TECHNICAL REPORT THREE

CHEMISTRY BUILDING

November 29, 2010

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Construction Management

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EXECUTIVE SUMMARY

Technical Report Three is intended to identify areas of the 265,000 SF Chemistry Building that can be modified based on critical industry issues, value engineering, constructability, and schedule reduction / acceleration. The largest challenge associated with the construction of this university laboratory was the completion date. Numerous delays at the beginning of the project and the date being pushed up proposed a threat to achieving this task.

To learn more about the Chemistry Building, the project manager, Jay Davis with Turner Construction, was interviewed. From the conversation, it was concluded that there were various amounts of **constructability challenges**. The two major challenges were a result of design changes and lead time on the curtain wall. These challenges were all addressed by the project team and the appropriate actions were taken to maintain a productive site. In order to make this possible, **schedule acceleration plans** were implemented. This plan comprised of a combination of overtime work, increased crews, early starts, and re-sequencing work. A **value engineering** idea presented by Turner Construction also helped save one to two months of time. Besides saving time, blasting during excavation resulted in almost a one million dollar cost savings. Value engineering was important to the owner and the end result was just under twenty million dollars of savings.

Through the interview process, problems that took place during construction process of the Chemistry Building were identified. After an in-depth analysis of these problems was completed, four areas were recognized for possible research and technical analysis. These areas are based on the curtain wall system, sustainable techniques, schedule analysis, and site logistics. All of these areas lead into possible research topics for the spring thesis proposal.

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Constructability Challenges:

Curtain Wall

The curtain wall comprised of a glass façade with aluminum framing. The first challenge associated with this was the lead time. Because of the size of the glass, the only place that was capable of producing it was Italy. Due to the amount of time to produce and ship, the lead time did not allow time to finalize the contract drawings. As a result early design assist with the subcontractor, Permasteelisa, was implemented. This allowed for early production. Lead time also became a problem for replacement glass for pieces that were defective or broken during installation. After ordering a piece of glass it took approximately two months to end up onsite. With the challenges of lead time and getting the curtain wall onsite, Turner Construction had to build temporary walls to enclose the building in order for the mechanical rough in process to continue.

The next challenge pertaining to the curtain wall was the glass on the three exterior stair towers. The original design called for heat strengthened glass on the interior and exterior panes. Permasteelisa's engineers showed with calculations based on the design the inside pane did not have to be heat strengthened. During installation the interior pane of the glass started to crack around the edges. The first action taken was to change the toggles that were torqued down to hold the glass in place. The original toggles would pinch the glass against the framing causing it to crack. After the toggles were changed, the breakage percentage of the glass decreased. However, a percentage of the glass was still breaking. The final solution was to widen the gap between each piece of glass which would give the installer more room to torque down the toggles. In addition to that, all the glass was replaced with the original design of heat strengthened panes on the interior and exterior. Changing out the glass required a lot of logistics planning between Permasteelisa, the owner, and Turner. The stair towers are located along a road that needs to stay open during normal business hours. This was crucial because it affected the type of crane used, the crane location, and the days/hours the crew would work. One option was to bring in a tower crane that could reach all the towers and allow the road to stay open while work was completed during normal working hours. Each stair tower comprised of 115 pieces resulting in a total of 345 pieces to be replaced. With the rate for removal and installation on an estimated average of 7 pieces/day, it would take about 50 days or 400 hours to complete this task. Based on those numbers, if this work was completed only on off hours or weekends, it would take almost half a year to complete. This activity would also take a crane, boom lift, lull, and six workers to complete. Therefore, it was an expensive problem to solve.

