TECHNICAL ASSIGNMENT TWO

LancasterHistory.Org
Lancaster, PA

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Comprehensive Architectural Engineering Senior Project I
Construction Management
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EXECUTIVE SUMMARY

The following technical assignment analyzes key information regarding the LancasterHistory.org project that impacts project execution. The $13.5 million project is located just outside of Lancaster City, PA on Presidents Ave. It is a renovation/addition, totaling in a 32,068 square feet of area. Benchmark Construction is the general contractor on the project, and Centerbrook is the architect. Its construction began in October 2011, and final completion was slotted for the first of this month (11/1), however delays postponed the milestone and the building is still being commissioned.

The project schedule was one of the key aspects of the project, as the owner required it to be completed by the first. Unfortunately, this was delayed due to unforeseen soil conditions early into the project. The schedule in this report details the original plan, and more information regarding the delay may be found in the constructability challenges portion of this report. BIM was only utilized in the design phase of the projects life, but it is recommended that BIM extend throughout the entire duration, should the owner be convinced. A detailed structural system estimate is presented in this report as an extrapolated model. In addition to the structural estimate, a general conditions estimate is provided. All aspects described above have an impact on the delivery of the project, regarding cost and time, two quintessential aspects for any service provided, but particularly the construction industry. Enjoy!

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DETAILED STRUCTURAL SYSTEMS ESTIMATE

In providing a detailed structural systems estimate for the LancasterHistory.org project, I selected the middle roof arc area as a module. On the structural drawings, the area spans from location C to location E. I have chosen to use this as a modulus because it is proportionately larger and smaller than the neighboring roof arcs in length and height. All modules are the same width. Please see Appendix A for detailed estimate and calculations.

On the lower level foundation plan, there are spread footings on the East and West sides of the building, spanning 50 feet each. In addition, there are two F7 type footers each at locations C and E. There are two F8 footers at location D. Last, there are three F6 footers and a F4 footer in this module. The concrete slab on grade of the lower level encompasses a 50'X59' area. Formwork is done by a three man crew, consisting of a carpenter, a foreman and a laborer. Rebar is placed with a rodman and a foreman, and WWF is placed with a rodman and a common laborer. The concrete is poured via a three men crew of a foreman, a common laborer and a vibrator operator. The lower level slab and ground level topping are finished, protected and cured with a two person crew of a laborer and finisher.

At ground level, there are five W24X55 beams. Three of the W24X55 beams span 17'6", one spans 15' and the last spans 11'6". There are two WT-1 beams, a W10X30 and three HSS members also. Structural steel for this level and for all other levels is set and welded in moment connections. It is set with a crane operator, foreman and steelworker, and it is welded with a field welder, equipment operator and gas welding machine.

The roof framing consists of three bays along FRAME B and FRAME C, spanning locations C and E. The outer walls have GB-4 girders and the two inner girders are GB-3. Bridging occurs at 1/3 points between these girders. 1 3/4 "X16" LVL rafters located 2'4" on center from FRAME B to FRAME C. There are two LVLs at the elevator shaft for lateral stability. The shaft also contains a W8X31 member. A HSS12X8X1/2 serves as a lintel over the stairwell window on the west side. Lumber is placed with a foreman, laborer, carpenter and a crane operator for the girder beams.

The structural FRAME B has all HSS 12X8X1/2 members. The two middle columns extend from the BOF elevation to the EAVE, and the two exterior columns extend from the ground level to the eave. Six HSS beams connect the columns, three at ground level and three at eave level. All are moment connections.

The structural FRAME C has all HSS 12X8X1/2 columns. The two middle columns extend from the BOF elevation to the top of the arc at 23’3”, and the two exterior columns extend from the ground level to the top of the arc. Six HSS beams connect the columns, three HSS 16X8X1/2 at approx. 12’ above grade and three at approx. 22’ above grade. All are moment connections.

From the ground level up, there is 878 sqft of masonry on the first shear wall and 788 sqft of masonry on the second shear wall. This is placed with a five person crew, consisting of a foreman, a layer, a mortar mixer, a laborer and a hod carrier.

The total cost of the structural system of the building for the selected module is just over one hundred thousand dollars ($107,290.49). Materials will cost $79,454, labor will cost $21,224 and equipment will cost $1,218. These values will be extrapolated to estimate the costs of the entire addition. The SQFT area of the addition is 19,755, and the SQFT area of the selected module is 6,133, so the extrapolated ratio is 3.2211. By multiplying this with the module’s cost, it is estimated that the total cost of the building addition will be three hundred forty-five thousand, five hundred and ninety-three dollars ($345,593).

	MATERIAL	LABOR	EQUIPMENT	TOTAL
Module	$79,454	$21,224	$1,218	$107,290
Addition	$255,929	$68,365	$3,923	$345,593

Detailed structural estimate breakdown for module

DETAILED PROJECT SCHEDULE

Overview

The construction schedule for LancasterHistory.org is critical to the project's success, because the owner requires it to be delivered by a certain date. Notice to proceed was received by Benchmark construction on October 3, 2011, and the project was expected to be complete thirteen months later, by November 1, 2012. This target complete date was not reached due to soil complications (see Constructability Challenges on page 13). Also, several change orders were requested by the owner. The detailed construction schedule in this report does not include delays, and it represents the schedule that was originally planned by Benchmark. The schedule can be found in Appendix C of this report (page 23). It details the duration of the construction, and it includes renovation work as well as construction completed for the addition. Many construction sequences overlap in order to expedite the construction process, and a summary of the construction sequencing can be found on the following page.

Sequencing

To meet the construction completion deadline, many construction sequences overlap, and there is very little float. Essentially, sequencing is completed from north to south for all categories of construction. In this way, the addition extends out from the existing building. Several enclosure activities are conducted at the same time the building structure is sequenced. As such, building Dry-in is scheduled for April 26, 2012. Lower level construction activities are completed at the same time as ground level activities to further expedite the schedule. It can be noted that building commissioning is scheduled to take an unusually large portion of time relative to project duration. It is scheduled to take 97 days, which can be attributed to the complex nature of MEPF elements of the building and the projects goal to reach LEED Gold certification.

