15.0 Parking Garage Construction Sequence

15.1 Background Information

The parking garage for the Redland Tech project was constructed in two phases. The first phase included 90% of the foundation work, excluding the southeast corner of the garage. This corner was constructed in the second phase; it was left out because this allowed an access point to the basement of the garage for structural precast member deliveries and crane movement. Figure 13 below shows the dirt access ramp and the area of the CIP foundation walls that were left out of the first phase. The crane erected the first phase of precast members from the basement of the garage. After the crane was finished erecting the precast members of the first phase, it was dismantled and taken offsite to another project. Whenever the first phase was complete, the foundation crew finished constructing the last 10% of the garage foundation. Once the foundation was finished, the precast erectors brought another crane back to the site and erected the remaining 10% of precast members. There was a 46 day gap in the erection of precast panels.

Figure 13 – Above picture shows the dirt access ramp and the area where the CIP foundation walls were left out for precast member delivery.

15.2 Goal

The goal of this analysis is to determine if there was a more efficient method to construct the parking garage. The garage was finished before the end of the project but the sequencing method used was not ideal and caused many problems for the entire project team.

15.3 METHODS

- Consult with Precast Erectors (the erection company) to determine other possible methods to construct garage.
- Consult with Tindall Corporation (designer and precast panel fabricator) to determine other possible methods to construct garage.
- Consult with Clark Construction to determine the feasibility of recommended techniques.
- Develop plan and size crane as necessary.
- Develop 4D BIM model to assist in planning construction
- Determine schedule impacts and cost savings with new sequencing method.

15.4 RESOURCES

- Precast Erectors
- Tindall Corporation
- Clark Construction
- Manitowoc Crane Guide
- Revit Architecture
- NavisWorks
- Microsoft Project

15.5 EXPECTED OUTCOME

An alternative construction sequencing will be established for the parking garage that will eliminate the 46 day gap in the erection of the precast panels. This alternative method will be more efficient and save money for the project team.

15.6 ACTUAL CONSTRUCTION SEQUENCE

The parking garage at Redland Tech Center could not be constructed with the crane located outside the building foot print. There were two reasons for this, the first being the close proximity to the other buildings and a sedimentation pond which did not enough room for crane travel on the perimeter of the building. Second, even if there was enough room for crane travel, due to the size of the parking garage precast members and spans, it would have been cost prohibitive to use a crane with enough capacity to make the picks across the garage footprint. It was determined by the construction team the best way to erect the parking garage was in two sequences.

Each phase of construction included the footings, foundation walls, and erection of the precast panels. The first phase included all of the building except the southeast corner of the garage.

The area included is depicted in Figure 14 below. The scope in Phase One, shown in red, excluded column lines D-F/1-4. Phase Two, shown in purple, finished the remaining footings, foundation walls, and erection of the precast panels. All six floors were erected in each sequence.

Figure 14 – Parking Garage Sequencing: Phase One shown in red, Phase Two shown in Purple

Figures 15-18 below show the 4D BIM model of the actual construction sequence. See Appendix B for more screenshots of the 4D BIM model created for this analysis.