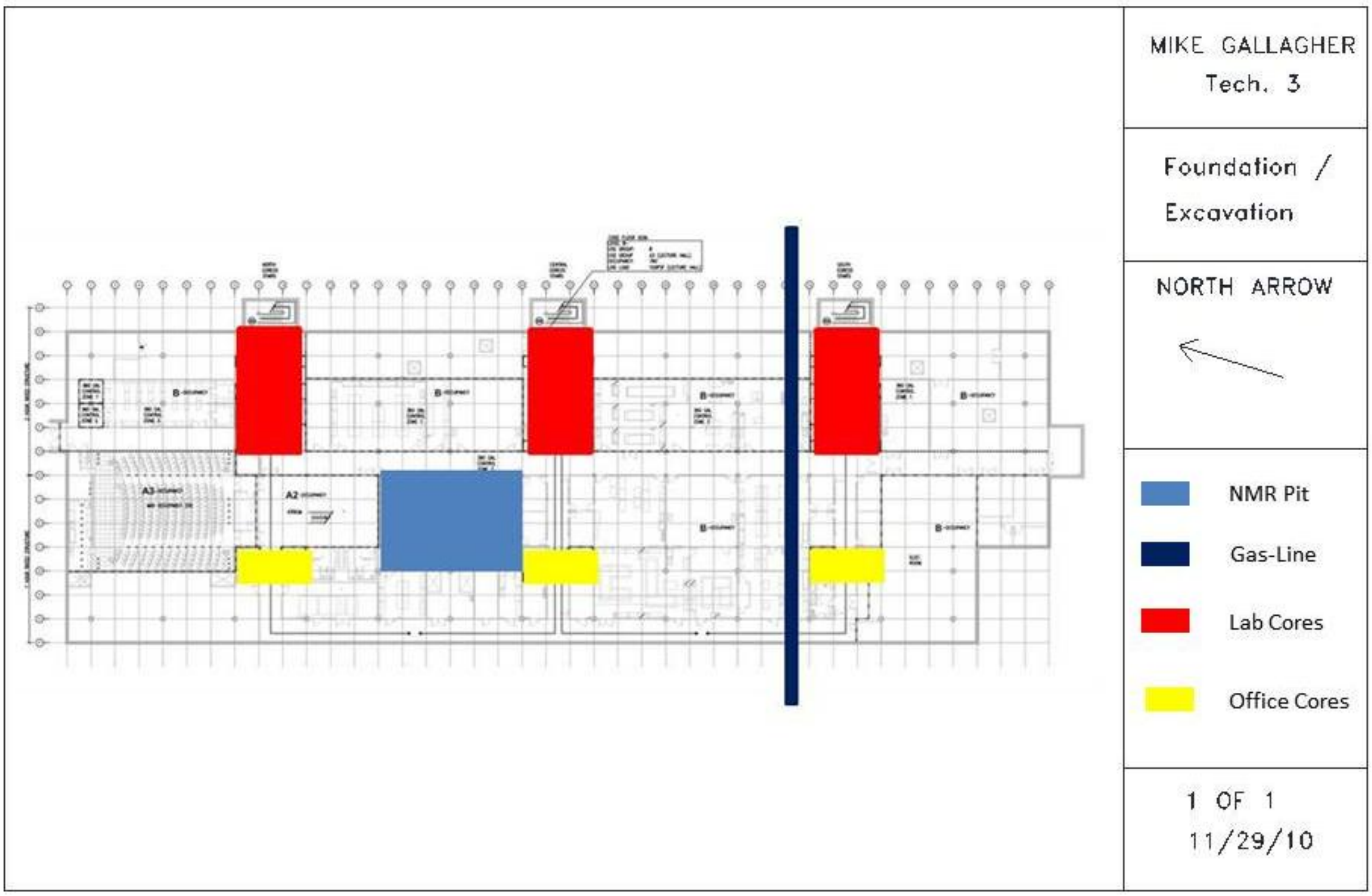
An agreement between the three was to rip out finished site work and pour a pad for a mobile crane to sit on. The pad's location allowed the crane to reach all three towers, work normal hours, and complete the work the best based on time and cost. Below are pictures to better visualize the curtain wall and stair towers.

Foundation and Excavation Work

Another major challenge during construction of the Chemistry Building was the owner did not move a gas utility line in time for excavation/blasting. The original plan was to start at the south end of the site and excavate working back toward the North. As you can see in the diagram below, the location of the utility line made it impossible to execute their plan. Thus, the only option was to work from the center of the site to the North while the owner removed the utility line. As a result the ramp was also moved from the Northwest corner to the middle of the west side of the building. Once the gas line was removed, Turner started to blast and excavate in both directions moving away from the center of the building footprint. As a result, the blasting sequence and plans needed to be modified. With the utility line still present, it was not possible to blast large areas of the foundation at a time. Therefore, it took a large amount of smaller blasts to cover the same area. Blasting took one month longer to complete because of this.

Besides the gas line not being removed on time, there were strict requirements associated with blasting. The surrounding buildings house highly complex experiments that could be ruined by the vibrations from the blasts. Consequently, some days no blasts were permitted and other days blasts were restricted to take place during a one hour window in the afternoon.

Design changes presented another challenge for Turner Construction. One of the labs located in the basement is for Nuclear Magnetic Resonance, also referred to as NMR. The NMR lab is located at the deepest part of the foundation and houses a lot of large equipment. Because of a scope change, work went on hold in this area for a month while the Architect redesigned it. The new design contained larger equipment; therefore a larger footing was required. In order to continue work while this area was on hold, additional shoring needed to be installed and schedule changes.



MIKE GALLAGHER
Tech. 3
Foundation / Excavation
NORTH ARROW
NMR Pit
Gas-Line
Lab Cores
Office Cores
1 OF 1
11/29/10