LancasterHistory.org Construction Sequences Breakdown			
	Duration	**Start**	**Finish**
Preconstruction	15 days	3 October 2011	21 October 2011
Foundation	46 days	18 October 2011	21 December 2011
MEPF	191 days	12 December 2011	10 September 2011
Structure	88 days	12 December 2011	13 April 2012
Enclosure	59 days	6 February 2011	26 April 2012
Exterior	69 days	4 April 2012	11 July 2012
Ground Level	120 days	26 April 2012	15 October 2012
Lower Level	61 days	30 April 2012	25 July 2012
Commissioning	97 days	18 June 2012	1 November 2012

GENERAL CONDITIONS ESTIMATE

The General Conditions Estimate for the LancasterHistory.org project encompasses project personnel, site expenses and miscellaneous costs for the project. The personnel involved in the project include a project manager, assistant project manager, administrative assistant, superintendent and a foreman. Project site expenses are incurred primarily from utilities but also from maintenance, company trucks and dumpsters amongst others. These line items are chosen by looking at the project's site plan from Tech Report 1 and from looking at the project schedule (see Appendix C on page 23). Last, miscellaneous costs are incurred from insurance, bond and permits.

The estimate comes out to over half a million dollars ($576,641). This number was reached using RS Means, combined with information provided by Benchmark Construction. The cost of utilities, bond, permits and the general conditions total cost are known. Means was used to estimate all other costs. These costs were occasionally manipulated within reason to reach the actual general conditions total cost given by Benchmark. By comparing the general conditions cost with the total project cost for the LancasterHistory.org project, it is determined that general conditions account for only six percent (7.5%) of the original schedule.

LINE ITEM	AMNT.	UNIT	RATE	TOTAL COST
PERSONELL				
Project Manager	10	WEEKS	$ 3,200	$ 48,000
Assistant Project Manager	30	WEEKS	$ 2,800	$ 84,000
Administrative Assistant	20	WEEKS	$1,550	$ 31,000
Superintendent	10	WEEKS	$ 3,560	$ 35,600
Foreman	20	WEEKS	$ 2,560	$ 51,200
SITE EXPENSES				
Utilities	1	N/A	N/A	$116,445
Site Maintenance	54	WEEKS	$ 230	$12,420
Dumpsters	30	EACH	$ 400	$12,000
Fencing	30	WEEKS	$ 100	$ 3,000
Company Trucks	54	WEEKS	$ 240	$ 12,960
Drawings & Specifications	1	N/A	N/A	$ 2,500
CPM Schedule	1	N/A	N/A	$ 4,000
Signage	1	N/A	N/A	$ 1,500
Cell Phones	13 (5)	MONTHS	$ 40	$ 2,600
Postage & Shipping	30	WKS	$ 75	$ 2,250
Porta-Johns	8	MONTHS	$ 550	$ 4,400
MISCELLANEOUS				
Insurance	1	%	$ 7,697,206	$ 76,972
Bond	1	N/A	N/A	$ 56,550
Building Permits	1	N/A	N/A	$ 19,241
TOTAL COST				**$ 576,641**

BUILDING INFORMATION MODELING USE EVALUATION

Before developing a BIM use list it is important to list the goals of the project as they relate to BIM. The projects goals listed in this report are specific to the LancasterHistory.org project (see Appendix C for BIM Goal List). They encompass all stages of the building's creation from planning to design to operation. As a note, the owner does not require BIM for building operation, and Benchmark opted to not use any BIM in the construction process. The goals are then be used to determine how BIM is applied to the project (see Appendix D for Level-1 Process Map).

After listing the projects goals, a chart is created in the form of a BIM Goal List. Each goal is paired with potential BIM applications that are or would be used to facilitate reaching them. Further, the goals are ranked in priority from low to high. This is used to allocate resources later in the BIM planning process. From the chart on page 27, it can be seen that the most important BIM uses for this particular project include (In descending order): Phase Planning (4D Modeling), 3D Coordination, Sustainability (LEED) Evaluation, Building System Analysis, Construction System Design (Virtual Mockup), Site Utilization Planning, and Space Management/Tracking. BIM use analysis is later conducted in this section to determine BIM use implementation.

Phase Planning is the combination of a 3D model with the added element of time. It is used to demonstrate the construction sequence and space requirements of the project, allowing for better communication between involved parties. This is important to reduce project cost and schedule duration. It is to be used in the design and construction phases of the project. Required resources include scheduling software, a 3D model and 4D modeling software.

Three-Dimensional Coordination is important because it is used to determine major system conflicts before they happen. It is used in the design and construction phases of the project. Its applications are crucial to this project in particular, because there are so many separate entities involved in the design process. It would have greatly facilitated the communication between parties, saving time and money.

Sustainability (LEED) Evaluation helps the goals of the LancasterHistory.org project by bringing sustainable criteria to it in all phases of facility life. It is used in tandem with Building Systems Analysis via 3D coordination to save time and money by quickly analyzing design changes and bringing about a quality design. It is also used to reduce operational costs for the owner. Perhaps most importantly, the model supplements the LEED evaluation, to actually make the building green.

Building System Analysis is what it sounds like. MEPF and solar aspects of the LancasterHistory.org building are analyzed. These components of the building are analyzed to ensure they meet the owner's criteria in the design phase and the design criteria in the construction/commissioning phase of the project. Further, it could be used to make sure systems continue to operate properly in the maintenance phase, had the owner requested this service. This BIM application requires systems analysis software.

Virtual Mockup is used on the project in its design phase to analyze construction and increase planning, to increase construction productivity and to decrease language barriers between parties. Because of the unusual shape of the roof arcs in the LancasterHistory.org project, this BIM application is used to communicate enclosure of the building. This is very important to ensure the building's longevity (i.e. so that water damage does not occur). It only requires 3D modeling software, but it would be used with many other BIM applications.

Site Utilization Planning is facilitated with BIM because space and sequencing can be more realistically represented than with just two dimensional drawings. Labor, materials and equipment can all be accounted for. The BIM application of Site Utilization Planning saves time and more effectively evaluates construction safety concerns. It is used with Phase Planning, and it is particularly important for the LancasterHistory.org project, given its ambitious schedule and the fact that nearby facilities remain operational.

Space Management is used on this project to effectively allocate, manage and monitor space usage for the LancasterHistory.org Project. This is important for the project at hand because it is an addition that requires much more space than the existing building. This BIM application helps the owner and architect determine how much space is needed for various historical artifacts and exhibits in the design phase. It can also be used in the maintenance phase to monitor artifacts and other resources during the facilities operation. It requires space mapping and bi-directional model manipulation software.

