critical path, risk to completion date, areas of potential acceleration, and finally cost and techniques. The two major critical path items were the erection of steel and the ordering of precast. Both of these items ended up causing problems that resulted in delaying the schedule. Measures were also taken to accelerate the schedule which resulted in making up for a lot of lost time due to the delays that had occurred. The primary method of accelerating the schedule was hiring extra manpower or having workers work overtime or weekend hours.

Value engineering on the student center was limited due to the fact that it was a publicly owned project which was hard bid. In projects such as this it is very difficult to add in value engineering items because there is very little incentive and also very little mechanism available. Although value engineering was used at a minimum on this project, Midstate Construction did spend a lot of time giving the owner opinions and ideas on areas where improvement could be made, money could be saved, etc. This was done in an effort to strengthen the owner-contractor relationship. If a strong relationship develops between the two repeat business between the two is likely in the future.

There are several issues dealing with the project that should be noted. For starters, the installation and supporting of the brick veneer created many challenges due to small tolerances. Looking into the use of an alternative support system for the brick will hopefully help to find a better method. The precast concrete prefabrication process also created problems along the lines of confusion and ultimately delays. The benefits of involving a precast subcontractor with the original design team will be investigated. Also, the method used to erect the steel frame of the building will be analyzed and alternative methods such as using multiple crews and cranes will be looked in to, since the method of using one crane and one crew resulted in a several month schedule delay. Finally, the benefits of incorporating sustainable design features such as PV panels and solar thermal technology will be analyzed and compared to see if such ideas would be beneficial.

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Constructability Challenges

The three biggest challenges that had to be dealt with during the construction of the Santa Rosa Junior College Student Center deal with small tolerances on brick façade, installation of precast, and lastly roof tiles.

Small Tolerances of Brick Façade:

The brick façade on the student center is supported by ledger angles which are welded to the structural metal studs and WT's which are then welded to the bent plates at the edges of the concrete slabs. The vertical brick modules on the façade require very small tolerances to make sure that they are consistent throughout and also to keep the entire brick façade perfectly vertical. A tolerance of ¼" was used for the vertical placement of the support angles and a similar tolerance was utilized for the horizontal placement. The small tolerances make it extremely difficult to weld angles around the perimeter of the building. The ledger angles that were welded to metal studs were much less of a problem than the WT's. The WT's pose more of a problem because it is much harder to install structural steel to small tolerances than it is to install metal studs. That being said, the WT's presented a huge problem due to the fact that the steel subcontractor used on the project attached the WT's to the bent plates in the shop rather than waiting to do it in the field. The bent plates were then installed with the WT's already attached. The decision to install the bent plates this way proved to be a disaster and made it virtually impossible to keep the plates to the required tolerances.

The steel subcontractor was forced to fix his mistake by correcting the placement of his WT's, both in the horizontal and vertical direction. The challenge of fixing this mistake began by having the building lines surveyed to provide exact locations of where the outside face of the brick needed to be. The next step was to transfer the acquired layout vertically up the building so that the metal studs would be installed perfectly, even though the structural steel locations varied by significantly more than the ¼" tolerance. The placement of the vertical ledger angles were also laid out by a surveyor so that they would be exactly where they needed to be.

Installation of Precast:

One of the biggest problems associated with the precast concrete elements of the student center is the fact that the elements were fabricated long before the building had been constructed to the point that they could field measure and verify the exact sizes. Also, the precast concrete was prefabricated in Mexico which made the process even more tedious. The precast panels used on the project were to be designed to fit perfectly into place. If an element was off by ½", you would end up with a joint that is ½" or 1-1/4" instead of the planned ¾". This may not seem like much but if it was allowed to happen it would stand out blatantly to the naked eye. To avoid problems such as this the approved precast shop drawings were sent to all of the affected subcontractors which includes structural steel, metal and stud framing, metal flashing, window sub, etc.. This strategy allowed the subcontractors to help to find conflicts early on before they became more expensive field fixes later on. Also, through the course of construction of all of the structural elements references were constantly made to all of the precast shop drawing details along with the structural drawings so that conflicts could be resolved as construction was going on. Many conflicts were caught this way throughout the construction of the SRJC Student Center.

