Scheduling Construction Projects At The Appropriate Level Of Detail

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Abstract:
Schedules may include hundreds of tasks performed by dozens of trades and suppliers. Detailed schedules allow coordination of resources including labor, equipment and material to complete complex projects that are months and years in duration. The Last Planner System (LPS) in Lean Construction focuses on creating reliable workflow. A key principle in the LPS is planning at the appropriate level of detail (LOD). In general, construction schedules are not reliable at the daily level more than a few weeks into the future. However, many construction schedules are prepared as if the timing of tasks are predictable to the day for months in advance. Planning at an inappropriate LOD is considered waste in Lean Construction. Planning at an inappropriate LOD may occur because the clients/owners or upper level managers in the construction company expect it or simply because computer scheduling software facilitates it. Another contribution to inappropriate LOD is that schedulers may work in a different department from the Last Planners, causing a communication gap within the organization. This project will show how computer scheduling software can be used in conjunction with the LPS to create dynamic schedules that reduce waste in theLOD.

Index Terms - Last Planner System (LPS), level of detail (LOD).

I. OVERVIEW OF THE LAST PLANNERPROCESS

The Last Planner Planning Cycle is shown in Fig. 1, which shows the top-down planning of work with increasing level of detail (LOD) that is key to the implementation of the Last Planner System (LPS) (Lean Construction Institute, 2007).

Planning begins with the master schedule which includes milestones or essential dates determining the planning of the different phases a project goes through. Every level in the hierarchy contains more detailed planning with a shorter planning horizon. Master schedules are set by stakeholders with the authority to commit dates and resources at intervals for the organizations.

Phase scheduling develops a detailed schedule that progresses throughout the project by expanding the master schedule into a lot of detailed project components at the appropriate time. Using collaborative planning combined with phase scheduling or pull planning, activity durations, handoffs and relationships are further evaluated. Pull planning is a process that begins with the last activity that has to be completed, and determines the preceding activities by sequentially working backwards and asking the question, "What should be finished before this activity might begin?" In the phase schedule, planners start to incorporate and coordinate activities. The level of detail (LOD) in the phase schedule is determined by the need that the phase schedule specify the handoffs between the parties concerned in doing the work in that phase. These handoffs become production goals. A handoff is achieved once preceding work is finished and seceding work begins. A rule of "pulling" is to only do work that releases work requested by the downstream client. This reduces the waste of overproduction. Working backwards from a target completion date focuses on work activities that add worth. Team planning involves representatives of all stakeholders that do work within the phase. Typically, team members write brief descriptions of work they must perform on Post It notes in order to release work to others or work that must be completed by others to release work to them. They stick those task descriptions written on sticky notes to a wall in their expected sequence. Pull planning leads to negotiation and cooperation between the stakeholders. It is important to develop a logic network with affordable durations and assumptions that will fit in the time allotted for the milestone. The goal is a realistic plan that suppliers and subcontractors agree is workable. The team can use schedule buffers to prevent the waste of work waiting for workers or workers waiting forwork.

Production planning begins with expanding or adding the activities on the phase schedule into the look-ahead plan. This is the stage where planning begins to focus on production. The look-ahead plan is a rolling six week plan. The plan is updated weekly to identify and address constraints that threaten reliable workflow. Identifying responsibilities and making assignments ready follows analyzing resource management information such as labor, material and equipment needed. The look-ahead planning process is the middle level in the planning system

The Weekly Work Plan is the most detailed plan in the system and is where detailed production plans are elaborated and

evaluated. Plan accuracy at this level is achieved by creating solely quality assignments and honest promises for handoffs of work between the stakeholders with the goal of achieving as close as possible a reliable flow of work. A reliable flow of work avoids waiting. It protects the unit delivering the work from upstream vulnerability. The work assignment is a measurable commitment to complete a task. At the end of each week, assignments are checked for completeness and scored by a percent planned completion rate (PPC) so as to measure the reliability of the planning system. Resolving reasons for plan failures and acting on these reasons is the basis of learning and continuousimprovement.