Next, a BIM use analysis chart is created (see Appendix D on page 27). This chart determines parties involved in the BIM Process, and it rates each party capability per BIM use. After considering additional resources or competencies required, a decision is made to proceed or not to proceed with the considered BIM applications and relevant parties. It is determined in this report that Phase Planning, 3D Coordination, Building System Analysis, Virtual Mockup, Site Utilization Planning and Space Management are all to be implemented on the LancasterHistory.org project, (It can be noted that LEED Evaluation is not practical for this project because the project size is too small to achieve profit.). Active parties in the BIM process are determined to be the owner, architect, contractor, MEPF engineer, structural engineer and occasional subcontractors (excavation, structural-steel, mechanical & electrical subs.). Given the resources and experience of the LEED certified Architect on the project, LEED Gold Certification can still be achieved.

To better understand the implementation of the BIM Uses, BIM project execution process is designed. In doing so, a process map is established, which defines various processes performed by parties. It also communicates information exchanges between parties. This map is later used to determine member selection criteria, contract structure, BIM deliverable requirements and IT infrastructure. A BIM Overview Map for the LancasterHistory.org project can be found in Appendix E.

Critical Evaluation:

Given both the goals and personnel involved in the LancasterHistory.org project, the BIM uses selected are appropriate. Each party creates their own models and brings them to coordination meetings, which are held every Thursday morning. Significant design changes are submitted to relevant personnel as soon as possible, and models are shared online to keep information current. Benchmark personnel should communicate with subcontractors on-site when applicable and keep up-to-date models (from all parties) for documentation purposes.

BIM was used on this project only by the owner, architect and structural engineer to each of their benefits. It was not used by Benchmark or the MEPF engineer given the size of the project and experience of the parties. However, the complicated nature of the building's various elements suggests time and money could have been saved in the long run had the contractor and MEPF engineer implemented BIM. It is particularly surprising that 3D and 4D models were not utilized by the contractor, since various 3D models were already developed in the design phase of the project. Benchmark should utilize BIM in the construction phase of the project and could keep a record model in case the owner has difficulty with maintenance and later changes its mind. Thus, BIM should have been utilized in all phases of LancasterHistory.org's construction to maximize its potential value for everyone.

PLAN	DESIGN	CONSTRUCT	OPERATE
4D Model	4D Model	4D Model	4D Model
3D Coordination	3D Coordination	3D Coordination	
Building System Analysis	Building System Analysis	Building System Analysis	Building System Analysis
	Virtual Mockup	Virtual Mockup	Virtual Mockup
	Site Utilization Planning	Site Utilization Planning	
Space Management	Space Management	Space Management	Space Management

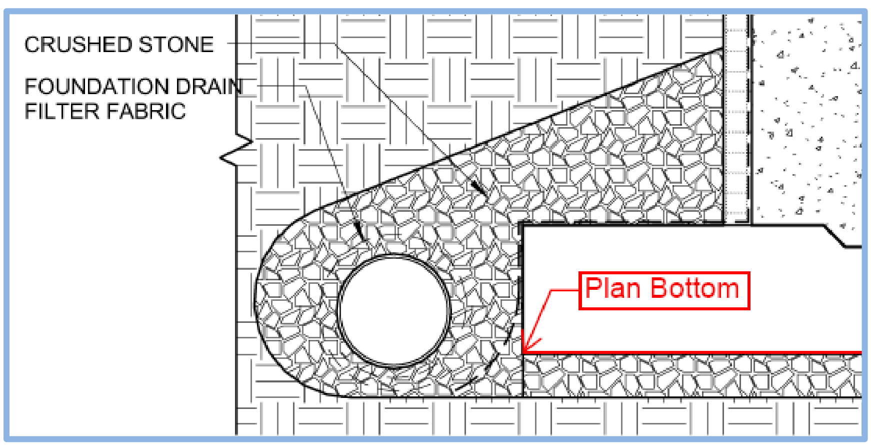
BIM Uses

CONSTRUCTABILITY CHALLENGES

Differing Soil Conditions

Plan bottom for contract documents is specified to be at an elevation of three hundred ninety-nine feet (399'). However, the specified Stratham Type II soil was not encountered within rock bin #2 until 2' below plan bottom at an elevation of three hundred ninety seven feet (397'), as determined by Benchmark and D.H. Funk (site subcontractor) and validated by ECS Testing Agency. In addition to the unsuitable soil condition, a change order request had to be filed by Benchmark for the additional excavation below the plan bottom.

As can be expected, the change order request cost extra time and money. First, there was lag time for the change order to be processed and approved. Further, extra excavation had to be done, extra waterproofing had to be installed, and extra backfill had to be done. Consequently, the construction of the CMU exterior walls (see Appendix C on page 23) was delayed, and the Dry-in Building Milestone could not be reached.