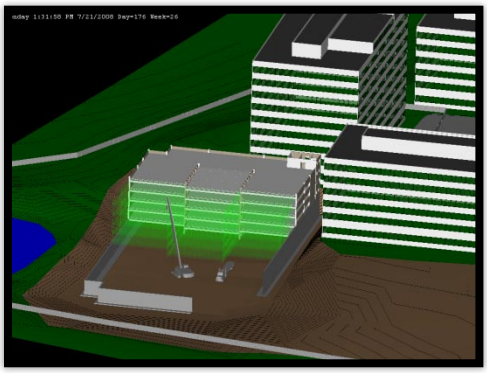

Figure 15 – Phase 1, Precast Sequence 3

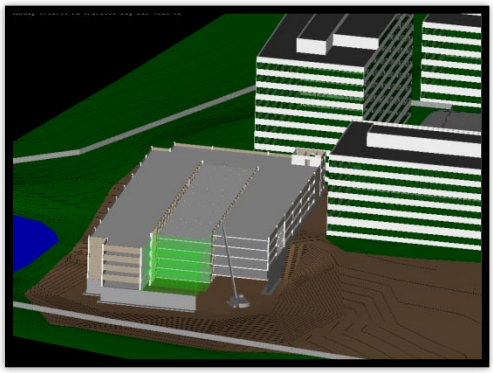

Figure 16 – Phase 1, Precast Sequence 6

Figure 17 – Phase 2, Foundation

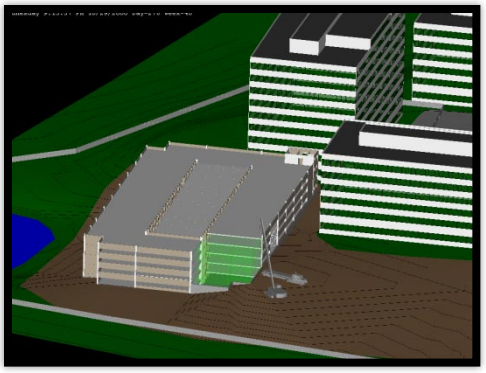

Figure 18 – Phase 2, Precast Sequence 7

Table 12 below is a summary of the actual schedule for the parking garage. For the complete detailed schedule of the parking garage construction, see Appendix C.

Activity	Duration	Start	Finish
NTP	0 days	6-Feb-08	6-Feb-08
Mobilization	2 days	6-Feb-08	7-Feb-08
Excavation	25 days	8-Feb-08	12-Mar-08
Footings	138 days	13-Mar-08	19-Sep-08
Under Slab MEP	19 days	12-Sep-08	8-Oct-08
Foundation Walls	108 days	2-May-08	29-Sep-08
Slab	22 days	16-Sep-08	15-Oct-08
Precast Panels	116 days	2-Jun-08	7-Nov-08
Mobilize	5 days	2-Jun-08	6-Jun-08
Sequence 1: A- F/10-12	10 days	23-Jun-08	4-Jul-08
Sequence 2: A- F/8-10	10 days	7-Jul-08	18-Jul-08
Sequence 3: A- F/6-8	10 days	19-Jul-08	31-Jul-08
Sequence 4: A- F/4-6	10 days	1-Aug-08	14-Aug-08
Sequence 5: A-C/1-4	10 days	15-Aug-08	28-Aug-08
Sequence 6: C-D/1-4	10 days	29-Aug-08	11-Sep-08
Remobilize	5 days	20-Oct-08	24-Oct-08
Sequence 7: D-F/1-4	10 days	27-Oct-08	7-Nov-08
Top Out	0 days	7-Nov-08	7-Nov-08
MEP Rough Ins	70 days	10-Nov-08	13-Feb-09
Garage Finishes	70 days	1-Dec-08	6-Mar-09
Site Work	65 days	10-Nov-08	6-Feb-09
Elevators	58 days	8-Dec-08	25-Feb-09
M.E.P. Systems	45 days	10-Nov-08	9-Jan-09
Exterior Hardscape	30 days	24-Nov-08	2-Jan-09
Landscaping	40 days	15-Dec-08	6-Feb-09
Parking Striping	15 days	15-Dec-08	2-Jan-09
System Testing	5 days	26-Feb-09	4-Mar-09
Final Inspections	20 days	5-Mar-09	1-Apr-09
Substantial Completion	0 days	1-Apr-09	1-Apr-09

Table 12 – Actual Garage Construction Schedule

Notice in the above schedule summary, there is a 46 day gap in the erection of the precast panels. This gap was cause by the sequencing used for the construction of the parking garage. Some of this delay was caused by the time needed for the concrete foundation crew to come back to site and finish the foundation work in Phase Two. But most of the time was due to project specifications stating minimum cure time for the concrete foundations before the precast panels could be erected and place load on the foundation. The specifications stated that the concrete must cure to 28 day strength before any load can be placed on the foundation. Due to this time delay, the erection crew disassembled the crane and moved it to another project.

Whenever the Phase Two foundation work reached strength, Clark notified Precast Erectors to remobilize and finish erecting the Phase Two precast panels. Precast Erectors brought a different crane to site and finished the last sequence of work in 10 days. Precast Erectors was not paid for the remobilization charges, approx. $70,000, as there was only one mobilization fee provided in the subcontract.