Concrete Cores

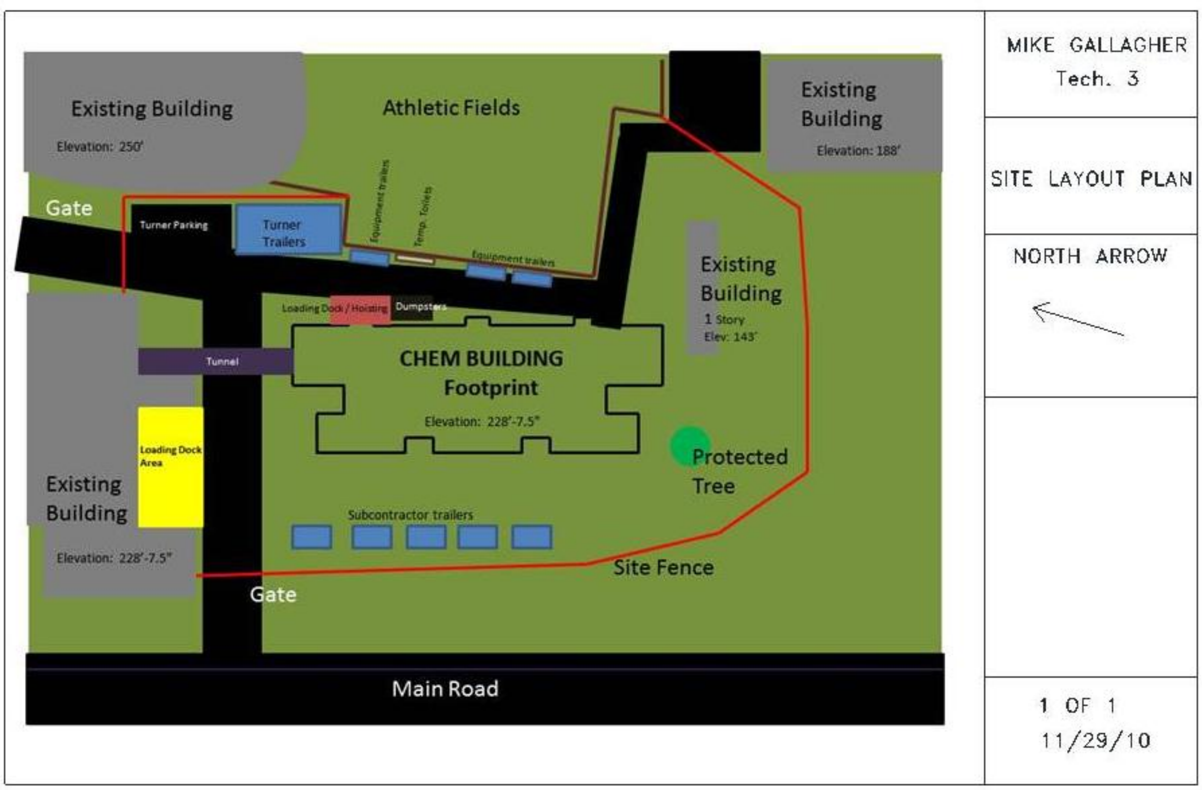
After the concrete cores were already bid and started, the design of them was changed. Because the concrete cores are a crucial part of the structural system, if held up it would delay the entire schedule. The structural steel ties into these concrete CIP shear walls, and they need to be completed before steel erection can start. Turner Constructions response to this challenge was to pay overtime to redraw and work on the cores.

An additional challenge with the concrete cores was the mechanical drawings were not completed when construction on them started. In order to account for this, Turner Construction and the design team estimated where some of the mechanicals would penetrate the cores. This was done to save time and cost by limiting the number of locations where drilling would take place.

Above is a picture of the construction of the concrete cores.

