Executive Summary

Two months into excavation and foundation construction, Capital One began to have desires to obtain their future Lecture Hall a few months prior to the previously agreed upon date noted in the contract. Without adequate notification of the owner's project intentions, DAVIS Construction was unable to adjust work sequencing and other methods which may cut down on the overall duration for foundation completion. Whatever time that could have been saved, would almost have had to wait until interior activities began.

In this analysis, we will take a look at the actual foundation schedule created by photo observations and note the possible room for improvement. A more efficiently sequenced schedule is then produced and its duration is compared to that of the original. With the assistance of *NavisWorks JetStream*, construction activities and their accompanying construction images, schedule differences are noticed. Overall, 23 working days can be saved had the general contractor been given sufficient time in preparing a foundation schedule.

The structural breadth work within this analysis includes soil calculations necessary to determine proper shoring forces. Additional costs of the rakers are included and compared to that of DAVIS' liquidated damage of $1,000/day in the event of late building turnover. With an estimated shoring cost of $11,258 and the 23 day schedule savings, execution of the Ulma rakers seems to be a valuable activity. Moreover, this 4 week reduction can save approximately $45,437 in General Conditions costs.

Background

As with every base building project, excavation and foundation work are two of the most crucial aspects in construction. Although they are the most distant activities from building turnover, they can set an initial trend for months to follow. Jobs that get behind from the beginning may end up being quite stressful and force project teams to play catch up all the way till the end. On the other hand, when days, weeks, and even months of schedule time are saved due to careful planning, projects tend to run more smoothly.

In the case of the Lecture Hall, Capital One neglected to inform the general contractor of their premature ideas of an early project turnover, one that was nearly two months prior to the contract date. About 14 weeks into construction, after the basement excavation was complete and cast-in-place walls were in progress, Capital One approached DAVIS with its proposal to hand over the building early.

At that point in time, DAVIS was left with few options to accelerate or re-sequence the core and shell schedule. The only thing they could do was hope to make up time within the Lecture Hall's interior work. If the project teams had created a more open path of communication at an earlier stage, additional schedule considerations may have been discussed.

In the case where an early completion is brought to the attention of the Project Manager sooner, the most feasible and least costly option they would have is to re-sequence work. Secondly, with sufficient notice, it might have been possible to implement sheeting and shoring techniques that would save both time and money. In the worst case scenario, if project turnover was in fact late, Capital One will charge DAVIS $1,000 dollars every day after the July 31st contract date.

Proposal

To obtain a better understanding of typical sequencing and location of trades, a 3-dimensional model and its accompanying schedule will be linked in *NavisWorks JetStream*. After an evaluation of possible time saving work arrangements are considered, an alternate schedule will be proposed. In addition to sequencing, the use of shoring rakers shall be included as a possible time saving device. After each schedule ha been discussed, a direct visual comparison of the two scenarios will be provided. Assuming the foundation directly affects the critical path, a cost analysis will confirm the valuable nature of this shoring consideration.

Actual Foundation Schedule

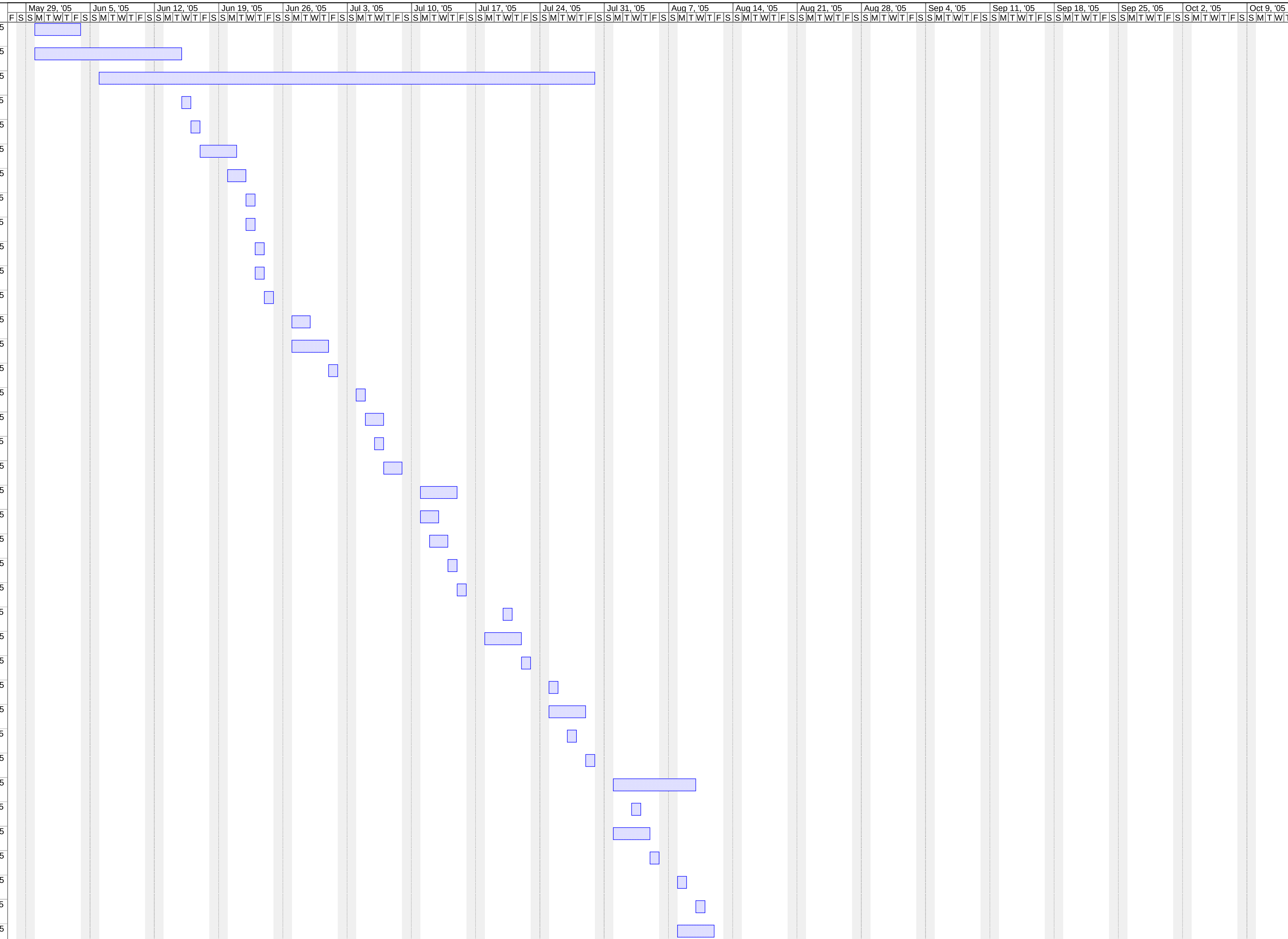
The detailed schedule provided on the following two pages was obtained through the evaluation of hundreds of carefully dated construction photographs. Key elements for completion of the Lecture Hall foundation were noted and later organized into a rational order with proper time durations. Since no detailed schedule was created by the general contractor, as shown in the "Demolition" and "Concrete Structure" phases of **Appendix B**, this revised timetable was created.

With site mobilization and excavations beginning at the end of May, base building demolition was able to commence in the first week of June. Come April 15, 2005, the basement excavations were complete and drilling began for the hydraulic elevator. As footing excavations progressed over the next two weeks, framing of the first wall pour along the south facing wall was complete by April 30th. While Wall #1 was poured on the first day of May, footing excavations continued in a clockwise manner through "Pour #2, 3, and 4," catching up to the Shear Wall Pour #2 on the west wall. Over the next two weeks, the outer curved wall's continuous footings were poured and Wall #5 was framed. The final three concrete pours continued in a clockwise manner, ending by August 31st. The cast-in-place basement floors were staged in three sections, occurring on the 15th and 16th of August and completed on September 6th. Work within the adjacent garden atrium and auditorium nose sections did not begin until mid-September, once steel began to be set in place. This backfilling delay was due to the need for the walls being tied in place with the first floor steel. Without any type of support system, backfilling too early would have caused the basement walls to fail. Foundation construction within the atrium and auditorium progressed over the next month and did not conclude until October 12th.