I. PLANNING AT THE APPROPRIATE LEVEL OFDETAIL

The LPS has become an accepted model for improving the reliability of construction schedules and reducing waste. It is highly collaborative and visual. Construction schedules are modeled with computer software that allows rapid updating, monitoring and "what if" analysis. An interesting phoenomenon occurs where computer scheduling programs and the LPS meet. Because of tradition, and a lack of coordination between master schedulers and planners in the production system, the computer software model of the schedule often fails to reflect the same level of detail (LOD) present in the LPS. One more reason is "because that's how we were taught to do it. Organizations in our industry have done it that way for years… it has become the standard, but nobody knows why. We often say the owner wants it, but if you dig deep with the owner to see what they really want, its often far less detail than we usually give them." (Snelling, 2018). Schedulers are often disconnected from the subcontractors and superintendents that constitute the "last planners" in the production system. In many cases, schedulers plan in more detail than needed. The LOD is inappropriate when the ability to predict the production rates and processes is low. In many cases computer generated schedules may show activities predicted to the daily LOD when the known accuracy is only in weeks or months. In the LPS this extra work is known as waste. Little work has been done to understand and overcome this form ofwaste.

In a recent article, Oracle revealed that they are working on a solution related to Lean Scheduling. They are going to update Primavera (P6) software so that users can make a Lean Schedule with "complete coordination and command for more successful and profitable projects" when using the software. Oracle will be offering a Cloud based solution which enables a "low cost of entry" and "assures a lower management burden." The company claims that the software will automate processes and integrate project data across the organization – from the back office to the front office and in the field – to "enable complete coordination and command of even the most complex construction projects." The company is attempting to bring scope, cost, and scheduling into a single platform, to allow visibility from the sub-task level up to the enterprise view. (Oracle Lean Scheduling Solution, 2018) As with the master scheduler problem, the Oracle solution will involve a computer user working in an office and one who is not intimately involved in coordinating actual site work. Again, as with traditional scheduling, the planning will not be at the appropriate level of detail at the proper time. This raises concerns. Moving the pull planning model from sticky notes on a wall to a computer screen is likely to reduce the collaborative planning that is the strength of theLPS.

The focus of this research is the actual construction schedule of the UALR Fine Arts Design Building. This construction project was used to identify methods for planning at the right LOD at the right time. Figure 2 shows the master schedule with milestones. The milestones signify points in time and are designated by diamonds. This is the appropriate LOD for the beginning of the project. More detailed planning should only occur at the appropriate time. However, in most projects, the activities are planned out to the daily level from the project beginning. This "over planning" reflects an inaccurate LOD and is waste. Schedulers have not been sucessful documenting the ever expanding LOD that occurs in the LPS. The construction schedule for the recently completed Fine Arts building was recreated by adding detailed activities at the appropriate time to document the processes that could be used for implementing a better correlation between current computer scheduling processes and the LPS with respect to LOD.

Figure 3 shows additional LOD added to the master schedule. This phase schedule expands the milestone "Topping Out Ceremony" as the 1stphase in the Phase Scheduling. This phase consists of "Site Work", "Bldg A Structural Steel Erection" and "Bldg B Pre-Engineered Metal Building". Additional LOD has been added for each of these tasks to illustrate the method where LOD is added at the appropriate time. The phase schedule should be planned six weeks before work in the phase begins. This plan is made by the parties who are actually performing work, such as subcontractors involved in this project, and not by the individuals who constructed the master schedule. The popular computer scheduling applications all have this capability. Tradition and lack of coordination seem to prevent schedulers from being comfortable expanding the activities in the schedule at the appropriate time and LOD. Figure 4 shows a useful feature found in all computer scheduling applications. This feature allows sub tasks to be summarized or "rolled up" into summary bars for clarity.