Minimizing Disruption to the Buchanan Estate

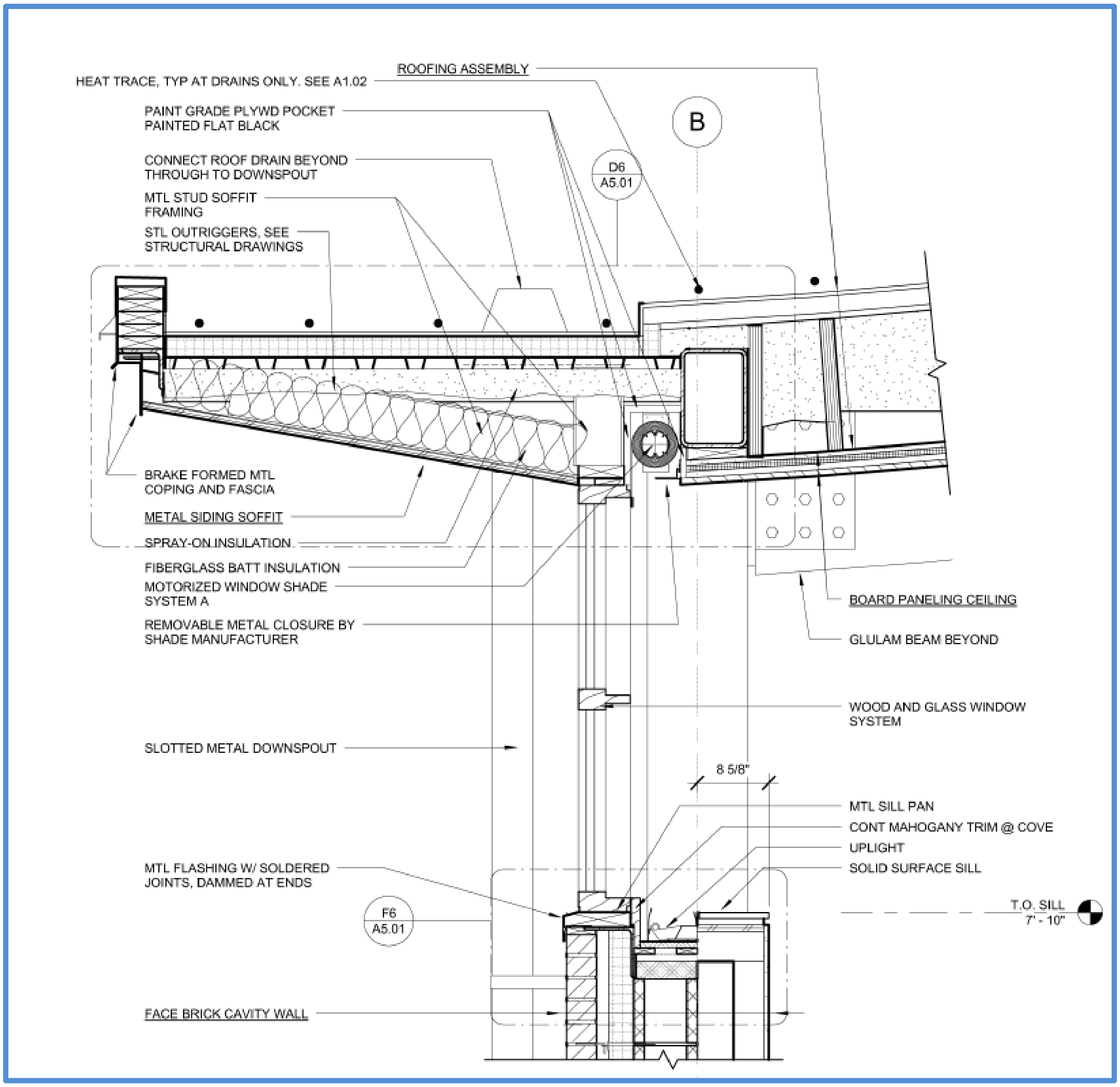
The construction site for LancasterHistory.org hosts the Wheatland residence, a historical landmark, and it remained open for the duration of the project. Safety was a top priority in this regard, as the Wheatland residence remained in operation for the duration of construction.

Museum goers need to be protected, which means a lot of fencing and signage. Many children that attend the site with their families and it is important that none get onto the construction site unmonitored. As an added precaution, there is a double gate with a lock. Construction noise was minimized on site, with work synchronized to accommodate museum tours. This required very detailed scheduling and planning.

In addition to the Wheatland Residence, the site happens to host the Louise Arnold Tanger Arboretum. As such, the owner, required that several rare species of trees go unharmed and that most of the 104 varieties of trees go unharmed. Some protected trees were situated right in the middle of construction, so tree fences and nets were used to supplement meticulous logistical planning. Benchmark wished to uproot several trees, but the owner would not allow it (see *Technical Report 1* for site fencing and logistics plans).

A Leak-proof Enclosure

One of the biggest concerns in the construction industry is that water damage will inhibit the longevity of the final product. This type of damage is extremely prevalent in buildings, and it is typically not covered under insurance. Given the unusual architectural design and shape of the LancasterHistory.org project (see above drawing), the building is especially at risk. During the enclosure phase of construction, inspection around windows is quintessential (see clerestory window below). The flat roof above the soffit requires proper drainage installation as well. The brick façade of the building should have well placed weep holes to allow breathability, should moisture get behind it.



WORKS CITED

RS Means, Square Foot Costs 2013

BIM Execution Planning Guide V2.1

APPENDIX A: DETAILED STRUCTURAL ESTIMATE DATA

Cost Estimate - Standard Construction Project

Detail - With Taxes and Insurance

Estimator :
Project Size : sqft

Description	TotalCost	$/sqft	$/0000	% of Est
CONTINUOUS FOOTING FORMS	2,719.06			2.534
COLUMN FTG FORMS	2,688.48			2.506
FNDN WALL FORMS	691.25			0.644
SLAB ON GRADE EDGE FORMS	345.68			0.322
SLAB EDGE FORMS	689.50			0.643
WALL REBAR	433.69			0.404
FOUNDATION WALL REBAR	1,495.83			1.394
CONTINUOUS FOOTING REBAR	1,455.20			1.356
COLUMN FOOTING REBAR	805.45			0.751
MAT FOUNDATION REBAR	239.41			0.223
6x6 W1.4/W1.4 MESH	2,354.57			2.195
6x6 W2.1/W2.1 MESH	2,939.22			2.740
3000 PSI DIRECT	1,295.76			1.208
3000 PSI DIRECT	1,645.60			1.534
3500 PSI DIRECT	2,881.09			2.685
3000 PSI DIRECT	12,688.07			11.826
CONCRETE TOPPING	1,195.08			1.114
FLOAT FINISH	1,514.70			1.412
PROTECT & CURE	711.70			0.663
PC HOLLOW CORE PLANK	12,473.02			11.626
8" CONC BLOCK	7,280.90			6.786
W10 x 30	1,095.20			1.021
W24 x 55	5,348.48			4.985
HSS 6X6X3/8"	429.00			0.400
HSS 6X4X1/2"	404.00			0.377
HSS 6X6X5/16 COLUMNS	2,145.00			1.999
HSS 10X4X1/4"	845.50			0.788
HSS 12X8X1/2 COLUMNS	11,912.00			11.103
HSS 12X8X1/2"	1,489.00			1.388
HSS 14X6X1/2" BEAMS	10,140.00			9.451
HSS 16X8X1/2" BEAMS	12,552.00			11.699
2X12X19 1/2 RAFTERS	203.05			0.189
6 3/4X30 GIRDER BEAMS	2,184.00			2.036
Total Gross Cost	**107,290.49**			**100.000**