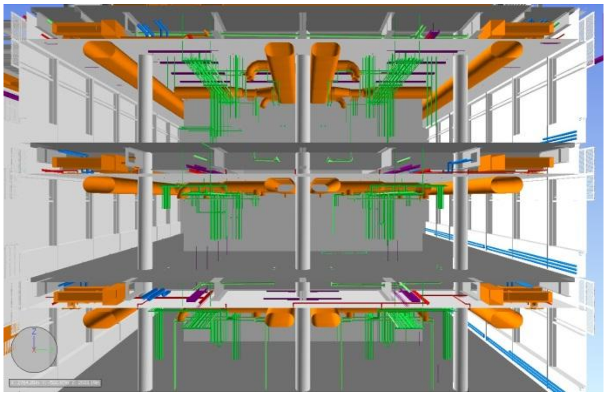
Site Access

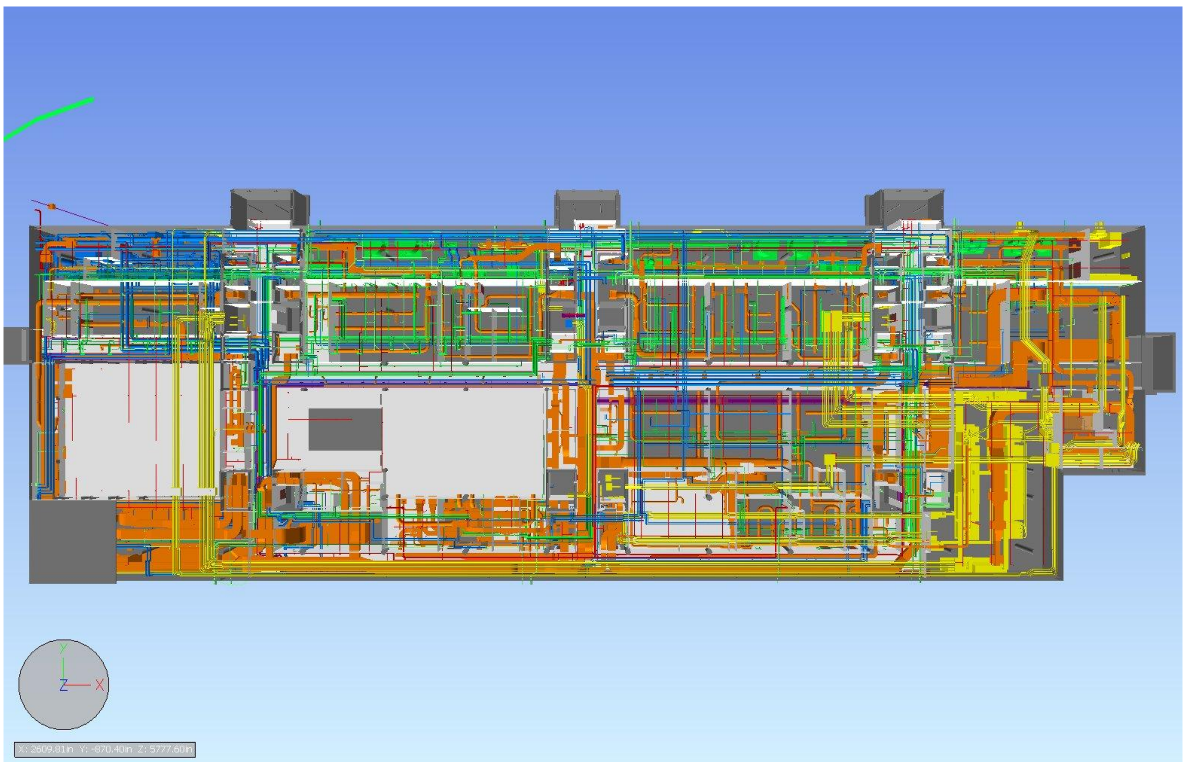
The primary challenge onsite was one of the neighboring buildings contained a loading dock that needed to maintain function at all times. This effected site logistics and crane placement because the loading dock used the same entrances as the construction site. This can be seen on the diagram below of the site. The other challenges onsite were linked to this. A pedestrian bridge crossing the main road was to be constructed closing one of the entrances for a period of time. When that entrance was reopened the other entrance needed to be closed for renovations on another neighboring building. The road between these two entrances also contained a tunnel the needed to be constructed to connect the Chemistry Building to a neighboring building. To make sure the project ran smoothly construction activities on the Chemistry Building needed to be coordinated with the surround activities. Everyone needed to work together to make sure the pedestrian bridge finished on-time so renovations could start on the next building. In order for the bridge to start on-time the tunnel was dug and partially completed. A temporary bridge was built over the tunnel to keep access to the loading dock. Once the temporary bridge was functional, the northwest entrance could be closed for construction on the pedestrian bridge. The way Turner overcame the challenges on-site were intensive planning and constant communication with the owner and surround activities.



MEP

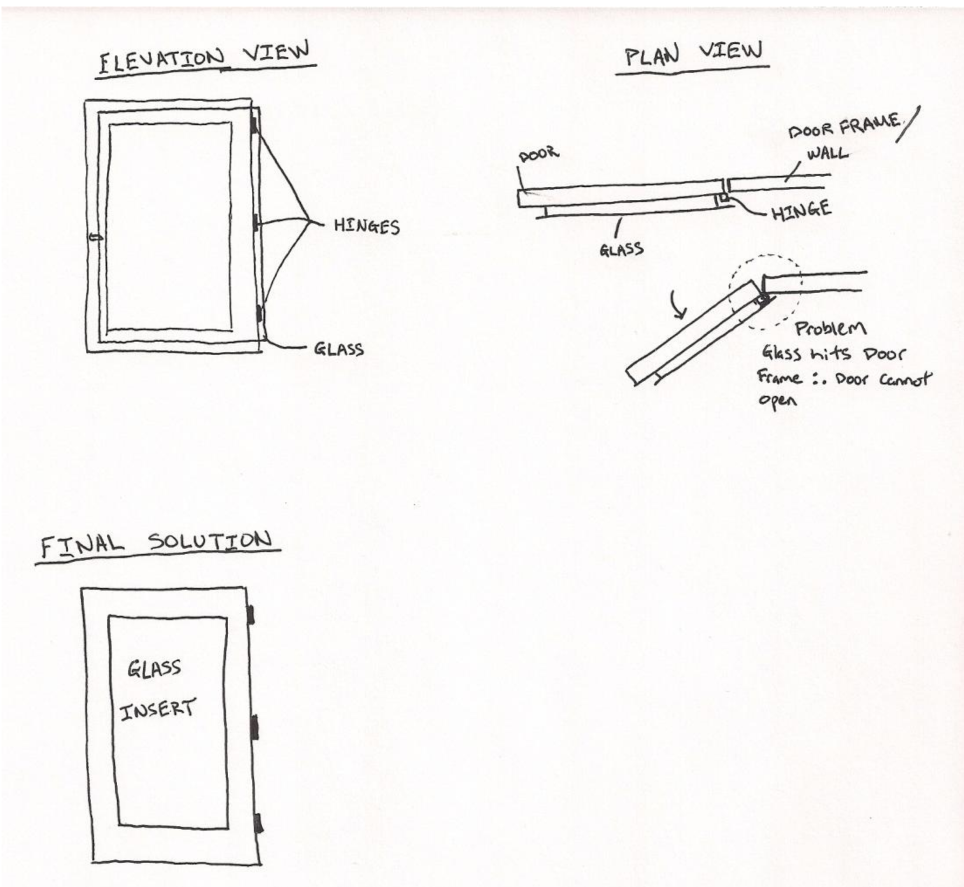
The Chemistry Building is comprised of an office side, 4-story atrium, and lab side. These three differing spaces made the mechanical systems very complex and difficult to design. In order to get the most efficient and highest quality system, changes were constantly taking place. There were so many changes that a period of six months passed and there was no progress. As a result Turner's parent company, Hochtief AG based in Germany, built a 3D mechanical and structural model. In order to make up for the lost time, Turner decided to release the sheet metal orders for the duct work based on the 3D Model.