Although the schedule seemed to develop in a sequential manner, an outsider's intuitive predictions of wall locations would not be correct. As shown on the final page of this analysis section, walls #1 and 2 are not neighboring each other. Without diving into the sequencing shortcomings, the process in which the curved walls were framed and poured arose as a concern. With only a few foot gap between the walls, adequate space for workers to frame and shore hardly existed. Just as Capital One was late on properly informing the general contractor of their early completion ideas, DAVIS could not properly implement a more demanding timeline of trades in the most efficient manner. Subcontractor workings were somewhat sporadic and did not shoot for the goal of foundation completion, leading into further construction on the first and second floors.

Lecture Hall Foundation Schedule - Actual

ID	Task Name	Duration	Start
1	Site Mobilization	5 days	Mon 5/30/05
2	Site Grating, Excavation, Layout	12 days	Mon 5/30/05
3	Base Building Demolition	40 days	Mon 6/6/05
4	Drill for Elevator Hydraulic	1 day	Wed 6/15/05
5	Excavate/Frame Elevator Pit	1 day	Thu 6/16/05
6	Excavate/Frame Line 26-27 Footings	2 days	Fri 6/17/05
7	Excavate/Frame Wall #1 Continuous Foc	2 days	Mon 6/20/05
8	Pour Elevator Pit	1 day	Wed 6/22/05
9	Pour Wall #1 Continuous Footing	1 day	Wed 6/22/05
10	Layout Curved Walls and Shear Wall #2	1 day	Thu 6/23/05
11	Strip Pit	1 day	Thu 6/23/05
12	Pour Line 26-27 Ftgs	1 day	Fri 6/24/05
13	Excavate Curved Wall Ftg	2 days	Mon 6/27/05
14	Frame/Shore Wall #1	4 days	Mon 6/27/05
15	Pour Wall #1	1 day	Fri 7/1/05
16	Pour Curved Wall Ftg	1 day	Mon 7/4/05
17	Excavate Shear Wall Continuous Ftg	2 days	Tue 7/5/05
18	Strip Forms Wall #1	1 day	Wed 7/6/05
19	Pour Shear Wall Continuous Ftg	2 days	Thu 7/7/05
20	Frame/Shore Wall #2	4 days	Mon 7/11/05
21	Excavate/Frame Wall #3 Continuous Ftg	2 days	Mon 7/11/05
22	Excavate/Frame Wall #4 Continuous Ftg	2 days	Tue 7/12/05
23	Pour Wall #3/4 Continuous Ftg	1 day	Thu 7/14/05
24	Pour Wall #2	1 day	Fri 7/15/05
25	Strip Forms Wall #2	1 day	Wed 7/20/05
26	Frame/Shore Wall #3	4 days	Mon 7/18/05
27	Pour Wall #3	1 day	Fri 7/22/05
28	Pour Outer Curved Wall Continuous Ftg	1 day	Mon 7/25/05
29	Frame/Shore Wall #4	4 days	Mon 7/25/05
30	Strip Forms Wall #3	1 day	Wed 7/27/05
31	Pour Wall #4	1 day	Fri 7/29/05
32	Run PVC/Conduit Cellar Grade	7 days	Mon 8/1/05
33	Strip Forms Wall #4	1 day	Wed 8/3/05
34	Frame/Shore Wall #5	4 days	Mon 8/1/05
35	Pour Wall #5	1 day	Fri 8/5/05
36	Pour Inner Curved Wall Continuous Ftg	1 day	Mon 8/8/05
37	Strip Forms Wall #5	1 day	Wed 8/10/05
38	Frame/Shore Wall #6	4 days	Mon 8/8/05



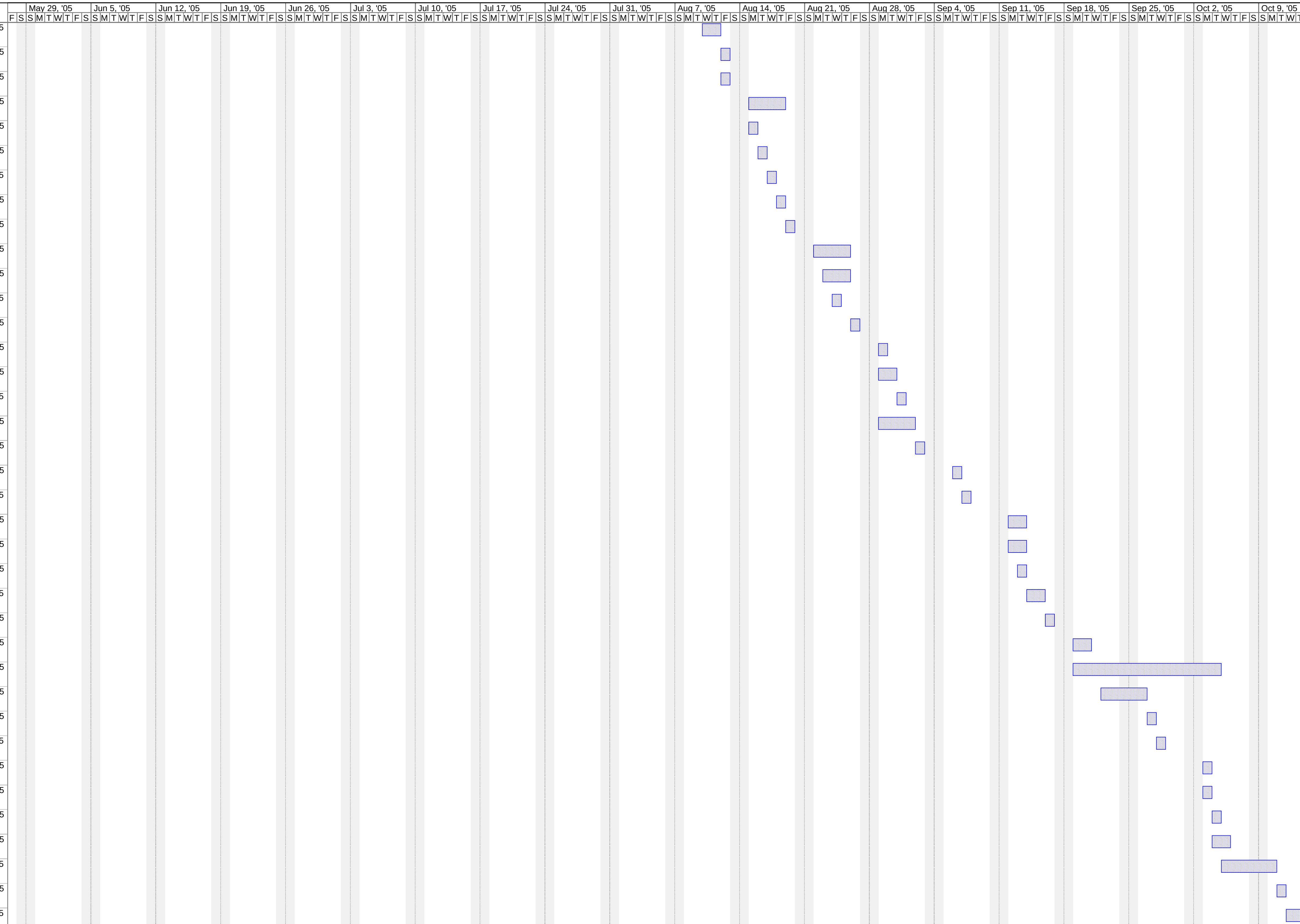
Project: Lecture Hall Foundation~534
Date: Tue 4/4/06

Task		Progress		Summary		External Tasks	
Split		Milestone		Project Summary		External Milestone	