Roof Tile Installation:

Due to the way that the precast head pieces are attached at the roof eaves, the pieces had to be installed before the metal roof deck, insulation, and roof tiles could be installed. This created a serious scheduling problem, since the roof tiles needed to start from the bottom of the roof and work up toward the top. The other problem associated with this is that spray on fireproofing was required to be applied to the bottom side of the metal roof deck. By specification the fireproofing could not be installed until the roof tiles had been completed. All of this leads to a massive amount of critical tasks being delayed all due to the installation of precast head pieces. To get around this nightmare of a problem a plan was submitted to the school in which the last five rows of roof tiles would be left off and all of the upper rows would be completed. This plan needed to first be approved by the Division of the State Architect and then by the school. This plan required some special tie-in details for the metal deck, insulation, the waterproofing layer, and the roof tiles. The plan was approved and construction was able to proceed with the majority of the roof tasks while they had to wait for the precast pieces to be delivered.

Schedule Acceleration Scenarios

There are many different things during the course of construction that can cause the need for schedule acceleration. Below is an evaluation of different schedule acceleration scenarios for the Santa Rosa Junior College Student Center in Santa Rosa, California.

Critical Path:

Early on in the project the two biggest critical path items were erection of the steel and ordering of the precast. Although concrete is the first thing to happen, the shop drawings required and lead times for pouring concrete are relatively short. Steel and precast, however are not as simple.

The steel shop drawings for the project were comprised of approximately 600 full sized sheets, so it is not too hard to understand why it would take the steel subcontractor a long time to produce them and the structural engineer and architect a long time to review them. After the drawings are approved, there is a substantial lead time before steel can be received by the subcontractor, fabricated, and finally delivered to the site for erection. Negotiations for production of shop drawings took 8 weeks and erection was to begin 2 weeks after the approval of the shop drawings and continue for about 5 months. The completion of the shop drawings was on time but the start of the steel erection was late by a month. The completion of the structural steel and welding ended up being a couple months late.

The precast drawings were a problem because many of the details on the structural plans simply did not physically work. The fact that the structural drawings were so inadequate resulted in an extension of about 80 days on the project and a change order for the structural changes that were required. The precast had to be able to be structurally supported, but it also had to have the ability for minor final adjustments. The shop drawings, along with being incredibly detailed, need to be able to work with the architectural and structural design drawings. Also, they need to be submitted to the DSA for approval. To get an idea of how fast DSA works, the sprinkler drawings for the student center were submitted in the Spring of 2008 and were approved in October of 2009, almost a year and a half after being submitted. Other than the drawings, another thing that causes critical path issues is the fact that the precast holds up a lot of different trades for both the interior and exterior of the building.

The steel and precast are probably the two biggest challenges to staying on schedule, although it does depend a lot on the quality of subs you have involved with each trade. On this project the steel subcontractor could have been much better while the precast sub was great. Also, a very good metal stud subcontractor was used on the center. If a sub-par contractor had been used the metal studs would have become more of a critical path issue on the student center project. After these major items, the next biggest challenge was getting the windows ordered and delivered. Most of the interior finishes have stipulations in the specs that say that the building must be "conditioned" before the interior finishes can even be delivered to the site. The building cannot be conditioned however until the building has been completely enclosed, including windows. Unfortunately the window sub that was used had a major weakness in the fact that he had trouble getting submittals in on time. Also, Midstate Construction had to end up charging him for their time to put plastic covering over the windows throughout the winter months (In Santa Rosa, CA, the winter consists of a lot of rain.). While the plastic kept most of the rain out, it did not keep enough of the temperature shifts out to be able to meet the spec criteria for interior finishes. Another problem with windows in general is that they are usually manufactured by very large corporations. The problem that arises with getting materials from large corporations is that you have absolutely no power over them. Kawneer, the company used for the windows on the SRJC student center, is a huge supplier of commercial window products and could care less if they lose one unhappy subcontractor.