Figure 5 shows activities for the next phase of the project planned at the appropriate time and LOD. This phase covers "BldgA Envelope/Exterior Finishes", "Bldg B Envelope/Exterior Finishes", and "Bldg B Interior Rough In". Additional activities are planned and added to the schedule. In current practice, schedulers plan these activities before the project begins. The LPS considers it as waste

when planning occurs months ahead of the appropriate time without knowledge of exactly how the work will be coordinated. This paper demonstrates how computer scheduling applications can implement the best practice processes used in the LPS.

Figure 6 shows the Six Week Look-Ahead Schedule for the first phase. Additional activities have been added to this schedule, but at the appropriate time and LOD. Note that in some scheduling applications, such as Microsoft Project (MSP), tasks are renumbered when sub tasks are inserted. The project planning should progress in this fashion with phase planning and look-ahead planning occuring just as needed and in the appropriate LOD for the point in time.

The look-ahead schedule is the last LOD appropriate for computer applications. The weekly work plan is typically prepared just one week ahead of time. It is prepared by the stakeholders that will actually perform the work. The computer schedule could be expanded to capture this detail if desired, but there is little benefit other than documentation of the process.

II. CONCLUSION

This approach in using computer scheduling applications in coordination with the LPS represents a significant departure from and improvement to current practice by eliminating the waste of unnecessary planning and improved coordination between the "last planners" and the scheduling specialists. Planning should occur at a time which makes the resources for the activities ready and controls the production process. Construction project schedulers should adopt this planning technique to reduce waste and mirror the LPS.

REFERENCES

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[2] Snelling, Rebecca. National Director for Lean Construction. JE Dunn Construction. (personal communication, March 29, 2018) gives reasons on why schedules are more detailed than they needed to be.

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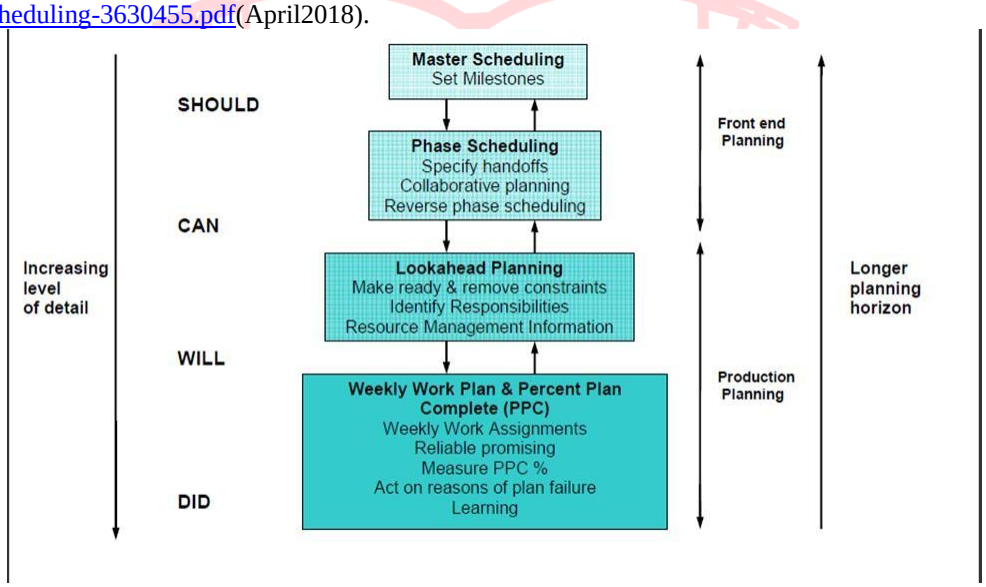
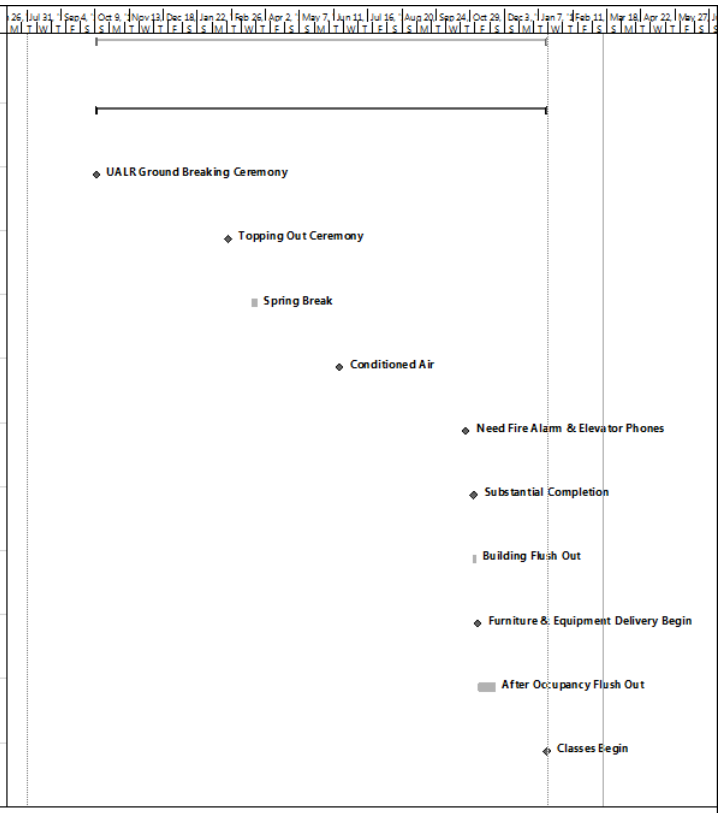