Doors

The owner wanted doors that were not practical. They originally wanted a glass door where the glass would cover the hinge. The problem with this is the door could not open if the glass covered the hinge. This can be better understood by the diagram below. Turner proposed a metal framed door with a large glass insert. The owner rejected this idea. Next, Turner modified the original door plan to have the glass stop just shy of the hinges to allow it to be functional. This was rejected also. Finally after six months to a year of design changes, an agreement was reached on metal framed doors with a large glass insert.



Schedule Acceleration Scenarios

The critical path of the schedule always went through the lobby/atrium. Throughout the entire job the atrium was used as storage for tools and other deliveries for the building. Because of this it did not look complete until right before the building was turned over. It was also the most critical part of the schedule because it connected the lab and office sides. Because it tied everything together, it was crucial everything was on schedule to prevent major delays on the lab side, office side, or both sides. The other items on the critical path in order are as follows:

- Demolition
- Excavation and Foundation work
- Concrete Cores
- Steel Erection
- Close in the Building (Exterior wall and Roof)
- Mechanical Rough-in
- Floors and Walls
- Finishes

The biggest threat to the project completion date is changes. After reading the challenges presented above, it is clear that changes drastically affected this project. Because of all the delays from changes, a schedule acceleration plan was incorporated. The original completion date when the project was bid showed the project would be completed in September. With the gas line not being moved in time, NMR pit being changed, Concrete core changes, and changes to the steel shop drawings, the completion date quickly got pushed back to November. The first action to get the completion date back to November was to use blasting during excavation. Originally the owner was not going to allow blasting, but after bringing on a blasting consultant it was acceptable. Blasting resulted in a total savings of one month. The next action was to double the crews working on the concrete cores. At one point the concrete contractor had four cranes onsite. In addition to that, it was possible to start the steel early. Finally, the scheduled completion date was back to September.

A little more than a year before the completion date, the owner decided they wanted the building to be completed in July 15th, 2010. In order to make this possible, Turner put together an overtime program that can be seen below. This program allowed Turner Construction to reduce the schedule by two months in the final year of construction.

Line No.	Area	Expediting	Estimated OT	Sub	Sub Budget	Neg Float - GMP	GMP Float	Comments
1	B Labs Redesign (ASI-126)	N/A	N/A			N/A	N/A	Reprogrammed Space. Review as separate COR w/ premium time to get 7/15/10. Not req'd for 7/15.
1A	ASI-126 - 2nd Floor OT	TBD	TBD					
1B	Remaining Level B Labs	TBD	TBD					
2	Balancing/Hood Programming/Control	0	449,790			Y	-31	Balancer+ Siemens +Waldner+AirCon+Midwest+ABE on 6 day work week
				Tech	69,000			
				Siemens	53,570			
				ABE	34,500			
				Waldner	55,850			
				Halo	64,500			
				Midwest	59,490			
				Aircon	52,650			
				Thermo/ Fisher	50,300			

				Expediting	10,000			
3	Area 5 Sitework	0	N/A			Y	-33	Not Req'd for TCO/ Subst Comp
4	Auditorium	N/A	N/A			N	26	Seat Bases/ Wood Ceiling - How submittals
5	Level B Labs (Unchanged Areas)	0	53,850			N	39	Lab Flooring Prep Req. +
				Tech	w/ above			
				Siemens	-			
				Sloan	7,000			
				ABE	7,000			
				Waldner	7,000			
				Aircon	7,000			
				Midwest	7,000			
				Thermo/ Fisher	7,000			
				Sherland	7,000			
				Zack	4,850			
6	Bridge Sitework	$10,000	78,690			Y	-33	See SH - Sanitary + Storm@Armory Dr.