Deadline

Lecture Hall Foundation Schedule - Actual

ID	Task Name	Duration	Start
39	Gravel Fill and WWF Cellar Slab #1/2	2 days	Wed 8/10/05
40	Pour Wall #6	1 day	Fri 8/12/05
41	Excavate/Frame Wall #8 Ftgs	1 day	Fri 8/12/05
42	Frame/Shore Wall #7	4 days	Mon 8/15/05
43	Pour Cellar Slab #1	1 day	Mon 8/15/05
44	Pour Cellar Slab #2	1 day	Tue 8/16/05
45	Strip Forms Wall #6	1 day	Wed 8/17/05
46	Pour Wall #8 Ftgs	1 day	Thu 8/18/05
47	Pour Wall #7	1 day	Fri 8/19/05
48	Frame/Shore Wall #8	4 days	Mon 8/22/05
49	Set Steel Lines A-A.7	3 days	Tue 8/23/05
50	Strip Forms Wall #7	1 day	Wed 8/24/05
51	Pour Wall #8	1 day	Fri 8/26/05
52	Backfill West Side	1 day	Mon 8/29/05
53	Set Steel Lines BB-C	2 days	Mon 8/29/05
54	Strip Forms Wall #8	1 day	Wed 8/31/05
55	Frame/Shore Wall #9	4 days	Mon 8/29/05
56	Pour Wall #9	1 day	Fri 9/2/05
57	Pour Cellar Slab #3	1 day	Tue 9/6/05
58	Strip Forms Wall #9	1 day	Wed 9/7/05
59	Set Steel Lines C-DD	2 days	Mon 9/12/05
60	Backfill Atrium and East Side	2 days	Mon 9/12/05
61	Backfill and Level Nose	1 day	Tue 9/13/05
62	Excavate/Frame Nose Foundation	2 days	Wed 9/14/05
63	Pour Nose Foundation	1 day	Fri 9/16/05
64	Excavate/Frame Atrium Ftgs	2 days	Mon 9/19/05
65	Run PVC/Conduit Atrium Grade	12 days	Mon 9/19/05
66	Frame Nose Wall	3 days	Thu 9/22/05
67	Pour Nose Wall	1 day	Tue 9/27/05
68	Pour Atrium Footings	1 day	Wed 9/28/05
69	Set Atrium Steel	1 day	Mon 10/3/05
70	Strip Nose Forms	1 day	Mon 10/3/05
71	Backfill Atrium	1 day	Tue 10/4/05
72	Backfill Auditorium Nose	2 days	Tue 10/4/05
73	Frame Foundation Atrium	4 days	Wed 10/5/05
74	Set Nose Steel	1 day	Tue 10/11/05
75	Pour Atrium Slab	2 days	Wed 10/12/05



Project: Lecture Hall Foundation~534
Date: Wed 4/5/06

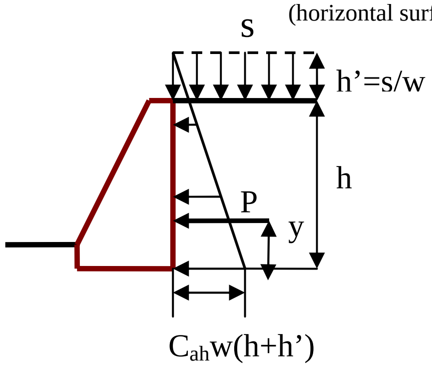
Task | Progress | Summary | External Tasks | Deadline
Split | Milestone | Project Summary | External Milestone

Proposed Shoring

Load Analysis

In order to calculate approximate loadings caused by backfilling, a Professional Engineer at Rathgeber/Goss and Associates suggested examples present in the "Design of Concrete Structures" text. From the diagram and equations to follow, an estimated force per horizontal foot of soil can be calculated. In turn, this force will be supported by rakers strategically placed to withhold the load for the largest possible on-center spans. For a better understanding of this process, please view **Appendix G**.

Figure 12. Earth Pressure
(horizontal surface with surcharge)



$$y = \frac{h^2 + 3hh'}{3(h + 2h')}$$

$$P = 1/2C_{ah}wh(h+2h')$$

Figure 13. Ulma Raker Support

With an estimated equipment surcharge to be 115 lb/ft2, a modified load height was figured to be around 3.28' above the footing. Our pressure per horizontal foot can be calculated at 2,997 lbs/ft. A resulting axial load in the shores would be around 1,546 lbs. With a maximum strength of 8,500 lbs, the proposed Ulma posts need to be placed every 5.5 feet on-center. Similar braces can be seen in the above photograph.

Cost Analysis

As quoted by Southland Concrete, a concrete subcontractor, the overall shoring work should cost around $11,258. The table to follow breaks down the estimate into labor, tools, and material costs.

	Unit Rate	Units	8/8/2005	8/9/2005	8/29/2005	8/30/2005	9/12/2005	9/13/2005	
Labor									
Carpenter	$36.00	HR	8	8	8	8	0	0	$1,152.00
Helper	$30.00	HR	8	8	8	8	8	8	$1,440.00
Laborer	$26.00	HR	0	0	0	0	8	8	$416.00
								Sub Total	$3,008.00
Misc Tools									
Bit	$5.00	DAY	1	1	1	1			$20.00
Hammer Drill	$25.00	DAY	1	1	1	1			$100.00
Cut Off Saw	$45.00	DAY					1	1	$90.00
								Sub Total	$210.00
Materials									
Ulma Shores	$15.00	EA	40						$600.00
Bolts (4/anchor)	$7.00	EA	320						$2,240.00
Bracing Anchors	$65.00	EA	80						$5,200.00
								Sub Total	$8,040.00
								Total	$11,258.00

Table 9. Ulma Shoring Estimate

Proposed Schedule

A revised schedule may be observed on the two pages prior to the final foundation analyses.

Preliminary Considerations

After careful scrutiny of the actual foundation schedule, one would be able to create a more efficient timetable of construction activities. In order to create such a schedule, a Project Manager should set some initial goals and requirements in which to achieve these goals.

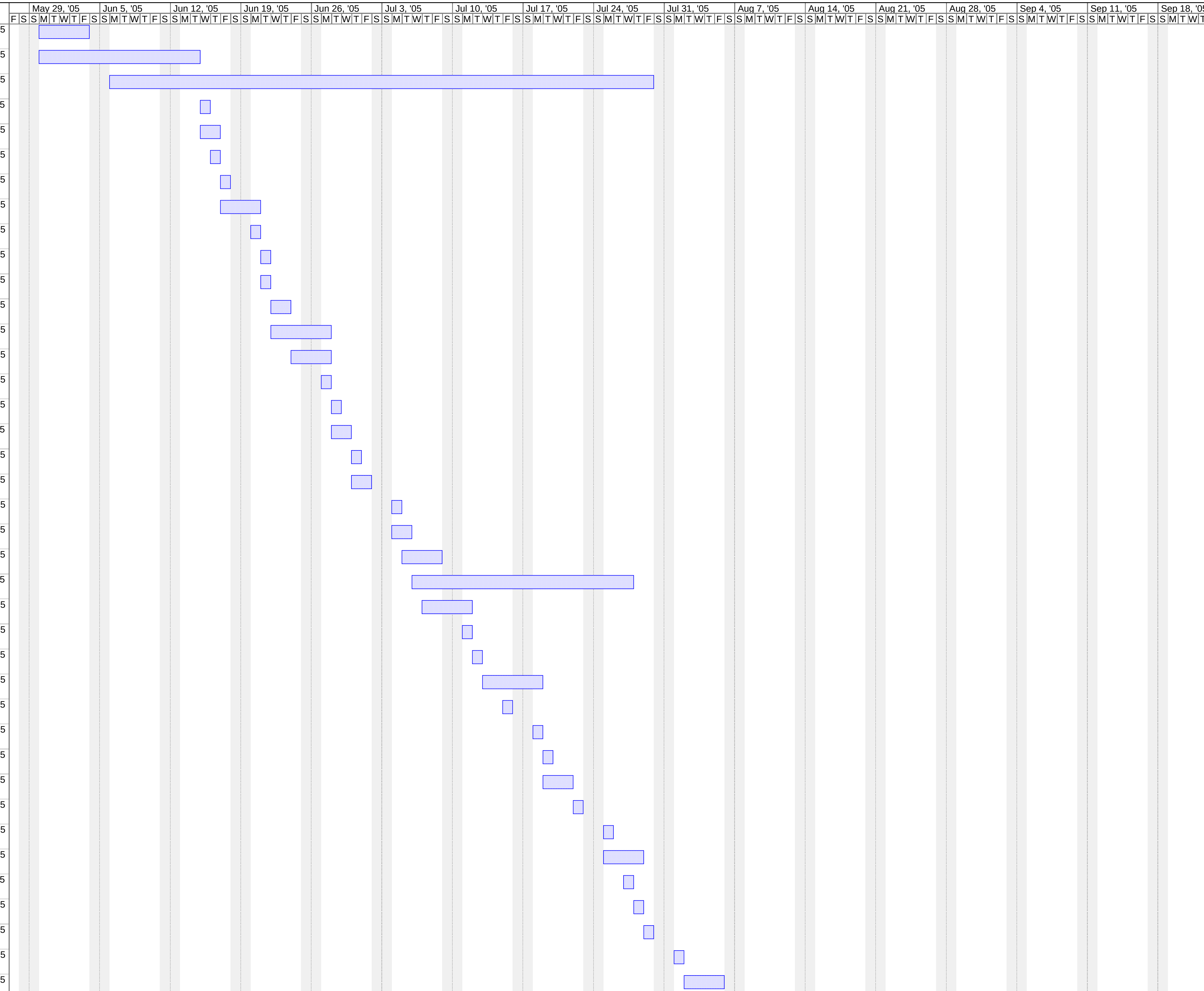
As stated in the proposal, the overall goal of this analysis is to obtain an earlier foundation completion date. For brevity purposes and a distinct finish line, the final activities shall include a slab-on-grade atrium pour and backfill within the auditorium nose. A secondary goal of this analysis is the implementation of a raker shoring system, which may further shorten the overall project duration for foundation work.