15.7 Proposed Construction Sequence

For this analysis, interviews were conducted with Precast Erectors, Clark Construction, and the Tindall Corporation (designer and fabricator) to understand the sequencing method used and to determine other possible construction sequence methods. It was determined that during the coordination meetings conducted at the Clark Construction trailers between the projects teams, the remobilization plans for the crane was never discussed. Precast Erectors and Clark Construction had different sequencing methods and they were never communicated to the other party. While this was neither parties fault, both noted that the coordination could have been better and a agreed upon plan been made.

The engineer of record, Jeff Lepard of Tindall Corporation, recommended using the same basic sequencing method except, to avoid having to wait for the concrete to cure, leave out the non-load bearing foundation wall on column line C-D/1. In this scenario, the crane would be able to erect all of the building from the basement of the garage up until the last sequence. Whenever the next-to-last sequence is finished being erected, move the crane through the opening in the foundation and erect the last sequence from outside the building perimeter. Once the last sequence is finished, the crane would be dismantled and the foundation crew returns to cast the final foundation wall. The superintendent for Clark Construction agreed that this sequencing method would work and does improve the process of constructing the parking garage.

Figures 19 and 20 below show the 4D BIM model of the revised construction sequence. See Appendix D for more screenshots of the 4D BIM model created for this analysis.

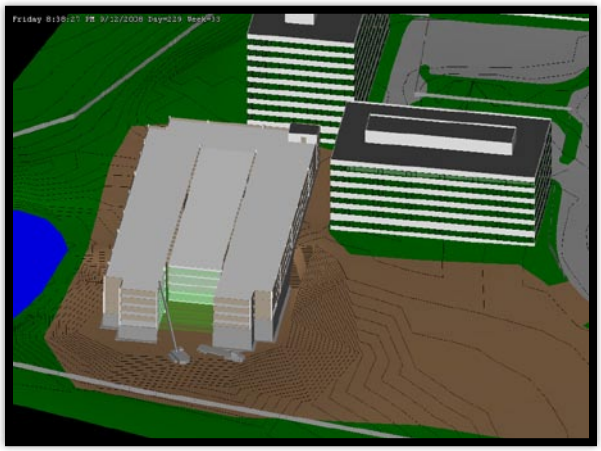

Figure 19 – Precast Sequence 7

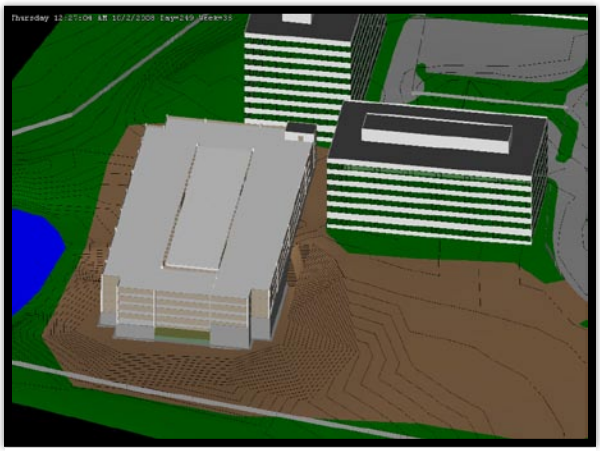

Figure 20 – Phase 2 Footing and Foundation Wall Construction

Table 13 below is a summary of the proposed schedule for the parking garage. For the complete detailed proposed schedule of the parking garage construction, see Appendix E.