				Nordic	6,800			
				Valley Crest	67,310			
				Weather	4,590			
				Expediting	10,000			
7	Atrium	$65,000	336,150			Y	-18	Submittals + Extreme Tolerance +
				Monarch	28,000			
				Port Morris	53,000			
				Daniel	106,000			
				Sloan	24,300			
				Armour	41,400			
				Mackeon	1,400			
				AirCon	3,300			
				Zack	78,400			
				Expediting	65,000			
8	Egress Stair	$60,000				Y	-33	Precast Redesign

			184,420					
				Perma	47,600			
				Daniel	20,650			
				Zack	6,120			
				Sabia	20,500			
				Sloan	39,600			
				AirCon	-			
				Boss	15,000			
				CARE	15,000			
				Miscellaneous	20,000			
				Expediting	60,000			
9	Level A Labs	$25,000	91,800			Y	-26	Going Typical Research to Tracking + Flooring Issues
				Sherland	4,000			
				ABE	18,600			
				Halo				

					32,700			
				Thermo/ Fisher	21,200			
				Waldner	-			
				Siemens	15,330			
				Midwest	13,300			
				Aircon	-			
				Armour	-			
				Sloan	6,300			
				Higgins	5,400			
				Expediting	w/ Halo			
10	Smoke Curtain	$5,000						Smoke Curtain Revs
				McKeon	5,000			
11	Level B Corridor	0	N/A					No OT Scheduled
12	Lab Level 2	0	26,700			Y	-4	Review CM
				ABE	19,000			
				Sherland	5,400			

				Sloan	2,240			
13A	Sitework Areas 2	0	29,900			Y	-33	Soil Testing/Remediation/Redesign
				Nordic	14,950			
				Valley Crest	14,950			
13B	Sitework Areas 3	0	44,900			Y	-33	Soil Testing/Remediation/Redesign
				Nordic	22,450			
				Valley Crest	22,450			
14	Atrium Bridge Rail	0	w/Atrium					W/ Atrium Review Racking Submittals - EMC in GMP OT
15	Entrance Doors	$20,000	12,720					Revised Doors - Lack of Design Info.
				Perma	12,700			
				Corporate	5,000			
				Expediting	15,000			
16	Granite End Walls	0	3,300			N	4	Granite Selection/ Shops
				LePore	3,300			
17	PV Panels	0				N	115	Revised PV Panels

			12,120					
				LB Electric	12,120			
18	NMR Area	$10,000	12,120					Wood Ceiling - Veneer Approval, Many Submittals
				Daniel	4,424			
				Sloan	4,424			
				Halo	4,424			
				Higgins	4,424			
				Armour	4,424			
19	Colonnade	0	98,830					Precast/ Granite/ Clg Panels - Lack Design +
				Perma	31,800			
				Nordic	24,300			
				USR	13,800			
				ABE	2,000			
				LePore	24,600			
				Higgins	2,000			

20	Core Areas (Lab & Office)	0	122,720					Metal Ceilings to Wood/Trespa Panel@Core Area
				Sloan	102,700			
				Armour	15,700			
				Sherland	4,320			
21	Punchlist Acceleration	0	TBD					
22	Fume Hood Vacuum Breaker Mods							
	Sub Total	$220,000	2,373,570					
	GRAND TOTAL		2,593,570					
	Lab Penthouse					Y	-18	
	Level 1 Lab					Y	-16	
	EXCLUSIONS:							
1	Office Furniture		TBD					
2	Café@ Level A		TBD					
3	Level 2 Office Revisions		TBD					
4	Vacuum Breaker at Fume Hoods		TBD					

This table was formed based upon certain activities that would not be completed by the date of July 15th. Based upon that, it was determined how much overtime work would be required to make that date. The table was then broken down based upon trades and a cost value was assigned to each one. To increase the schedule from the original September date to July 15th would cost about 2.594 million dollars.

In order to reduce the schedule, the technical trades worked overtime. The amount of overtime per week was determined based on preceding work. Sometimes five 10's were worked. Other times, 6 or 7 workday weeks were required. Occasionally, both were necessary at times. Typically with the non-technical trades, additional crews were brought in to complete the work.

There were two major things done with the mechanical systems to save time. All the controls had their software preloaded at the shops before they were delivered. A rough balance was also done initially. These two things sped up the process of achieving optimal performance quicker. Turner also reduced time by having a full-time commissioning agent onsite. This allowed the systems to be commissioned as items were completed instead of starting commissioning when everything was complete.

Because of the function of this building, it would not be practical to reduce the schedule anymore. The completion date of July 15th falls in a period between semesters. If the schedule was reduced more the completion date would fall in the middle of a semester, which would not be practical to move during. The owner changed the completion date from September to July 15th so everything could be moved and ready for the start of the new semester. It would be possible to work move overtime or increase crew sizes to reduce the schedule even more, but it would not be a good return on investment.

Value Engineering Topics

The owner set a goal of a certain dollar value amount to save in value engineering after Design Development and Schematic Design. Based on this, Turner Construction presented their value engineering ideas and the owner would approve or reject. Because of this, all the value engineering performed on the Chemistry Building was based on the owner's goals.

Almost 20 million dollars were saved based on the value engineering the owner approved. Some of the major ones are in the chart below.

Item	Benefits
Blasting during excavation	1-2 month schedule savings and about $1 million savings
Office to Corridor wall System 9'-3" in lieu of 12'-3" high	$162,800 savings
Revisions to Interior Atrium Façade	$2.34 Million Savings
Exterior lab & office façade - Glass & Metal in lieu of Stone	$3.91 Million Savings
Delete Raised Floor @ Offices	$626,000 Savings
Delete PV's on Penthouse Roof	$1 Million Savings
Target Casework Savings of 5%	$306,600 Savings
Lay-in 30 x 30 Acoustic panel tiles in lieu of metal @ Labs	$648,600 Savings and help Expedite schedule
Lay-in 30 x 30 Acoustic panel tiles in lieu of metal @ Offices	$475,300 Savings and help Expedite schedule

Some of the major value engineering ideas that were rejected are in the chart below.