With these goals in mind, it was necessary to finish slab-on-grade basement pours in a sequential manner. By completing the first two floor pours, rakers could be installed and backfilling start in the Garden Atrium Space. Once the third and final floor pour is complete, shoring on the adjacent walls can go in. Soon after, the auditorium nose backfilling and foundation work can begin.

Revised Schedule

With construction beginning on the same June 15th date, activity durations and estimated space concerns were taken into consideration. Elevator pit and footing excavations began immediately. As framing is going up along Wall #1, adjacent continuous footing digging occurred. To better utilize space needs, curved wall footing work took place on the opposite side of the foundation while Wall #3 was being started around the 24th. Moving along swiftly, shear wall excavations begin by June 30th and connect up with the curved wall footings already poured. With the creation of continuous footings, framing and pouring of walls progressed right behind. To better plan work for the curved walls, each was framed at separate time. As soon as the inner curved wall pour was complete on July 18th, framing was stripped and placed on the parallel outer wall. Following placement of conduit along the basement grade and sufficient footings and walls were poured, the first cellar slab transpired on August 1st. Shortly after floor section #2 was filled with gravel, another slab-on-grade pour was expected. Come the 8th of August, the first two floor pours had adequate time to cure and the Ulma raker supports could be installed. Once shoring along Wall #1 and #3 was complete, work within the Garden Atrium could commence.

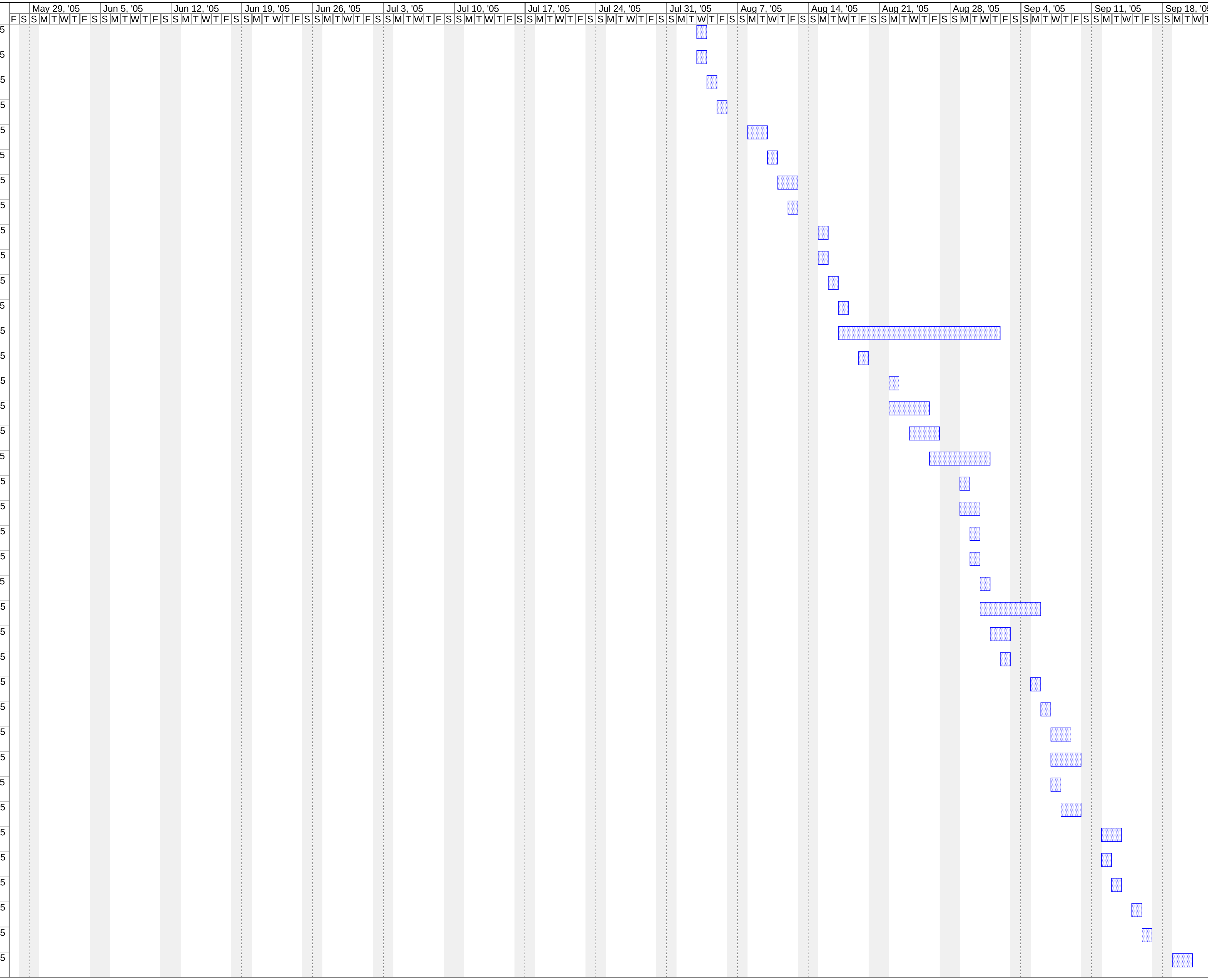
ID		Task Name	Duration	Start	Finish
1		Site Mobilization	5 days	Mon 5/30/05	Fri 6/3/05
2		Site Grating, Excavation, Layout	12 days	Mon 5/30/05	Tue 6/14/05
3		Base Building Demolition	40 days	Mon 6/6/05	Fri 7/29/05
4		Drill for Elevator Hydraulic	1 day	Wed 6/15/05	Wed 6/15/05
5		Excavate/Frame Line 26-27 Footings	2 days	Wed 6/15/05	Thu 6/16/05
6		Excavate/Frame Elevator Pit	1 day	Thu 6/16/05	Thu 6/16/05
7		Pour Elevator Pit and Line 26-27 Footings	1 day	Fri 6/17/05	Fri 6/17/05
8		Excavate/Frame Wall #1 Continuous Footing	2 days	Fri 6/17/05	Mon 6/20/05
9		Layout Curved and Shear Wall #2 Footings	1 day	Mon 6/20/05	Mon 6/20/05
10		Pour Wall #1 Continuous Footing	1 day	Tue 6/21/05	Tue 6/21/05
11		Strip Pit	1 day	Tue 6/21/05	Tue 6/21/05
12		Excavate Curved Wall Footing	2 days	Wed 6/22/05	Thu 6/23/05
13		Frame/Shore Wall #1	4 days	Wed 6/22/05	Mon 6/27/05
14		Excavate/Frame Wall #3 Continuous Ftg	2 days	Fri 6/24/05	Mon 6/27/05
15		Pour Curved Wall Continuous Footings	1 day	Mon 6/27/05	Mon 6/27/05
16		Pour Wall #1	1 day	Tue 6/28/05	Tue 6/28/05
17		Excavate/Frame Wall #4 Continuous Ftg	2 days	Tue 6/28/05	Wed 6/29/05
18		Pour Wall #3/4 Continuous Ftg	1 day	Thu 6/30/05	Thu 6/30/05
19		Excavate Shear Wall Continuous Ftg	2 days	Thu 6/30/05	Fri 7/1/05
20		Strip Forms Wall #1	1 day	Mon 7/4/05	Mon 7/4/05
21		Pour Shear Wall Continuous Ftg	2 days	Mon 7/4/05	Tue 7/5/05
22		Frame/Shore Wall #3	4 days	Tue 7/5/05	Fri 7/8/05
23		Run PVC/Conduit Cellar Grade	16 days	Wed 7/6/05	Wed 7/27/05
24		Frame/Shore Inner Curved Wall	3 days	Thu 7/7/05	Mon 7/11/05
25		Pour Wall #3	1 day	Mon 7/11/05	Mon 7/11/05
26		Pour Inner Curved Wall	1 day	Tue 7/12/05	Tue 7/12/05
27		Frame/Shore Wall #4	4 days	Wed 7/13/05	Mon 7/18/05
28		Strip Forms Wall #3	1 day	Fri 7/15/05	Fri 7/15/05
29		Strip Inner Curved Wall Forms	1 day	Mon 7/18/05	Mon 7/18/05
30		Pour Wall #4	1 day	Tue 7/19/05	Tue 7/19/05
31		Frame/Shore Outer Curved Wall	3 days	Tue 7/19/05	Thu 7/21/05
32		Pour Outer Curved Wall	1 day	Fri 7/22/05	Fri 7/22/05
33		Strip Forms Wall #4	1 day	Mon 7/25/05	Mon 7/25/05
34		Frame/Shore Wall #5	4 days	Mon 7/25/05	Thu 7/28/05
35		Strip Outer Curved Wall	1 day	Wed 7/27/05	Wed 7/27/05
36		Gravel Fill and WWF Cellar Slab 1	1 day	Thu 7/28/05	Thu 7/28/05
37		Pour Wall #5	1 day	Fri 7/29/05	Fri 7/29/05
38		Pour Cellar Slab 1	1 day	Mon 8/1/05	Mon 8/1/05
39		Frame/Shore Wall #2	4 days	Tue 8/2/05	Fri 8/5/05