Figure 1. The Last Planner Cycle

ID	Task Mode	Task Name	Duration	Start	Finish
0		**UALR Art & Design Center (Milestone)**	**321 days**	**Tue 10/11/16**	**Tue 1/16/18**
1		**Key Dates**	**321 days**	**Tue 10/11/16**	**Tue 1/16/18**
2		UALR Ground Breaking Ceremony	0 days	Tue 10/11/16	Tue 10/11/16
3		Topping Out Ceremony	0 days	Thu 2/23/17	Thu 2/23/17
4		Spring Break	5 days	Mon 3/20/17	Fri 3/24/17
5		Conditioned Air	0 days	Fri 6/16/17	Fri 6/16/17
6		Need Fire Alarm & Elevator Phones	0 days	Tue 10/24/17	Tue 10/24/17
7		Substantial Completion	0 days	Wed 11/1/17	Wed 11/1/17
8		Building Flush Out	3 days	Wed 11/1/17	Fri 11/3/17
9		Furniture & Equipment Delivery Begin	0 days	Mon 11/6/17	Mon 11/6/17
10		After Occupancy Flush Out	13 days	Tue 11/7/17	Thu 11/23/17
11		Classes Begin	0 days	Tue 1/16/18	Tue 1/16/18



Project: UALR Art & Design Center (Milestone)
Date: Thu 3/15/18

Task Milestone Summary Project Summary

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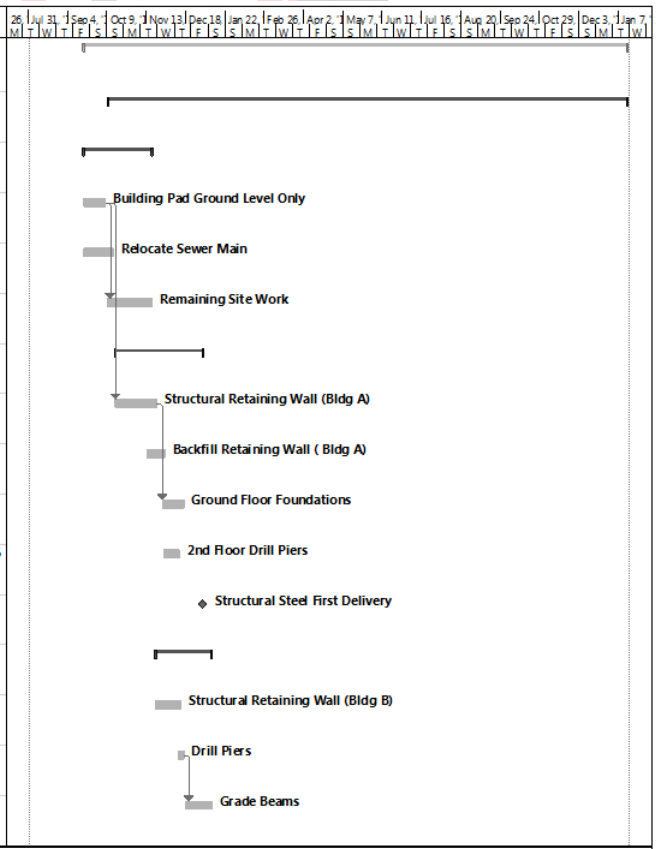
Figure 2. Master Schedule - Milestone Plan