Item	Benefits
Louvered Pergola in lieu of PV Panels @ Glass Roof	$2 Million Savings
Stained/sealed concrete in lieu of Rubber at Lab Floors	$644,000 Savings
Widen Cores 1LF & Steel in lieu of CIP Shear Walls	All Steel Building, reduce number of moment connections
Delete 120/208V substation and provide local step-down transformers in electric closets	$500,000 Savings
Exposed Steel and SOFP in lieu of metal Panel Ceiling at Labs, Leave unistrut grid	$426,800 Savings

Problem Identification

Public Safety

Because the Chemistry Building is located on a university campus, the safety of the students and faculty becomes a priority. In order to keep a productive site and maintain safety, walking paths need to be planned out and properly marked. The site needs to be completely fenced off and gates monitored to insure construction workers are the only personnel entering. The Chemistry Building is located next to athletic fields and a commuter parking lot. As a result, there is a lot of pedestrian traffic that presents a challenge. The fact that neighboring buildings are also under construction requires coordination between everyone to ensure the public's safety.

Gas-Line Removal

Cutting through the footprint of the Chemistry Building is a gas-line. This line was supposed to be removed before the site was mobilized. However, the gas-line was not removed until during excavation. This presented a major challenge because the blasting plans and site excavation could not be executed as planned. This resulted in excavation finishing one month later than scheduled.

Design Changes to NMR

In order to incorporate different equipment, the NMR pit went on hold for a month while the architect redesigned it. Because of the NMR's location, it affected excavation and foundation work. The footings went on hold for one month and the schedule needed to be changed in order to continue work around this area.

Concrete Core Changes

The concrete cores are on the critical path of the superstructure erection. When these shear walls got put on hold it became problematic. Each additional day this activity was delayed, it would push back the start of another activity that many days. With already having a tight schedule from delays of the foundation and excavation processes, additional delays were a major threat.

Mechanical Drawings Not Completed

Even after all the delays on the concrete cores, the mechanical drawings were not completed for them in time. As a result, it would cost a lot of money to drill through the cores to run utilities. It also presented another challenge due to the fact that it would increase the time for the mechanical rough-in process.

Site Logistics

The Chemistry Building is not an overly large site and is surrounded by other construction activities. There are only two points of entry to the site, but for the majority of construction only one will be open. This entry point can also never be blocked because a neighboring building that needs to maintain a functional loading dock also uses that entrance. This makes it difficult for deliveries and crane placement. As a result some activities with the crane and deliveries need to be scheduled off hours to reduce congestion.

Curtain Wall

Due to the glass size and the limited number of places capable of producing it, the entire curtain wall system is fabricated in Italy. Due to this, the lead time for materials became problematic. Enclosing the building and making it watertight is milestone on the schedule and very important to the construction process. The challenge of getting the curtain wall onsite to erect produces a threat to achieving this milestone.

Glass Stair Towers

There are three stair towers located on the west exterior of the lab side of the building. The actual stairs is the main structural component for these towers. The glass is then attached to aluminum framing and tube steel that is attached to the stairs. Each stair tower contains approximately 150 pieces of glass and a large percentage of glass in each tower was cracking. The glass was a tempered glass with a heat strengthened exterior pane. All the cracking took place on the interior pane. When replacement pieces were installed, a percentage was still cracking. Besides delaying site work because of crane placement, this was a major problem due to the substantial cost of the glass.

MEP Changes

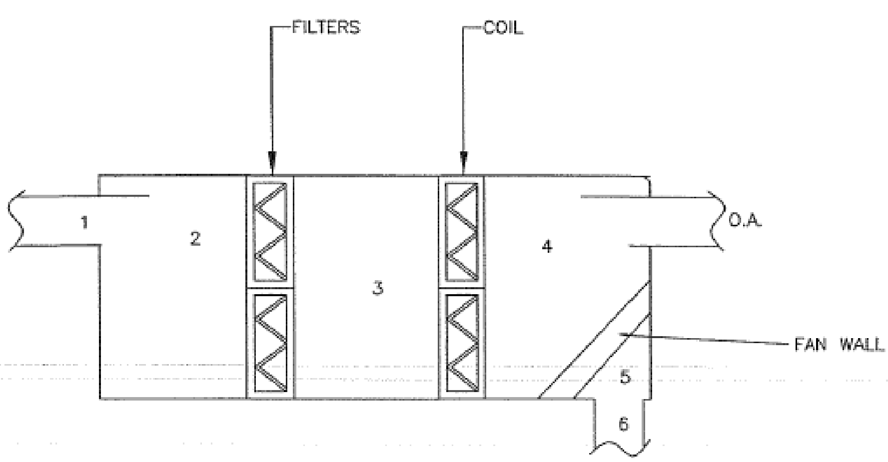
The Chemistry Building has three main areas; the labs, offices, and atrium. Having differing spaces within one building made it difficult to design an efficient mechanical system. There were constant changes and a six month period past with no progress. This caused challenges for the construction team because when materials were supposed to be ordered there was not a completed design.