EDF Report - Standard Construction Project

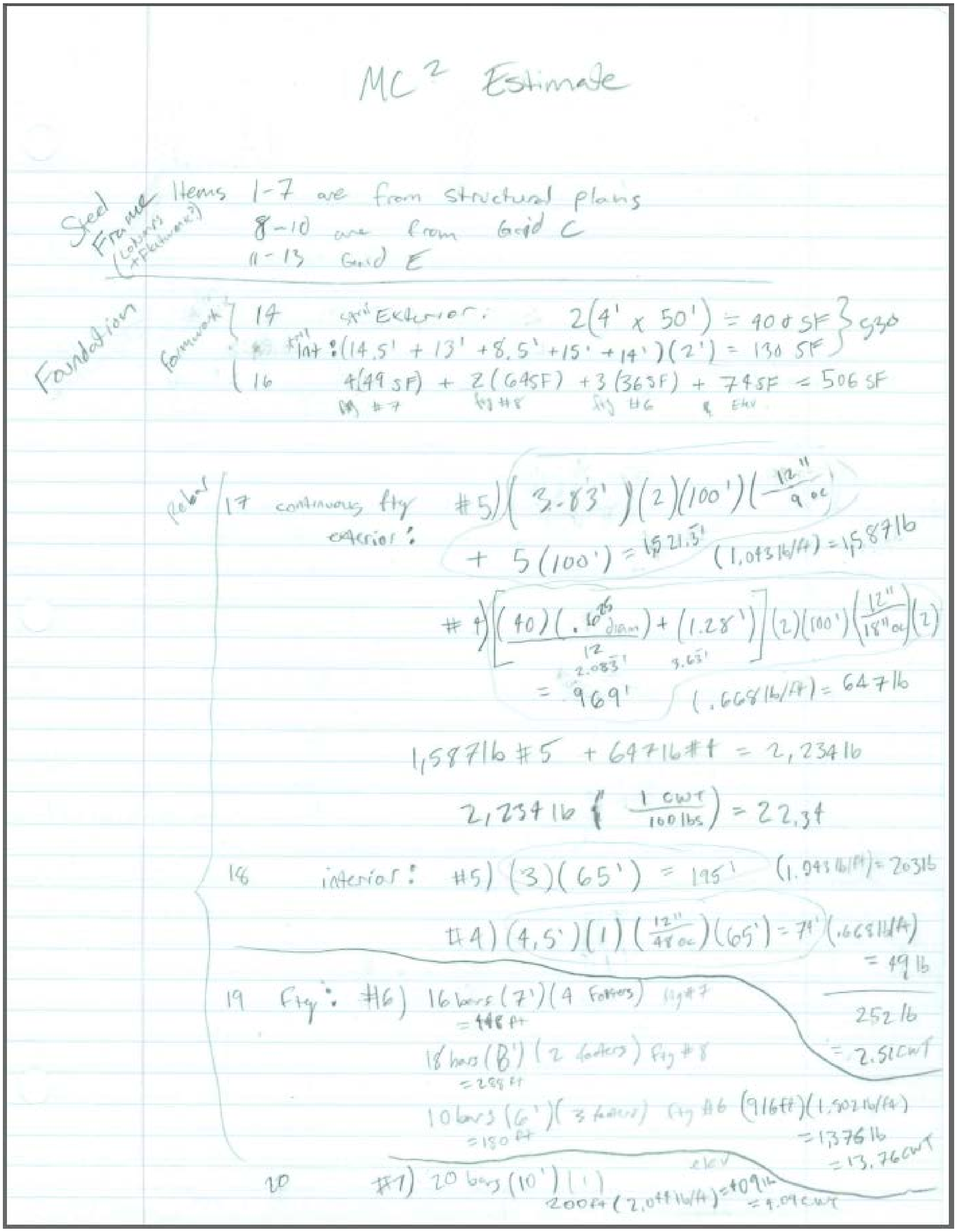
Estimator : erb5074
Project Size : sqft
Date : 11/12/2012
Time : 10:52 AM

Group 1: Divisions
Group 2: Major ItemCode Groups
Group 3: Minor ItemCode Groups
Group 4: Alternates

ItemCode	Description	Quantity	UM	Labor$	MH/Unit	Units/MH
Concrete						
Structural CIP forms						
Structural CIP forms						
Alternates Blank						
03110.100	CONTINUOUS FOOTING FORMS	530.00	SQFT	3.6583	0.139683	7.15909
03110.105	COLUMN FTG FORMS	506.00	SQFT	3.8412	0.146667	6.81818
03110.120	FNDN WALL FORMS	130.00	SQFT	3.7173	0.141935	7.04545
03110.200	SLAB ON GRADE EDGE FORMS	100.00	LNFT	2.3048	0.088	11.36364
03110.316	SLAB EDGE FORMS	176.00	LNFT	2.5608	0.097778	10.22727
	***** Total Alternates Blank*				*$7,133.96*	
	**** Total Structural CIP forms*				*$7,133.96*	
	*** Total Structural CIP forms*				*$7,133.96*	
Reinforcing steel						
Reinforcing steel						
Alternates Blank						
03210.160	WALL REBAR	7.26	CWT	32.9629	1.037037	0.96429
03210.165	FOUNDATION WALL REBAR	25.80	CWT	31.2281	0.982456	1.01786
03210.200	CONTINUOUS FOOTING REBAR	24.86	CWT	31.7857	1.00	1.00
03210.210	COLUMN FOOTING REBAR	13.76	CWT	31.7857	1.00	1.00
03210.230	MAT FOUNDATION REBAR	4.09	CWT	31.7857	1.00	1.00
	***** Total Alternates Blank*				*$4,429.59*	
	**** Total Reinforcing steel*				*$4,429.59*	
	*** Total Reinforcing steel*				*$4,429.59*	
Welded wire fabric						
Welded wire fabric						
Alternates Blank						
03220.010	6x6 W1.4/W1.4 MESH	87.00	SQS	18.8640	0.80	1.25
03220.011	6x6 W2.1/W2.1 MESH	90.00	SQS	22.0080	0.933333	1.07143
	***** Total Alternates Blank*				*$5,293.79*	
	**** Total Welded wire fabric*				*$5,293.79*	
	*** Total Welded wire fabric*				*$5,293.79*	
Structural concrete						
Structural concrete						
Alternates Blank						
03310.151	3000 PSI DIRECT	19.63	CUYD	11.0090	0.45	2.22222
03310.201	3000 PSI DIRECT	24.93	CUYD	11.0090	0.45	2.22222
03310.363	3500 PSI DIRECT	43.98	CUYD	11.0090	0.45	2.22222
03310.551	3000 PSI DIRECT	182.09	CUYD	14.6787	0.60	1.66667
03313.280	CONCRETE TOPPING	16.36	CUYD	12.0489	0.533333	1.875
	***** Total Alternates Blank*				*$19,705.60*	
	**** Total Structural concrete*				*$19,705.60*	
	*** Total Structural concrete*				*$19,705.60*	
Finishing						
Finishing						
Alternates Blank						
03350.132	FLOAT FINISH	5,500.00	SQFT	0.2754	0.010667	93.75
	***** Total Alternates Blank*				*$1,514.70*	
	**** Total Finishing*				*$1,514.70*	
	*** Total Finishing*				*$1,514.70*	
Curing						
Curing						
Alternates Blank						