ID	Task Mode	Task Name	Duration	Start	Finish
0		**UALR Art & Design Center (1st phase)**	**337 days**	**Mon 9/19/16**	**Tue 1/16/18**
1		**Key Dates**	**321 days**	**Tue 10/11/16**	**Tue 1/16/18**
12		**Site Work**	**45 days**	**Mon 9/19/16**	**Fri 11/18/16**
13		Building Pad Ground Level Only	15 days	Mon 9/19/16	Fri 10/7/16
14		Relocate Sewer Main	20 days	Mon 9/19/16	Fri 10/14/16
15		Remaining Site Work	30 days	Mon 10/10/16	Fri 11/18/16
16		**Bldg. A Structural Steel Erection**	**53 days**	**Mon 10/17/16**	**Tue 1/3/17**
17		Structural Retaining Wall (Bldg A)	27 days	Mon 10/17/16	Tue 11/22/16
18		Backfill Retaining Wall (Bldg A)	11 days	Mon 11/14/16	Tue 11/29/16
19		Ground Floor Foundations	15 days	Mon 11/28/16	Fri 12/16/16
20		2nd Floor Drill Piers	10 days	Tue 11/29/16	Mon 12/12/16
21		Structural Steel First Delivery	0 days	Tue 1/3/17	Tue 1/3/17
22		**Bldg. B Pre-Engineered Metal Bldg**	**33 days**	**Tue 11/22/16**	**Tue 1/10/17**
23		Structural Retaining Wall (Bldg B)	15 days	Tue 11/22/16	Tue 12/13/16
24		Drill Piers	5 days	Mon 12/12/16	Fri 12/16/16
25		Grade Beams	15 days	Mon 12/19/16	Tue 1/10/17



Project: UALR Art & Design Center (1st phase)
Date: Thu 3/15/18

Task Summary
Milestone Project Summary

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Figure 1. Phase Plan for First Phase

ID	Task Mode	Task Name	Duration	Start	Finish
0		**UALR Art & Design Center (1st phase)**	**337 days**	**Mon 9/19/16**	**Tue 1/16/18**
1		**Key Dates**	**321 days**	**Tue 10/11/16**	**Tue 1/16/18**
12		**Site Work**	**45 days**	**Mon 9/19/16**	**Fri 11/18/16**
16		**Bldg. A Structural Steel Erection**	**53 days**	**Mon 10/17/16**	**Tue 1/3/17**
22		**Bldg. B Pre-Engineered Metal Bldg**	**33 days**	**Tue 11/22/16**	**Tue 1/10/17**