Schedule / Schedule Reduction

One of the biggest challenges on the job associated with the Chemistry Building was the schedule. After reading all the challenges and problems presented above, it is clear that finishing on-time was going to be a problem.

Lab Penthouse AHU

During the commissioning and balancing process of the air handler units in the lab penthouse, it was noted that the energy consumption was too high. The cause of this was a static pressure drop of 2" between the exit of the fans and the exhaust duct (5 to 6 in diagram below). This was a major problem because the fans were using a lot more energy than they should in order to achieve the required exhaust CFM rate.



Static Profile

	1	2	3	4	5	6
AHU−1	−1.54	−1.52	−1.68	−2.69	+3.22	+1.18
AHU−2	−1.0	−1.17	−1.29	3.52	−2.75	.85
AHU−3	−1.04	−1.20	−1.39	−2.26	−3.74	+1.76
AHU−4	−.98	−1.0	−1.22	−2.43	3.23	+1.09
AHU−5	−1.65	−1.73	−2.6	−3.27	+2.60	+1.39

Technical Analysis Methods

Technical Analysis Method #1: Curtain Wall System

As described in the previous section and constructability challenges, the curtain wall system caused numerous difficulties for the construction team. The cost of this system was around 40 million dollars. With that in mind, and considering the extremely high cost per SF of $878/SF, I plan on investigating alternatives to the current systems. Cost on this project was not as important of a factor as it is on most projects. Because of that I feel there might be a different system that will have similar if not more benefits to the building. There are currently systems with photovoltaic capabilities in the glass, which is one type of system I would like to investigate.

The analysis I will conduct will take into account cost, schedule impacts, architectural appearance, and impact on the structural system. I will do research for different types of glass and contact manufactures. With that, I will gather and compare the specs of each system. From this I will be able to choose alternate appealing systems based on the items taken into account above.

Because of the size of the glass, it needed to be manufactured in Italy. An architectural analysis can be done to see if an alternate size would work, while continuing to keep a similar appearance. Similar, a different size glass may be capable of production closer to the site. This would reduce lead time and an analysis comparing schedules would be conducted. A cost analysis would also be conducted comparing initial costs of the glass, transportation costs, and costs based on schedule impact.

Technical Analysis Method #2: Sustainable Techniques

The Chemistry Building has numerous green elements, but is not slated to receive any LEED accreditation. There are PV trays on the roof, a greywater system, room occupancy sensors, highly efficient glazing, shading systems, and other green components. Energy consumption and sustainable features were definitely considered during the design and construction process. With that, an analysis can be conducted based on the LEED rating scale. This analysis will calculate out the current number of points the Chemistry Building achieves. With that an in-depth analysis will take place investigating the feasibility of achieving a LEED rating. Cost, payback time, and schedule impacts will be considered while performing this analysis.

The current PV trays on the roof are present more for an architectural feature than for function. With that in mind, and considering value engineering, a different shading/architectural system can replace the custom PV trays. This could save approximately two million dollars that could be used more efficiently to make the Chemistry Building more sustainable. One way this money could be used is for a cool roof, green roof, or a roofing system with photovoltaic technology in it. The reason why a green roof was not used on this building was because of its weight. An examination could be conducted to see how this increased weight would affect the structural system. Based on the information from AE 308 and 404, it could be determined which steel members need to be strengthened and then the cost increase could be estimated.

Technical Analysis #3: Site Logistics

Because the Chemistry Building is located on a smaller site that shares the site entrances with other activities, coordination was a challenge on this project. A pedestrian bridge was being constructed at the Northeast entrance, while renovations took place on the building at the Northwest entrance. As a result, the work associated with these two activities needed to be coordinated with the Chemistry Building's work. The tunnel that was constructed to connect the Chemistry Building to the building to its North also presented a threat to the site logistics. The tunnel fell on the roadway between the two entrances. If the Northwest entrance was closed and the tunnel was being worked on, deliveries would not be able to reach the loading dock for the building.

To help improve the coordination and planning process, a 4D model could be constructed. An analysis could then be conducted comparing the current schedule to the schedule linked to the 4D model. Research on 4D models will also be used to complete a compare and contrast diagram to the current planning process. From this, it can be concluded what benefits the 4D model and schedule would have to the Chemistry Building.

Technical Analysis #4: Schedule Analysis

With the delays in the beginning of the project and the owner changing the completion date, meeting the completion date was a real challenge on this project. Turner construction needed to make up 4 months of time in order to be successful. The main cause of delay was changes. A portion of the footings were put on hold for a month, work on the cores was put on hold for changes, and changes to the MEP systems caused major delays. Primavera was used and constantly adjusted to achieve the final completion date.

Although Primavera is typically used to schedule most projects, there are many other scheduling programs out there. With that, an analysis to compare Primavera to other programs may show an alternative program could be beneficial. Some of the programs that will be investigated are scheduling with 4D modeling, SIPPS schedules, and schedules linked to the BIM model.