Risk to Completion Date:

When asked what the biggest risk to not making the completion date in time, the project manager (Dana Vallimont), simply said, "It's due tomorrow!" This is because my interview with him was conducted on November 18, and the completion date was November 19, so I am sure you can imagine how much last minute things were being done on that day.

Many things contributed to the building not being done at that point in time (although they were very close). In most projects the time-clock stops at substantial completion. At this point the owner can occupy the building and get beneficial use. Generally, the architect does the punchlist right at or just before substantial completion. On the SRJC project there was really no such thing as "substantial" completion. The clock on the student center project does not stop until all of the architect's punchlist items have been completed.

A string of events put the project into this position. One of the big things was that the steel subcontractor spent a lot of time removing faulty work and re-doing it which resulted in a lot of lost time. The delay caused by the steel sub affected the ability to complete the slabs, walls, and roof. Secondly, the delay in getting the windows for the student center held up the start of the interior finishes. A substantial effort was made to resolve the issues with these items but only limited success was found in expediting them.

Areas of Potential Acceleration:

Although it is a little too late to accelerate the project schedule now, since it has been completed, some efforts were made to speed things up while construction was still going on. One area that an attempt was made to accelerate the schedule was with the steel workers. On several occasions Midstate Construction threatened to hire extra steel workers to assist the slow working ones on the job, but due to union and other issues, they never followed through. Although they did not hire extra steel workers, the threats did scare the sub to increase their crew sizes which did lead to more work getting done at a faster rate. Towards the end of the project a lot of effort was made to expedite finishes. For example, Midstate paid to split the shipment of wood slat ceiling material so that they could get going on the first half of the work while the second half was being manufactured. Also, some subcontractors were forced to work overtime when they were at fault for being behind schedule. Midstate paid the overtime portion of work for other subcontractors who were behind schedule, but were not at fault. As completion was neared of the main lobbies and the west end of the building, overtime was paid for the terrazzo and tile guys to come in and work on the weekends. This proved to be a smart idea considering that these two trades take up the entire floor and prevent other trades from being able to work in those areas. Working on weekends allowed the floor to be completed without interference from other trades.

Again, although it is too late to accelerate the schedule due to the project completion, the above measures were taken to speed things up as much as possible while construction was still going on.

Costs and Techniques:

As far as costs and techniques used on the project, those in charge went with several different methods. In some cases trades were made to make costs go away. In other situations costs were forced onto other subcontractors and also, some costs were forced to be paid. An example of the trading used dealt with small subcontractors, who always seem to be in a cash flow crunch. Midstate agreed to expedite payments ahead of time as a trade for the mason to increase his crew sizes and work weekends for no charge.

Value Engineering Topics

The main goal of Value Engineering is to save money while increasing the overall value or quality of the project at the same time. Value Engineering does not mean that you necessarily have to pursue cheaper upfront costs. Instead sometimes you must look at the cost over the entire life cycle of something when looking at it from a Value Engineering standpoint.

In the case of the SRJC student center it was hard to implement Value Engineering for the simple fact that it was a public works project. This type of project is hard bid and does not provide much incentive or mechanism for value engineering to occur. Had the project been a privately owned one, value engineering would have been a great idea. The reason for this is that the contractor would then have more incentive and wiggle room to play with value engineering ideas. The owner of the student center project was very clear that they wanted to focus on the architecture of the building which included the use of very expensive materials, especially on the façade where the brick and precast concrete were used. Since the owner was unwilling to waiver on the exterior architecture of the building, it was nearly impossible to use value engineering while meeting the owner's standards. Other than the pricey exterior of the building, the majority of materials used were standard with no reason for substitution.

Although not much value engineering was used by the contractor, Midstate Construction did spend time trying to help the SRJC with ideas for improvement. This strategy is smart because it helps to build a stronger relationship between the owner and the contractor which could result in future business together.

Problem Identification

Problem Overview:

There are several items involved with the construction of the SRJC Student Center that are areas that improvement can be made on. The problem areas were identified by searching for ways to simplify construction, reduce durations of activities, and also to decrease cost while not compromising quality of the overall project. Below is a list of several of the problem areas that can be investigated through a detailed analysis of technical building systems and construction methods.