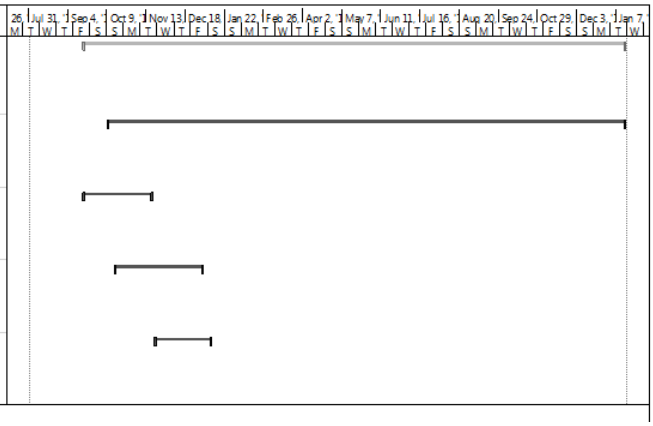
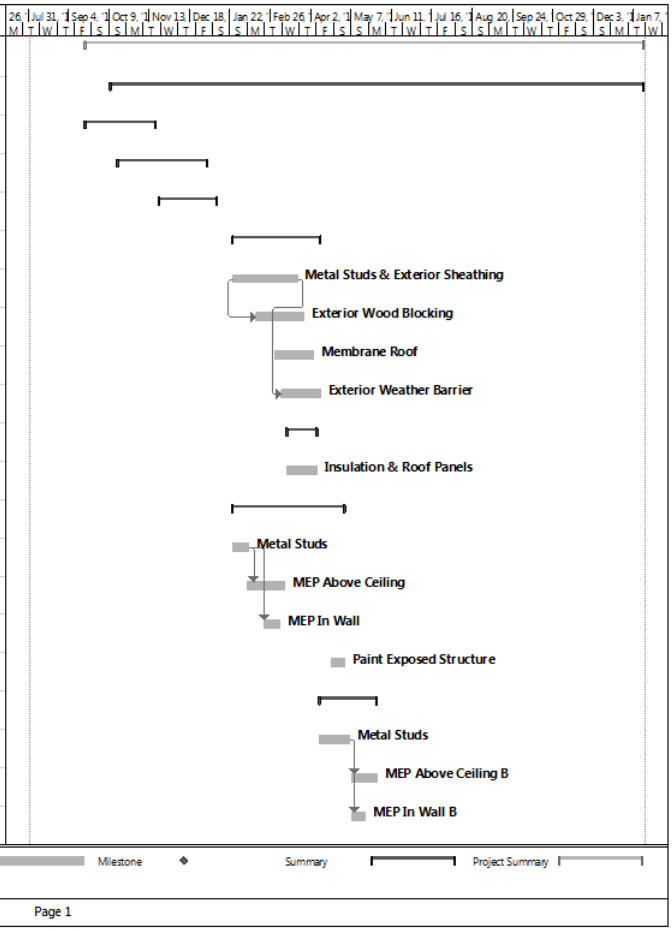


Figure 2. Summary Tasks

ID	Task Mode	Task Name	Duration	Start	Finish
0		**UALR Art & Design Center (2nd phase)**	**337 days**	**Mon 9/19/16**	**Tue 1/16/18**
1		**Key Dates**	**321 days**	**Tue 10/11/16**	**Tue 1/16/18**
12		**Site Work**	**45 days**	**Mon 9/19/16**	**Fri 11/18/16**
16		**Bldg. A Structural Steel Erection**	**53 days**	**Mon 10/17/16**	**Tue 1/3/17**
22		**Bldg. B Pre-Engineered Metal Bldg**	**33 days**	**Tue 11/22/16**	**Tue 1/10/17**
26		**Bldg. A Envelope / Exterior Finishes**	**54 days**	**Wed 1/25/17**	**Mon 4/10/17**
27		Metal Studs & Exterior Sheathing	40 days	Wed 1/25/17	Tue 3/21/17
28		Exterior Wood Blocking	30 days	Tue 2/14/17	Mon 3/27/17
29		Membrane Roof	24 days	Thu 3/2/17	Tue 4/4/17
30		Exterior Weather Barrier	24 days	Wed 3/8/17	Mon 4/10/17
31		**Bldg. B Envelope / Exterior Finishes**	**20 days**	**Mon 3/13/17**	**Fri 4/7/17**
32		Insulation & Roof Panels	20 days	Mon 3/13/17	Fri 4/7/17
33		**Bldg. A Interior Rough In**	**69 days**	**Wed 1/25/17**	**Mon 5/1/17**
34		Metal Studs	10 days	Wed 1/25/17	Tue 2/7/17
35		MEP Above Ceiling	25 days	Mon 2/6/17	Fri 3/10/17
36		MEP In Wall	10 days	Tue 2/21/17	Mon 3/6/17
37		Paint Exposed Structure	8 days	Thu 4/20/17	Mon 5/1/17
38		**Bldg. B Interior Rough In**	**35 days**	**Mon 4/10/17**	**Mon 5/29/17**
39		Metal Studs	20 days	Mon 4/10/17	Fri 5/5/17
40		MEP Above Ceiling B	15 days	Mon 5/8/17	Mon 5/29/17
41		MEP In Wall B	10 days	Mon 5/8/17	Fri 5/19/17