Project: Lecture Hall Foundation
Date: Tue 4/4/06

Task	Progress	Summary	External Tasks	Deadline
Split	Milestone	Project Summary	External Milestone	

ID		Task Name	Duration	Start	Finish
40		Gravel Fill and WWF Cellar Slab 2	1 day	Wed 8/3/05	Wed 8/3/05
41		Strip Forms Wall #5	1 day	Wed 8/3/05	Wed 8/3/05
42		Pour Cellar Slab 2	1 day	Thu 8/4/05	Thu 8/4/05
43		Pour Wall #2	1 day	Fri 8/5/05	Fri 8/5/05
44		Fasten Ulma Shores Walls 1/3	2 days	Mon 8/8/05	Tue 8/9/05
45		Backfill Atrium	1 day	Wed 8/10/05	Wed 8/10/05
46		Excavate/Frame Atrium Footings	2 days	Thu 8/11/05	Fri 8/12/05
47		Excavate/Frame Wall #8 Ftgs	1 day	Fri 8/12/05	Fri 8/12/05
48		Pour Atrium Footings	1 day	Mon 8/15/05	Mon 8/15/05
49		Strip Forms Wall #2	1 day	Mon 8/15/05	Mon 8/15/05
50		Backfill Atrium	1 day	Tue 8/16/05	Tue 8/16/05
51		Pour Wall #8 Ftgs	1 day	Wed 8/17/05	Wed 8/17/05
52		Run PVC/Conduit Atrium Grade	12 days	Wed 8/17/05	Thu 9/1/05
53		Gravel Fill and WWF Cellar Slab 3	1 day	Fri 8/19/05	Fri 8/19/05
54		Pour Cellar Slab #3	1 day	Mon 8/22/05	Mon 8/22/05
55		Frame/Shore Wall #9	4 days	Mon 8/22/05	Thu 8/25/05
56		Set Steel Lines A-A.7	3 days	Wed 8/24/05	Fri 8/26/05
57		Frame/Shore Wall #8	4 days	Fri 8/26/05	Wed 8/31/05
58		Pour Wall #9	1 day	Mon 8/29/05	Mon 8/29/05
59		Fasten Ulma Shores Wall 5/Curved	2 days	Mon 8/29/05	Tue 8/30/05
60		Strip Forms Wall #9	1 day	Tue 8/30/05	Tue 8/30/05
61		Backfill Atrium	1 day	Tue 8/30/05	Tue 8/30/05
62		Backfill and Level Nose	1 day	Wed 8/31/05	Wed 8/31/05
63		Frame Atrium Foundation	4 days	Wed 8/31/05	Mon 9/5/05
64		Excavate/Frame Nose Foundation	2 days	Thu 9/1/05	Fri 9/2/05
65		Pour Wall #8	1 day	Fri 9/2/05	Fri 9/2/05
66		Pour Nose Foundation	1 day	Mon 9/5/05	Mon 9/5/05
67		Pour Atrium Slab	1 day	Tue 9/6/05	Tue 9/6/05
68		Set Steel Lines BB-C	2 days	Wed 9/7/05	Thu 9/8/05
69		Frame Nose Wall	3 days	Wed 9/7/05	Fri 9/9/05
70		Strip Forms Wall #8	1 day	Wed 9/7/05	Wed 9/7/05
71		Set Steel Lines C-DD	2 days	Thu 9/8/05	Fri 9/9/05
72		Remove Ulma Shores	2 days	Mon 9/12/05	Tue 9/13/05
73		Pour Nose Wall	1 day	Mon 9/12/05	Mon 9/12/05
74		Set Atrium Steel	1 day	Tue 9/13/05	Tue 9/13/05
75		Set Nose Steel	1 day	Thu 9/15/05	Thu 9/15/05
76		Strip Nose Forms	1 day	Fri 9/16/05	Fri 9/16/05
77		Backfill Auditorium Nose	2 days	Mon 9/19/05	Tue 9/20/05



Project: Lecture Hall Foundation
Date: Tue 4/4/06

Task	Progress	Summary	External Tasks	Deadline
Split	Milestone	Project Summary	External Milestone	

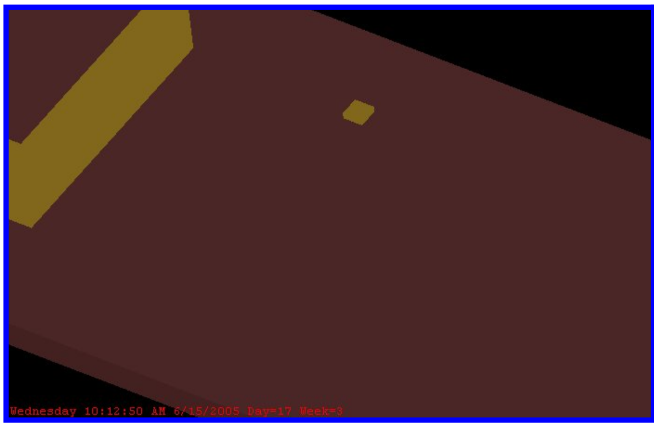
Foundation Schedule Analysis

The following images are provided to help visualize and compare the actual schedule enforced by DAVIS and a revised, more stringent timeline. With the objective of completing the basement floor pours and their surrounding walls as soon as possible, Ulma rakers could be inserted to provide support for backfilling. This backfilling would allow work to progress within the elevated garden atrium and auditorium nose areas. Additional subcontractor work sequencing is implemented to decrease the original leniency of activities.