- Brick Veneer
- Precast Concrete
- Steel Erection
- Sustainable Design

Brick Veneer Installation:

As mentioned several times before, the problem of having such small tolerances for the installation of the brick veneer façade created numerous headaches on the job site. The small ledger angles that were welded to metal studs were not as much of a problem as the WT's. The WT's were much more difficult to work with because it is much harder to install structural steel to small tolerances than it is to install metal studs. Also, the fact that the steel subcontractor attached the WT's to the bent plates in the shop rather than doing so in the field only added to the problem. Finding a more efficient way of supporting the brick veneer would more than likely have saved both time and money.

Right: Installation of brick veneer façade.

Precast Concrete:

Another big problem area on the project revolved around the precast concrete elements. Several things contributed to this. First of all the elements were fabricated long before the building had been constructed enough to field measure and therefore many pieces did not fit properly at first. Finding these problems in the field rather than earlier on made it much more difficult to make changes. Also, the concrete was prefabricated in Mexico, very far away from the construction site, making things all the more tedious. Finding a better way to go about the prefabrication process on this portion of the project would have saved a lot of problems and delays down the road.

Top Right: A precast member is lifted into place with the help of a winch.

Middle Right: Newly delivered precast concrete panels are stored and covered until it is time to place them.

Bottom Right: Several installed precast panels that form a "band" around the building. The small room for error in size can be seen at the small end joint where two panels meet.

Steel Erection:

Another problem that attributed to schedule delays was that caused by the installation of the structural steel. As stated earlier the steel shop drawings were completed on time but the start of the steel erection was a month late and the completion of the erection and welding of the steel ended up being several months late resulting in the need to be granted a 72 day extension to the original schedule. Finding a way to keep the steel on schedule would have resulted in eliminating other delays on the project that ended up occurring as a result of the steel erection process and would have ultimately caused the project to be completed on time for its original completion date.

Above: Single crane and crew at work during erection

Above: View of the crane at the beginning of the erection process from a neighboring building

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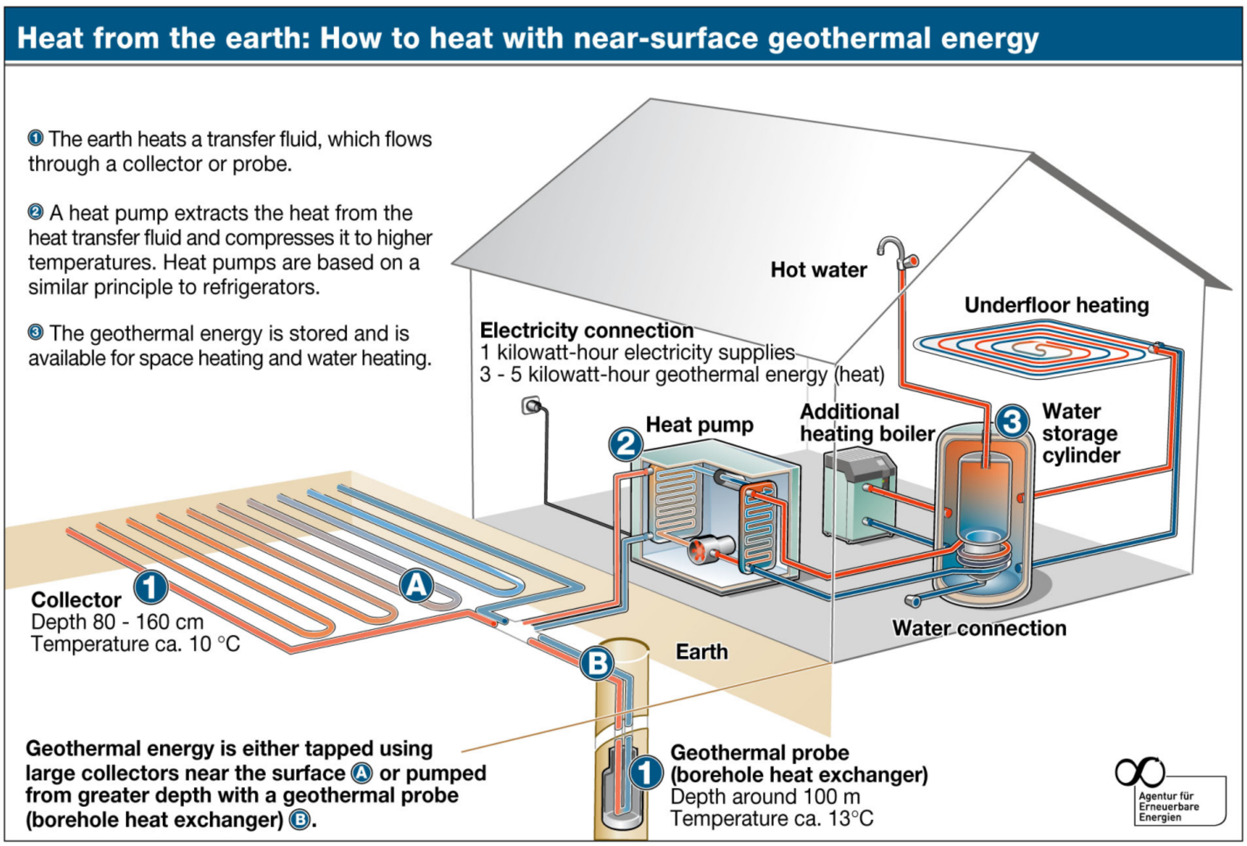
Sustainable Design:

Other than the geothermal system incorporated into the building, there is really no other key sustainable aspects of the building. In a world where green technology and sustainable design is becoming more and more prevalent every day it would be a good idea to invest some time and money into that area. Trying to achieve some sort of LEED certification or some other type of sustainable effort could have helped to increase the overall quality and output of the building.



Above: The above diagram shows the basic information as to how a geothermal system such as the one used on the SRJC Student Center project operates. **(This image was taken from** http://www.unendlich-viel-energie.de/uploads/media/Heating_with_geothermal_energy.jpg **)**

Technical Analysis Methods

Brick Veneer Installation:

The tight tolerances that had to be adhered to on the construction of the student center created numerous problems which led to delays on the schedule as well as wasted money. To combat this problem one should first look at the fact that some of the veneer is supported by metal studs while other parts are supported by structural steel. Having seen the problems associated with this method it may have been better to use an alternative system to support the brick. This analysis will make comparisons between the methods and materials used on the project to alternative methods and materials. Two major areas that will be focused on are cost and schedule impact.

Precast Concrete:

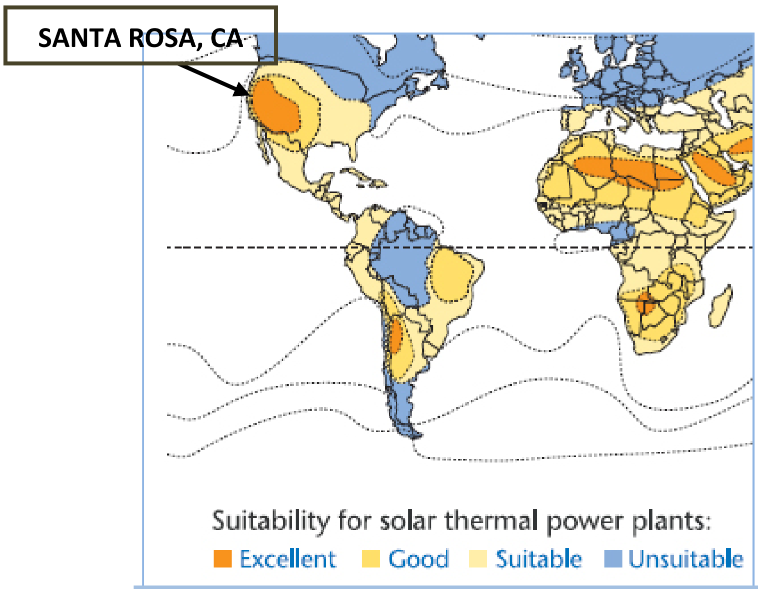
The fact that the concrete was prefabricated very early on in the project and that it was done very far away created installation issues that resulted in schedule delays. The delay that was associated with choosing to make the precast a design-build element could have been avoided if certain steps had been taken. This analysis will investigate the benefits of bringing precast subcontractor in to be a part of the initial design team. This would allow for his input on many issues that could have caused problems associated with the delay that occurred. Resolving these problems in the design phase instead of in the construction phase would be ideal. (From my understanding Santa Rosa Junior College has the same opinion as myself on this matter and will in fact be bringing a precast concrete subcontractor in to be a part of the initial design team.)