ItemCode	Description	Quantity	UM	Labor$	MH/Unit	Units/MH
03390.010	PROTECT & CURE	5,500.00	SQFT	0.1102	0.004267	234.375
	**** *Total Alternates Blank*				*$711.70*	
	*** *Total Curing*				*$711.70*	
	** *Total Curing*				*$711.70*	
Plant precast structural concrete						
Plant precast structural concrete						
Alternates Blank						
03410.105	PC HOLLOW CORE PLANK	2,650.00	SQFT	1.1228	0.035556	28.125
	**** *Total Alternates Blank*				*$12,473.02*	
	*** *Total Plant precast structural concrete*				*$12,473.02*	
	** *Total Plant precast structural concrete*				*$12,473.02*	
	* *Total Concrete*				*$51,262.36*	
Masonry						
Concrete masonry units						
Concrete masonry units						
Alternates Blank						
04220.303	8" CONC BLOCK	1,435.00	SQFT	2.8594	0.111304	8.98438
	**** *Total Alternates Blank*				*$7,280.90*	
	*** *Total Concrete masonry units*				*$7,280.90*	
	** *Total Concrete masonry units*				*$7,280.90*	
	* *Total Masonry*				*$7,280.90*	
Metals						
Structural steel						
Structural steel						
Alternates Blank						
05122.729	W10 x 30	20.00	LF	4.9900		
05122.863	W24 x 55	64.00	LF	3.5700		
05126.038	HSS 6X6X3/8"	1.00	EACH	51.0000		
05126.144	HSS 6X4X1/2"	1.00	EACH	51.0000		
05126.147	HSS 6X6X5/16 COLUMNS	5.00	EACH	51.0000		
05126.218	HSS 10X4X1/4"	1.00	EACH	55.0000		
05126.264	HSS 12X8X1/2 COLUMNS	8.00	EACH	57.0000		
05126.264	HSS 12X8X1/2"	1.00	EACH	57.0000		
05126.274	HSS 14X6X1/2" BEAMS	6.00	EACH	57.0000		
05126.284	HSS 16X8X1/2" BEAMS	6.00	EACH	57.0000		
	**** *Total Alternates Blank*				*$46,360.18*	
	*** *Total Structural steel*				*$46,360.18*	
	** *Total Structural steel*				*$46,360.18*	
	* *Total Metals*				*$46,360.18*	
Wood and plastics						
Wood framing						
Wood framing						
Alternates Blank						
06110.756	2X12X19 1/2 RAFTERS	429.00	BDFT	0.2133	0.007882	126.8646
	**** *Total Alternates Blank*				*$203.05*	
	*** *Total Wood framing*				*$203.05*	
	** *Total Wood framing*				*$203.05*	
Prefabricated structural wood						
Prefabricated structural wood						
Alternates Blank						
06171.358	6 3/4X30 GIRDER BEAMS	208.00	LNFT	2.5000	0.092372	10.82582
	**** *Total Alternates Blank*				*$2,184.00*	
	*** *Total Prefabricated structural wood*				*$2,184.00*	
	** *Total Prefabricated structural wood*				*$2,184.00*	
	* *Total Wood and plastics*				*$2,387.05*	

APPENDIX B: DETAILED STRUCTURAL ESTIMATE CALCULATIONS



MC² Estimate

Steel Frame (columns + platforms?)
Items 1-7 are from structural plans
8-10 are from Grid C
11-13 Grid E

Foundation

Formwork
14 ftg Exterior: 2(4' x 50') = 400 SF } 530
15 ftg Int: (14.5' + 13' + 8.5' + 15' + 14')(2') = 130 SF
16 4(49 SF) + 2(64 SF) + 3(36 SF) + 74 SF = 506 SF
ftg #7, ftg #8, ftg #6, Elev

Rebar
17 continuous ftg exterior: #5) (3.83')(2)(100')(12"/9" oc) + 5(100') = 1521.3' (1.043 lb/ft) = 1,587 lb
#4) [(40)(.5 diam/12) + (1.28')](2)(100')(12"/18" oc)(2) = 969' (.668 lb/ft) = 647 lb
2.083', 3.63'

1,587 lb #5 + 647 lb #4 = 2,234 lb
2,234 lb (1 cwt / 100 lbs) = 22.34

18 interior: #5) (3)(65') = 195' (1.043 lb/ft) = 203 lb
#4) (4.5')(1)(12"/48" oc)(65') = 73' (.668 lb/ft) = 49 lb
252 lb = 2.52 cwt

19 Ftg: #6) 16 bars (7')(4 footers) ftg #7 = 448 ft
18 bars (8')(2 footers) ftg #8 = 288 ft
10 bars (6')(3 footers) ftg #6 = 180 ft
(916 ft)(1.502 lb/ft) = 1376 lb = 13.76 cwt

20 #7) 20 bars (10')(1) elev
200 ft (2.044 lb/ft) = 409 lb = 4.09 cwt

Foundation (cont.)

Concrete

21 cont. footer ext 100' (4')(1') = 400 ft3 = 14.815 cu. yd

22 cont footer int 65'(2')(1') = 130 ft3 = 4.815 cu. yd

23 footers 4(49SF)(1.25') + 2(64SF)(1.5') + 3(36SF)(1.5')

elev 74SF (1') = 673 ft3 = 24.93 cu yd

SOG

24 conc. (2930SF - 80SF)(5'/12) = 1186 ft3 = 43.98 cu yd

2,850

26 WWF 50'/6' = 8.3 ⇒ 9 9x10 = 90 sheets

59/6 = 9.8 ⇒ 10

Foundation wall

29 form (13' wall)(100' long) = 1300 SQFT

30 rebar #4) 13(2)(100' long) 2600 } = 3467 ft (.668 lb/ft)

(12/18)(13')(100' long) } = 2,316 lb

#5) (12/18)(13')(100') 867 } = 1267 (1.043 lb/ft)

2(2)(100') } = 1,321 lb

2,316 lb + 1,521 lb = 2,588 lb = 25.88 CWT

31 conc. (1300 SF)(16"/12) = 173 cu yd

Elevated Deck (ground level)

31 Plank 2850 SF − 200 SF = 2,650 SF

33 WWF 90 − 3 = 87 sheets

35 topping 2,650 $\left(\frac{2'}{12}\right)$ = 442 ft³ = 16.36 cuyd

Masonry Shear wall

3-8 CMUs 778 SF on west
657 SF on east
1,435 SF

assume all the same type of 6" CMUS

39 rebar #4) 100' $\left(\frac{12'}{24}\right)$(15') 750 ft (.668) = 501 lb

Assume 15 avg length

#6) 10 (15') 150 ft (1.502) = 225 lb
726 lb
= 7.26 cwt

40 conc.