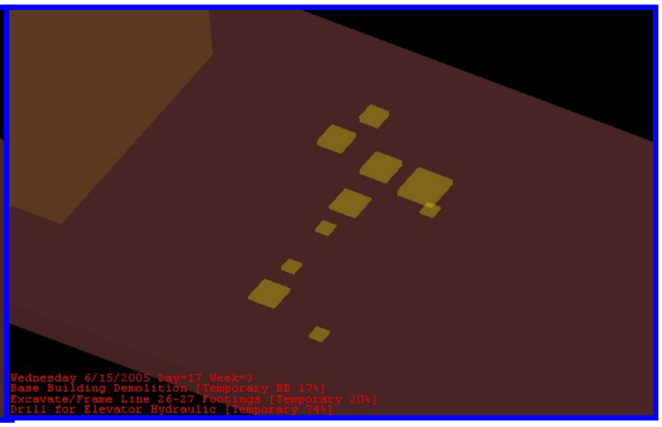
For reference purposes, South is to the left and North is to the right of the images. Two of the revised illustrations have been switched so proper foundation elements can be seen.

6 June 2005

Actual

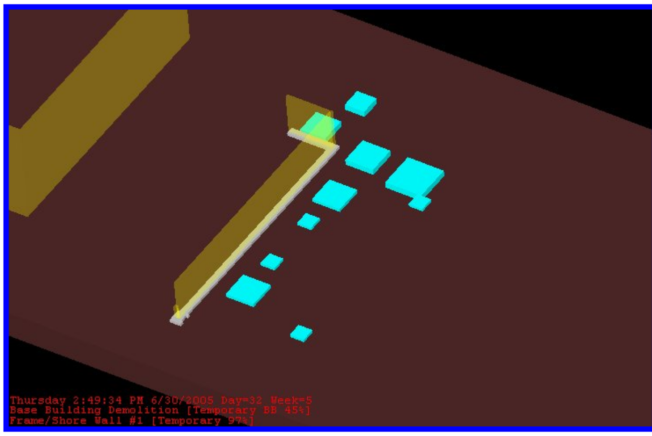
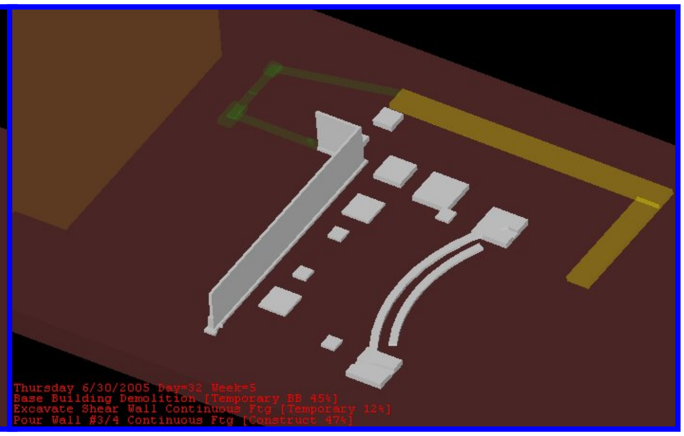


Revised



As depicted in the images above, foundation work began on the 6th in both scenarios. In the original schedule, only drilling for the hydraulic elevator was planned. If beginning in the morning, drilling should not extend much past lunch. This would allow excavation of the 26-27 line footings to begin, which is shown in the revised process. Within in the first two days of work, additional progress can already be visualized.

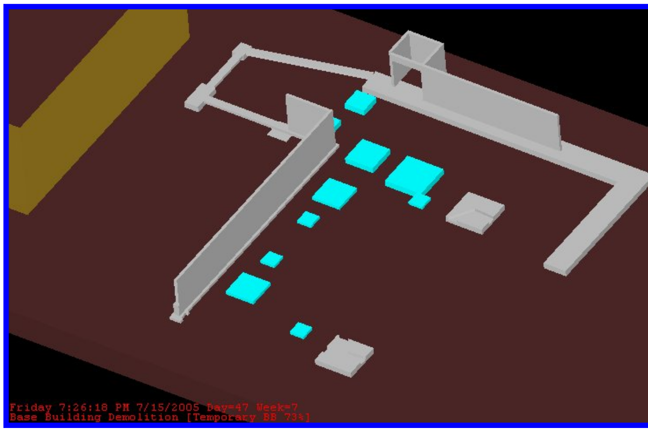
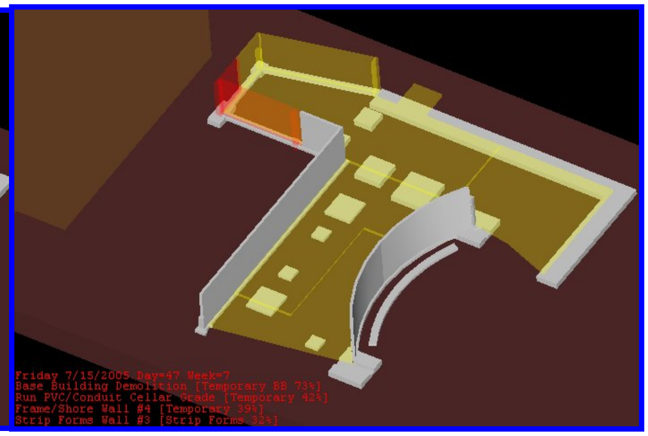
27 June 2005

Actual	**Revised**
	

Three weeks later, the original schedule had accomplished the pouring of Line 26-27 footings and framing of Wall #1 was in progress. Although not shown in the photograph, excavations for the curved wall footings began later that day.

In order to accomplish the need for the wall footing pours, excavations were planned to happen simultaneously, on opposite sides of the foundation where ample space is provided and could be performed efficiently. This created an opportunity to bring cement trucks on site for three of four neighboring days, completing “Wall Pour #1,” “Curved Wall Footing,” and the green “Wall #3/4 Continuous Footing” shown on the right, in a short amount of time. Excavation of the large shear wall footing was also in the process to be completed the following day.

15 July 2005

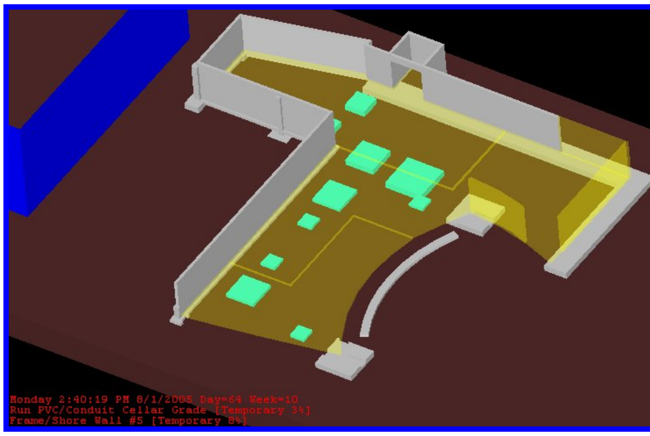
Actual	**Revised**
	

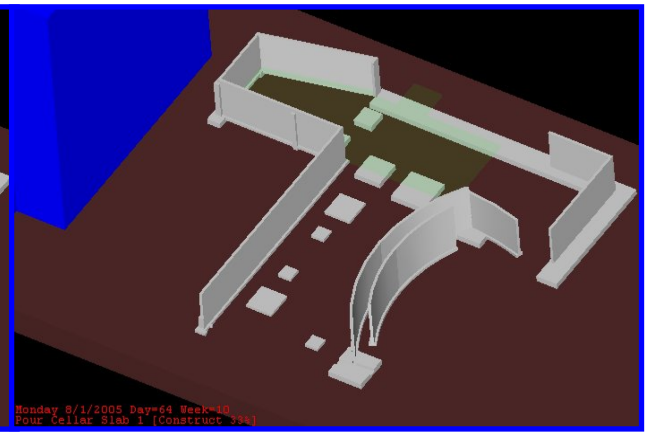
According to the schedule provided by DAVIS, 10-12 work days later, continuous footings wrapped all the way around to Wall #5. As the formwork from the first wall was removed, days later the large shear wall framing and shoring took place. Although the footing progress continued from Wall #1 to Wall #2, these two separate sections are located below the only standing walls. Transitioning from location to location did not seem efficient. Footings for the curved wall had also been poured come the 15th of July.