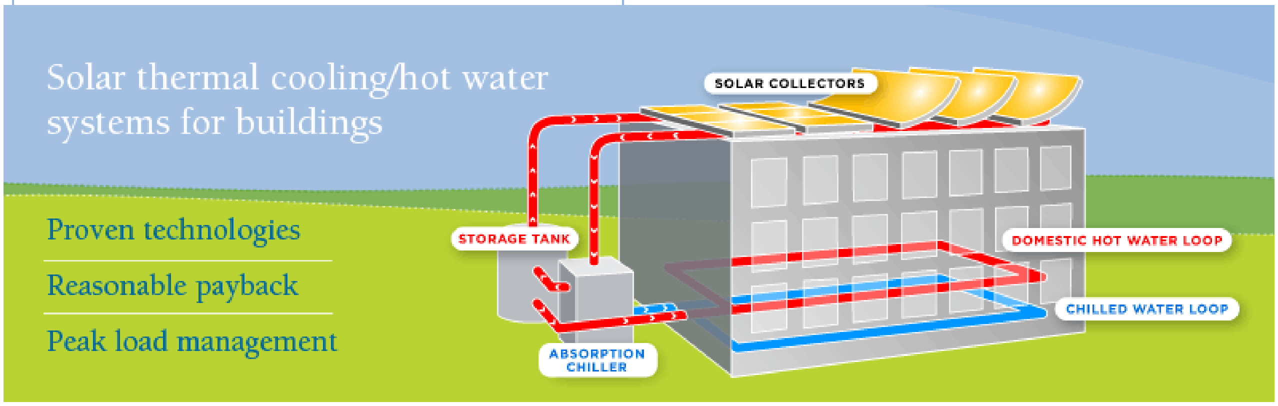
Steel Erection:

The method of erecting steel on the student center project resulted in long delays that held up many other activities on the project which in turn delayed the project completion date by 72 days. The delay that occurred could have been reduced if not completely avoided if alternative methods were used to erect and weld the steel. The steel on the student center project was erected using one mobile crane and started one month late. This analysis will look into the use of multiple mobile cranes and welding crews as opposed to what was used on the project. The cost of using an extra crane and extra labor will be investigated as well as how long it would take to complete the erection process this way. These investigations will then be compared to the cost and time it took for the erection process to be completed nearly three months late.

Sustainable Design:

The fact that very little effort was put into the sustainable features of the SRJC student center leaves a lot of options as far as what could be done to increase the sustainability of the structure. Since the building is being built in California this analysis will focus on the use of sustainable elements that are prevalent in that geographic region. The effects of using PV systems along with newly available solar thermal technology will be investigated. The much more frequent sunlight (as opposed to State College) creates an ability to use PV systems in areas such as the roof, walls, and windows to gather energy and also allows for the use of solar thermal technology for solar cooling. The investigation into the implementation of these comparisons between heating/cooling loads along with energy consumption levels of the structure with and without the sustainable features.





Top Left: A map showing that Santa Rosa is in an excellent area for the use of solar thermal technology
Top Right: An example of how PV panels can be used together with glass to provide shade and gather energy simultaneously
Above: A diagram showing how solar thermal systems work along with the use of an absorption chiller
(Images were taken from: http://greenterrafirma.com/images/solar-thermal-plants.jpg, http://news.xinhuanet.com/english/2009-01/10/xin_02210051909218432 7911.jpg, http://www.naturalenergytechnologies.com/images/home_diagram.gif **)**