Assume .126 cuft per BLK

1,435 / $\left(\frac{8 \times 16}{12}\right)$ = 134.5 ⇒ 135 Blocks

135 (.26 cuft) = 9.094 cuyd

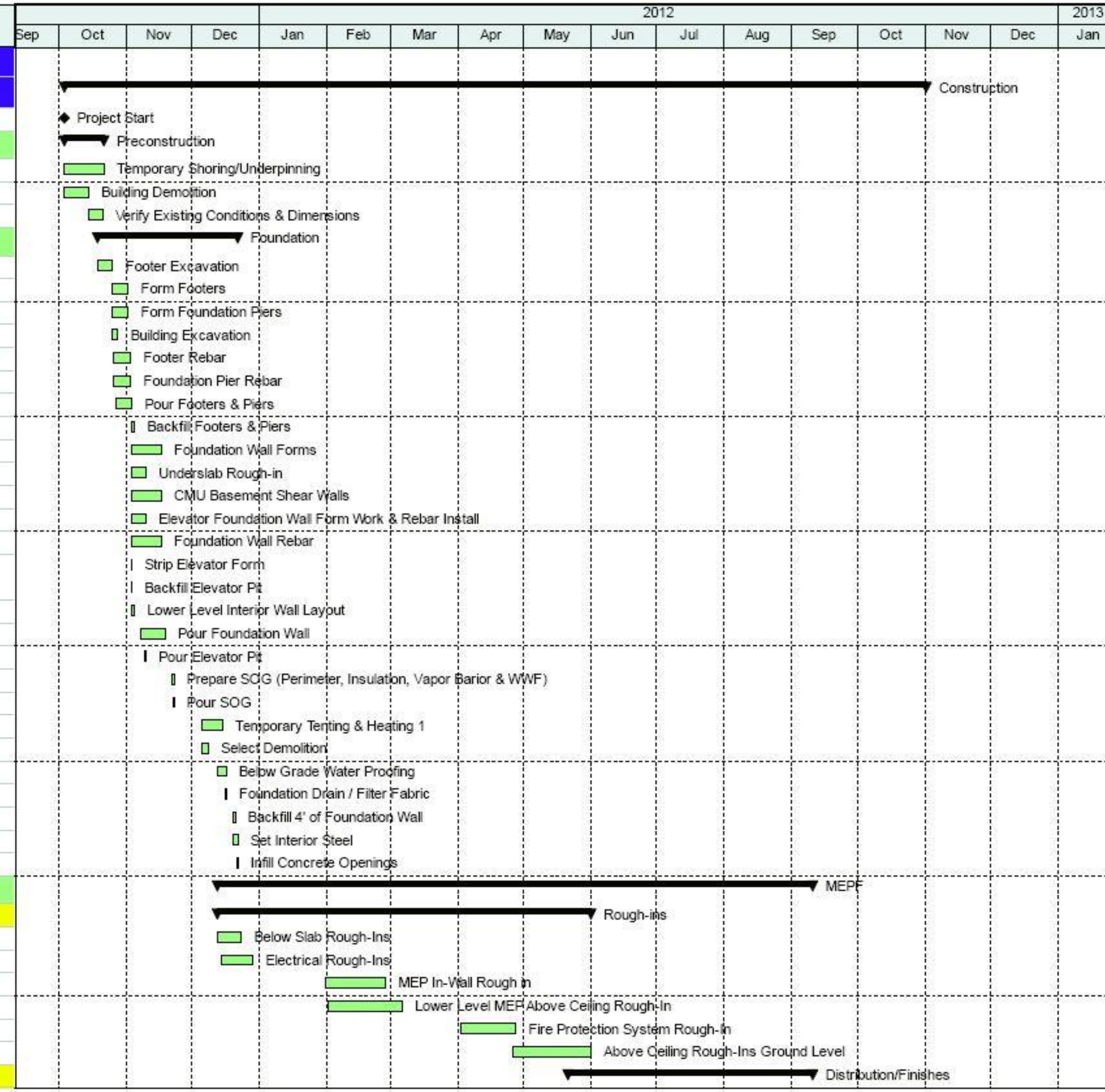
Roof
Assume are 15 feet long, flat

41 Rafters 52' × 59' = 3,068 SF

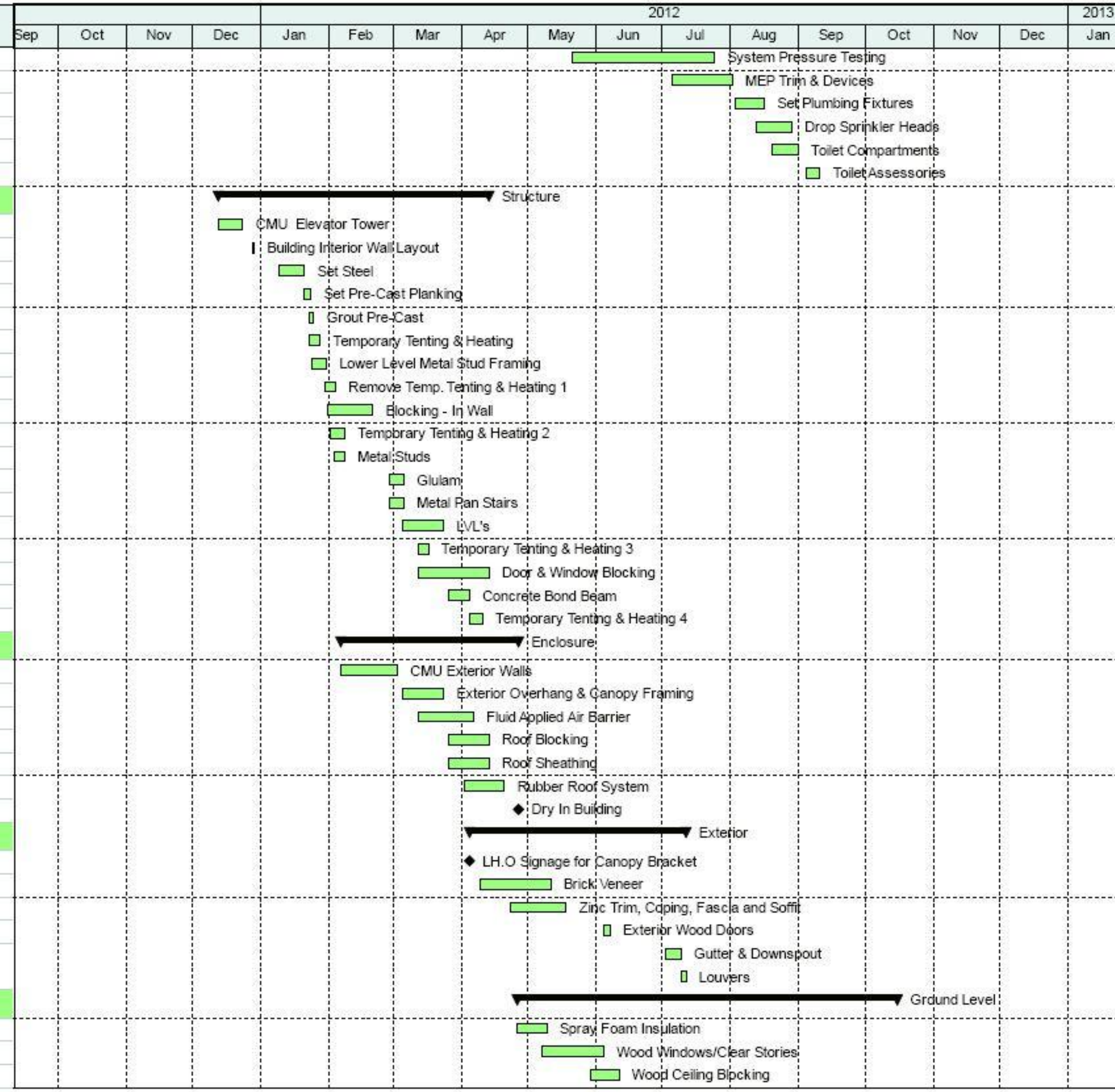
42 OB Assume 20" × 52' LVL joist instead of 6.75" × 30"