For the modified process, framing of the third and fourth walls continued, with the addition of the Inner Curved Wall. Since different materials were used for the curved walls, framing and pouring of Wall #3 and the curved wall could be done simultaneously on opposite sides of the foundation. As shown in the revised image, the red third wall was being stripped, allowing for the adjacent fourth wall to be framed. At this time, the Inner Curved Wall has already been poured and stripped. Running of conduit along the basement floor grade is also in progress where space is available.

1 August 2005

Actual | **Revised**



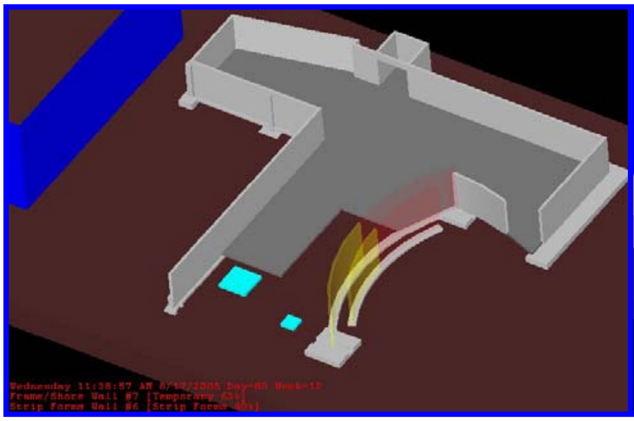


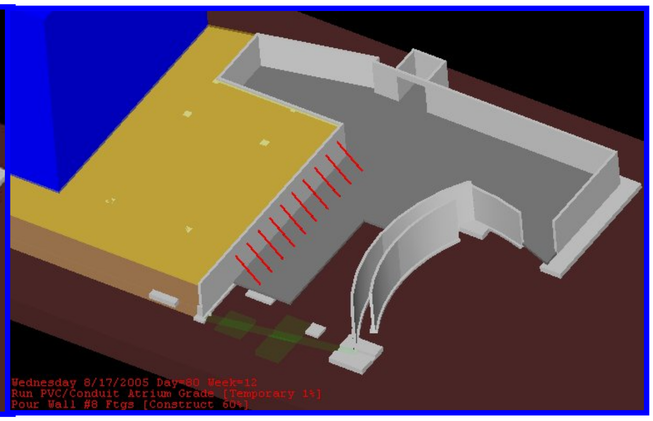
Since the last original schedule iteration, the concrete subcontractor had to back-track to Walls #3 and #*4*. Completion of these two sections occurred earlier today, August 1st. Framing of the fifth wall began while the fourth was being stripped. Running of conduit along the basement grade has begun and is to continue over the next week.

Over the past two weeks in the adjusted timeline, both the fifth and outer curved walls have been poured and stripped. Once Wall #4 was complete and conduit work had a few days to develop, the first slab section could be filled with gravel and welded wire fabric laid. At this point, "Gravel Fill and WWF Cellar Slab 1" were not expected to commence for almost another two weeks in the early schedule.

17 August 2005

Actual	**Revised**



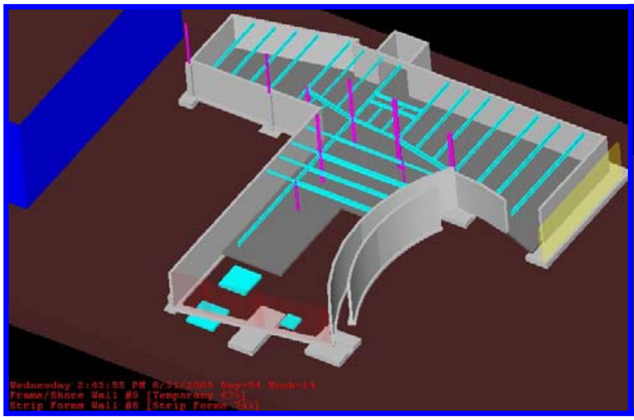
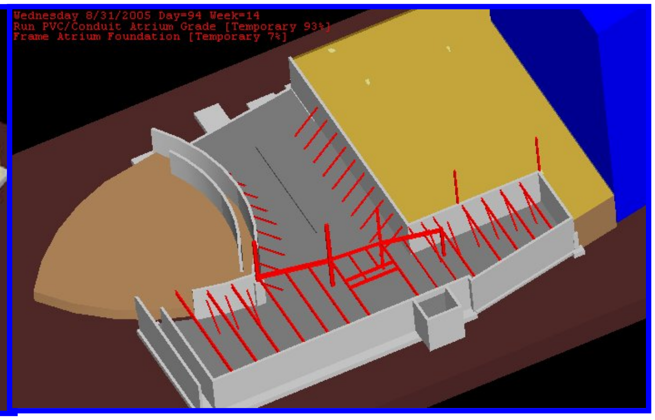


In the above illustration, you can see one of the concerns raised earlier about sequencing of the nearby curved walls. Instead of doing sections of the Inner and Outer Curved Walls at differing time periods, they did them simultaneously in two parts. By framing the inner wall and then attempting the other, workers were restricted to hardly enough free space to frame the outer wall efficiently. On a more positive note, at the period when framing was stripped from one portion, the same sections were used to frame the adjoining wall. Over the past few weeks, slab on grade activities for sections 1 and 2 were also accomplished.

From the time of the revised observation, the south and west foundation sections were accomplished. More specifically, on August 1st, the second wall was poured and before the end of the week, the first two basement slabs were completed. At this point in the new foundation schedule, further advancement could be made with the help of shoring rakers. With the first two slabs poured, rakers could be fastened to the floor and support the walls against backfilling. Over the course of 6-7 working days, the Garden Atrium is backfilled and footings are finished. Compared to the original timetable, atrium work was not scheduled for another 2-3 weeks.

31 August 2005

Actual | **Revised**

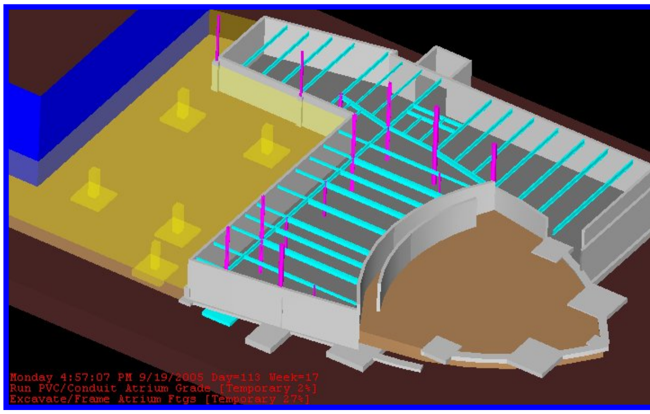



Two weeks later, the curved walls had been finished and close-up of the foundation was nearing completion. While Wall #8 was stripped, the last wall was being framed, excluding the auditorium nose section. Two phases of steel were also set along the A-A.7 Line and between Line BB and C. No work within the Garden Atrium or Auditorium Nose has yet to begin.

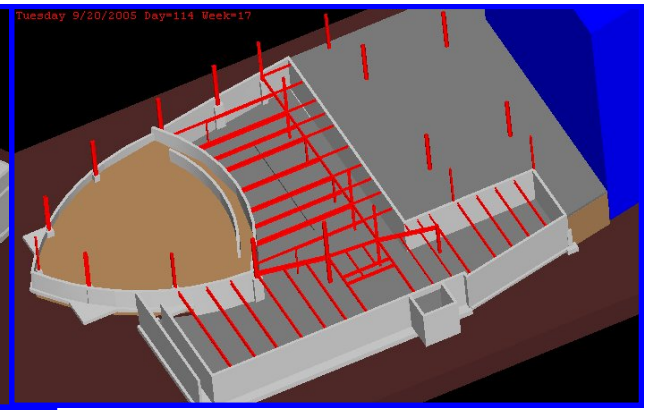
By August 31st, the modified schedule would be on the final stretch. Rakers along the curved wall would be in place and Auditorium Nose backfill progressing. Besides for the "Atrium Slab Pour," work in this area is complete and additional focus can transfer to the nose. Our main objective of basement slab pours and installation of shoring is quite evident in these visuals. Besides for a re-sequencing of activities to shorten the overall foundation schedule, it is easy to see the benefits provided by shoring to continue work in adjacent areas. Instead of waiting for steel to be set and tie in the walls for backfilling to occur, rakers can supplement the added steel function. As noted in the **Proposed Shoring** section, due to savings in schedule time, this system is cost effective as well.