Activity	Duration	Start	Finish
NTP	0 days	6-Feb-08	6-Feb-08
Mobilization	2 days	6-Feb-08	7-Feb-08
Excavation	25 days	8-Feb-08	12-Mar-08
Footings	145 days	13-Mar-08	30-Sep-08
Under Slab MEP	19 days	26-Sep-08	22-Oct-08
Foundation Walls	112 days	2-May-08	3-Oct-08
Slab	22 days	30-Sep-08	29-Oct-08
Precast Panels	85 days	2-Jun-08	25-Sep-08
Mobilize	5 days	2-Jun-08	6-Jun-08
Sequence 1: A- F/10-12	10 days	23-Jun-08	4-Jul-08
Sequence 2: A- F/8-10	10 days	7-Jul-08	18-Jul-08
Sequence 3: A- F/6-8	10 days	19-Jul-08	31-Jul-08
Sequence 4: A- F/4-6	10 days	1-Aug-08	14-Aug-08
Sequence 5: A-C/1-4	10 days	15-Aug-08	28-Aug-08
Sequence 6: D-F/1-4	10 days	29-Aug-08	11-Sep-08
Sequence 7: C-D/1-4	10 days	12-Sep-08	25-Sep-08
Top Out	0 days	25-Sep-08	25-Sep-08
MEP Rough Ins	70 days	26-Sep-08	1-Jan-09
Garage Finishes	70 days	17-Oct-08	22-Jan-09
Site Work	65 days	26-Sep-08	25-Dec-08
Elevators	58 days	24-Oct-08	13-Jan-09
M.E.P. Systems	44 days	26-Sep-08	26-Nov-08
Exterior Hardscape	30 days	10-Oct-08	20-Nov-08
Landscaping	40 days	31-Oct-08	25-Dec-08
Parking Striping	15 days	31-Oct-08	20-Nov-08
System Testing	5 days	14-Jan-09	20-Jan-09
Final Inspections	20 days	21-Jan-09	17-Feb-09
Substantial Completion	0 days	17-Feb-09	17-Feb-09

Table 13 – Proposed Garage Construction Schedule

15.8 Schedule Impact

A comparison of the substantial completion dates for the actual construction sequence and the proposed sequence reveals a substantial savings in construction duration for the parking garage. The proposed sequence has a completion date of February 17, 2009, versus April 4, 2009, for the actual construction sequence, a difference of 43 days. In both scenarios, the parking garage will be finished before the completion of the entire Redland Tech Center project, which is May 18, 2009. Being finished early may not seem beneficial at first, but it is very important for two reasons, efficiency of construction and weather delays.

Optimizing the construction process is one of the best ways for a construction company to minimize risk on a project. Shortening the duration of a project limits the amount of time people will have access to the site and the possibility of having an accident. In the case of this project, Precast Erectors will have had to erect and take down their crawler crane twice to construct the garage in the actual sequence. In the proposed sequence, the crawler crane would only be erected once.

Also, it didn't happen on this project, but a potential delay that could have been costly would be if Precast Erectors couldn't was unable to bring a crane back to the site on time for the second phase of precast erection. Redland's completion date could have been impacted if they were unable to bring the crane back within 6 weeks of the foundations being up to strength. It's best to use the equipment while it is on site versus having to bring it back later.

Reviewing the schedules for each sequencing scenario shows that the proposed sequence is less likely to have weather delays than the actual construction sequence. In the actual construction sequence, the site work, including hardscape and landscaping, is started in November and finished in February whereas the proposed sequence starts in September and finishes in December. While the Washington D.C. area usually does not get much snow, the actual construction sequence has a much higher risk of weather delays than the proposed sequence, possibly affecting Redland's completion date.

15.9 Cost Impacts

Using the proposed construction sequencing will not reduce the cost of constructing the parking garage. The shorter duration will not reduce the General Condition's cost to build the job because the GC's are built into the construction cost of the entire project. Clark Construction is not able to reduce their staffing or jobsite utilities by finishing the parking garage earlier.

In the actual construction of the garage, Clark did not have to pay Precast Erectors for the second mobilization costs due to contractual reasons. However, Precast Erectors did pay approximately $70,000 for the second mobilization. This cost could have been avoided for the erectors if they used the proposed sequence for construction.

15.10 Conclusion and Recommendation

The proposed construction sequence has several distinct advantages over the actual construction sequence. First, reducing the project duration reduces Clark Construction's risk on the project, both risk of accidents and construction delays. Second, the proposed sequence allows the site work to be completed by December versus completing the site work in the cold winter months of January and February in the actual construction sequence. Third, the proposed sequence will not reduce the construction costs of the parking garage for the owner; it will allow Precast Erectors to save on the second mobilization charge. All of these reasons would deliver better value to the project team.