Project: UALR Art & Design Center (2nd phase)
Date: Thu 3/15/18

Task Milestone Summary Project Summary

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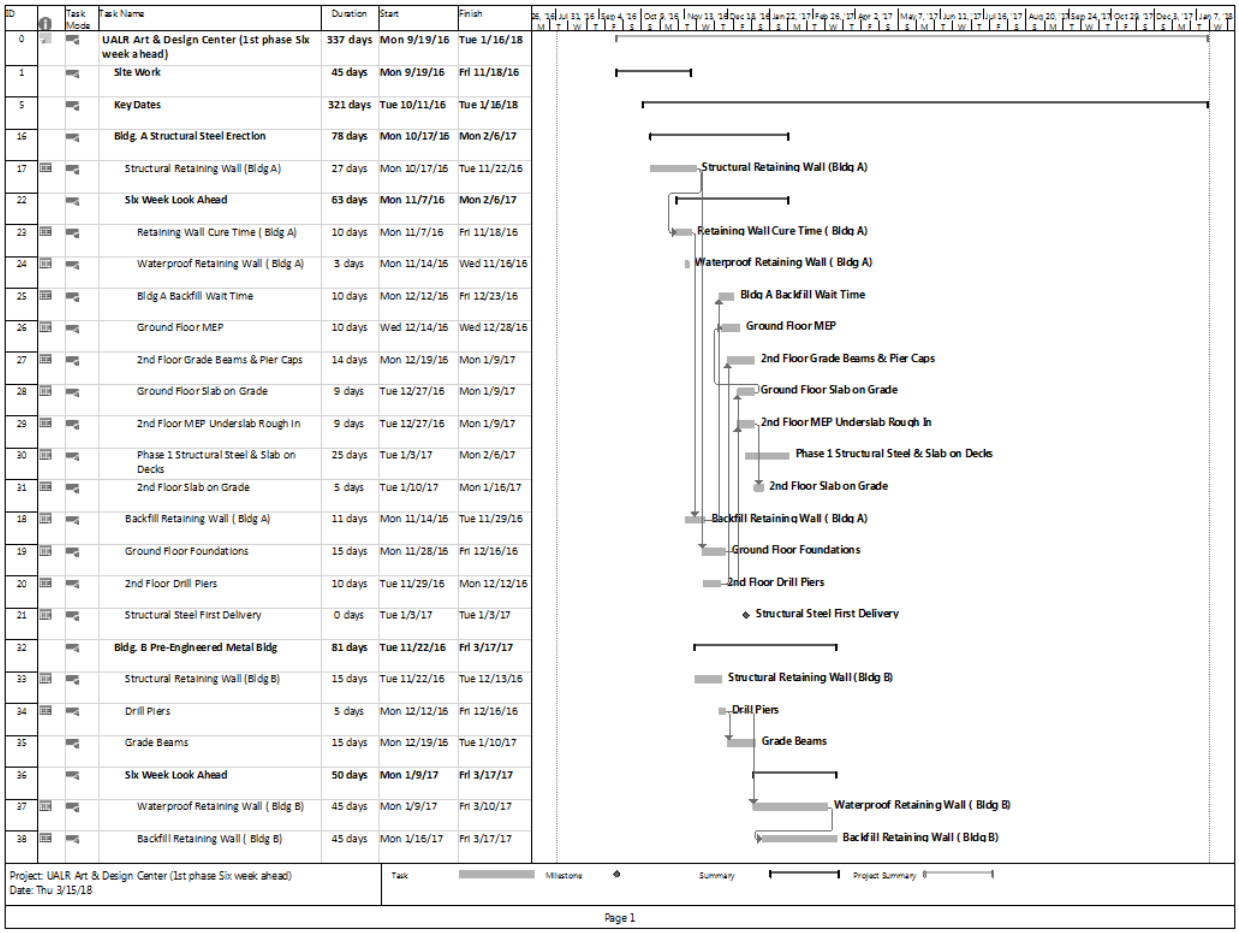
Figure 3. Phase Plan for Second Phase