19 September 2005

Actual



Revised

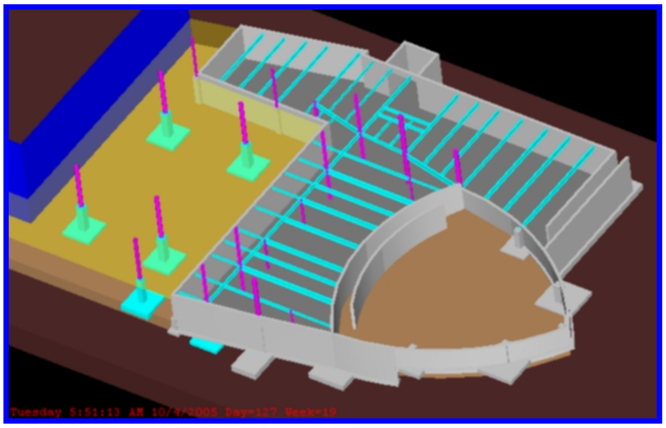


Further progress on the Lecture Hall foundation is noticed with the final wall and basement floor pours. The first phase of construction within the auditorium nose finally began the 13th. Over the next few days the nose foundation was excavated and poured. Work inside the Garden Atrium continued with running of conduit along grade and footing excavations.

By the 19th of September, as exemplified in the revised image, final backfilling of the auditorium was pretty much complete. Nose forms would have been removed and final installation of nose and atrium steel complete. Although further activities could have been shown over the next two deadlines, our purpose was target foundation erection and the implementation of rakers to accelerate scheduling in this scenario. Obviously with these results it is easy to observe the time saved due to stringent sequencing and a shoring system.

4 October 2005

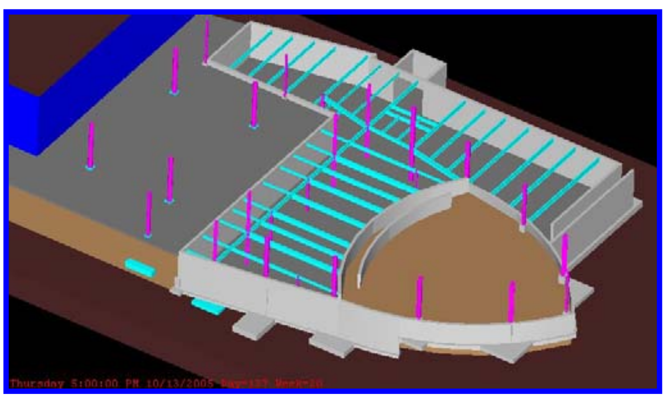
Actual



Two weeks after the revised foundation concluded, the auditorium nose wall was finally poured and forms stripped. With atrium steel going in, nose steel expected shortly, and final backfilling taking place, only a few last atrium activities were required for completion.

12 October 2005

Actual



A week later, the nose steel had been set and final pouring of the atrium slab took place. Over three weeks later than the carefully planned schedule, what could have been time savings, turned out to be time loss.

Conclusion

Within this analysis, the creation of alternative foundation schedules could have been endless. The revised timeline provided is an intuitive representation of a more efficient sequence of activities and addresses the problem spots noted in the original.

After a thorough investigation of the 4-dimensional models produced in *NavisWorks JetStream*, a savings of 23 work days was produced. With the purpose of targeting foundation erection, set start and end times needed to be developed. As stated earlier, four weeks of additional progress could have been shown for the revised schedule. Such a task was not achieved because of the need to emphasize a concrete date for foundation completion.

This large schedule reduction came with additional help from an Ulma raker shoring system costing an estimated $11,258. Initial project costs may suffer, but when comparing the general contractor's liquidated damage amount of $1,000 per day for late building turnover, shoring seems like a valuable option. Although a group of foundation activities may not all directly correlate to the Lecture Hall's critical path, it would have a significant impact on the progress to follow.

If the 23 day reduction can be applied to one month savings in project duration, a significant amount of General Conditions costs may be cut. Looking at the tables located in **Appendix H**, an estimated total difference of $45,437 is noted. Being approximately $34,179 more than shoring costs, this option is quite valuable.

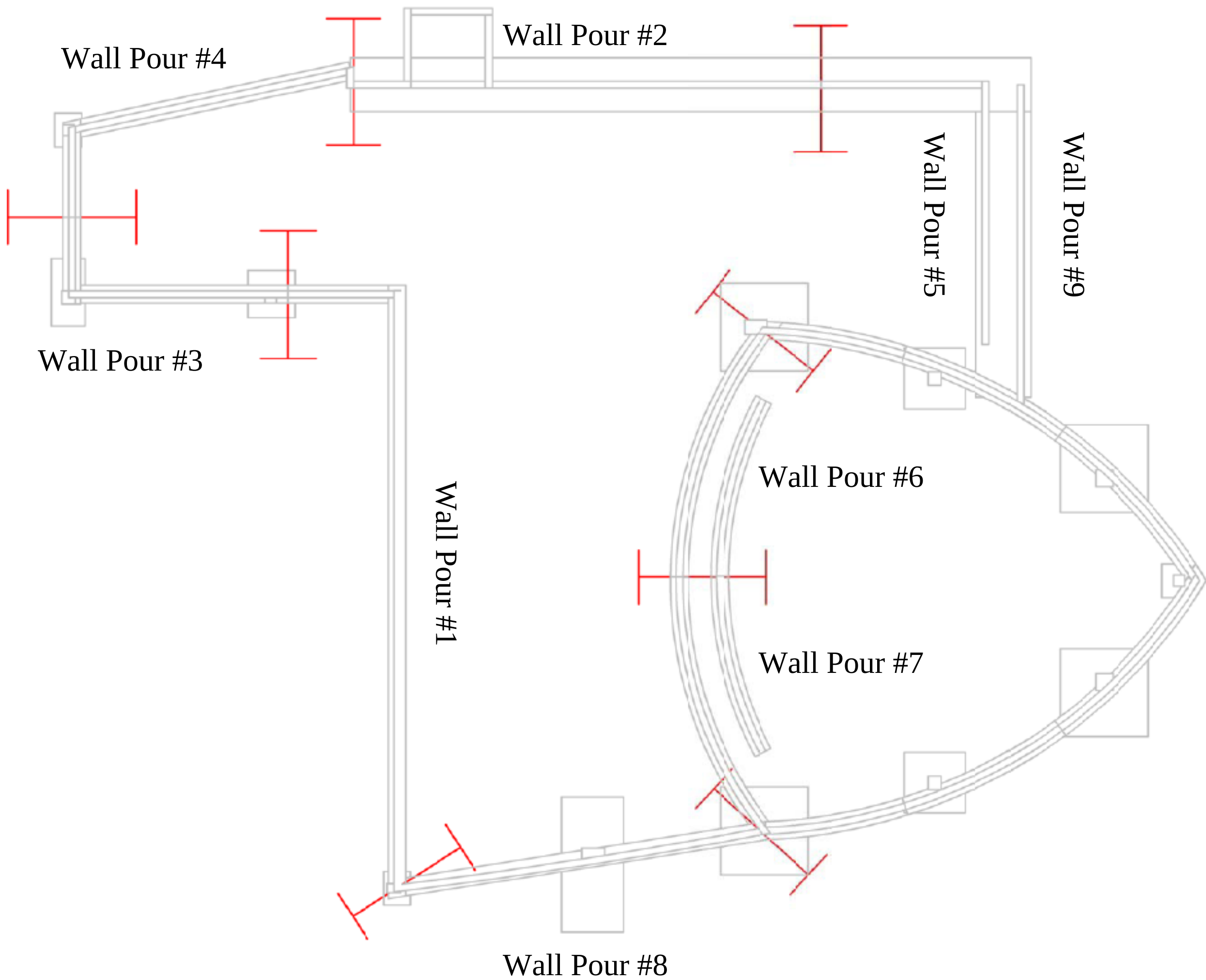


Figure 14. Foundation Wall Pour Sequencing