ID	Task Mode	Task Name	Duration	Start	Finish
0		**UALR Art & Design Center (1st phase Six week ahead)**	**337 days**	**Mon 9/19/16**	**Tue 1/16/18**
1		**Site Work**	**45 days**	**Mon 9/19/16**	**Fri 11/18/16**
5		**Key Dates**	**321 days**	**Tue 10/11/16**	**Tue 1/16/18**
16		**Bldg. A Structural Steel Erection**	**78 days**	**Mon 10/17/16**	**Mon 2/6/17**
17		Structural Retaining Wall (Bldg A)	27 days	Mon 10/17/16	Tue 11/22/16
22		**Six Week Look Ahead**	**63 days**	**Mon 11/7/16**	**Mon 2/6/17**
23		Retaining Wall Cure Time (Bldg A)	10 days	Mon 11/7/16	Fri 11/18/16
24		Waterproof Retaining Wall (Bldg A)	3 days	Mon 11/14/16	Wed 11/16/16
25		Bldg A Backfill Wait Time	10 days	Mon 12/12/16	Fri 12/23/16
26		Ground Floor MEP	10 days	Wed 12/14/16	Wed 12/28/16
27		2nd Floor Grade Beams & Pier Caps	14 days	Mon 12/19/16	Mon 1/9/17
28		Ground Floor Slab on Grade	9 days	Tue 12/27/16	Mon 1/9/17
29		2nd Floor MEP Underslab Rough In	9 days	Tue 12/27/16	Mon 1/9/17
30		Phase 1 Structural Steel & Slab on Decks	25 days	Tue 1/3/17	Mon 2/6/17
31		2nd Floor Slab on Grade	5 days	Tue 1/10/17	Mon 1/16/17
18		Backfill Retaining Wall (Bldg A)	11 days	Mon 11/14/16	Tue 11/29/16
19		Ground Floor Foundations	15 days	Mon 11/28/16	Fri 12/16/16
20		2nd Floor Drill Piers	10 days	Tue 11/29/16	Mon 12/12/16
21		Structural Steel First Delivery	0 days	Tue 1/3/17	Tue 1/3/17
32		**Bldg. B Pre-Engineered Metal Bldg**	**81 days**	**Tue 11/22/16**	**Fri 3/17/17**
33		Structural Retaining Wall (Bldg B)	15 days	Tue 11/22/16	Tue 12/13/16
34		Drill Piers	5 days	Mon 12/12/16	Fri 12/16/16
35		Grade Beams	15 days	Mon 12/19/16	Tue 1/10/17
36		**Six Week Look Ahead**	**50 days**	**Mon 1/9/17**	**Fri 3/17/17**
37		Waterproof Retaining Wall (Bldg B)	45 days	Mon 1/9/17	Fri 3/10/17
38		Backfill Retaining Wall (Bldg B)	45 days	Mon 1/16/17	Fri 3/17/17

Figure 4. Six Week Look-ahead Plan