APPENDIX C: DETAILED PROJECT SCHEDULE

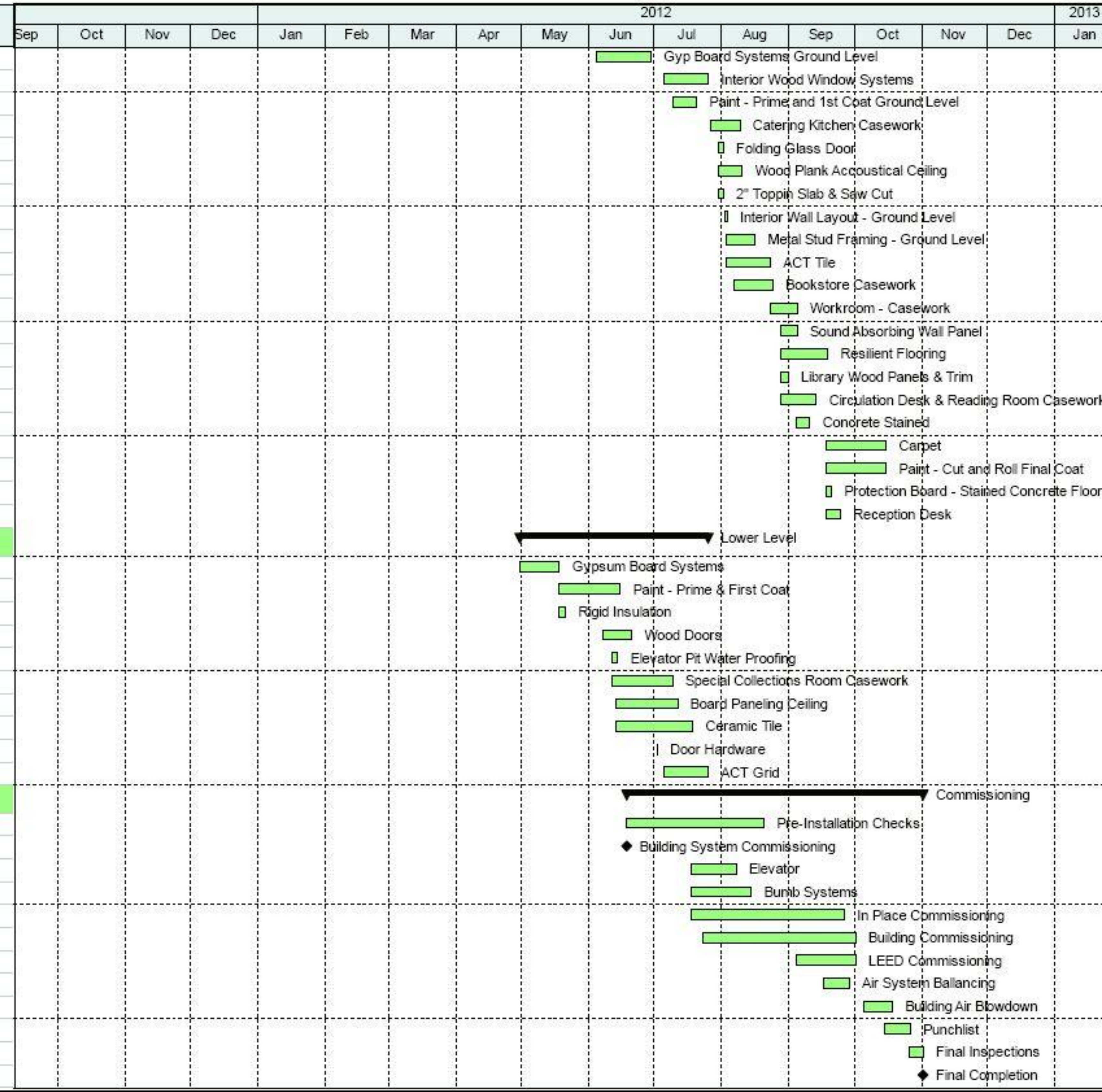
Activity ID	Activity Name	Activity Duration	Start	Finish
LancasterHistory.org		0		
Construction		278	03-Oct-11	01-Nov-12
A1000	Project Start	0	03-Oct-11	
Preconstruction		15	03-Oct-11	21-Oct-11
A1010	Temporary Shoring/Underpinning	15	03-Oct-11	21-Oct-11
A1020	Building Demolition	10	03-Oct-11	14-Oct-11
A1030	Verify Existing Conditions & Dimension	5	14-Oct-11	20-Oct-11
Foundation		46	18-Oct-11	21-Dec-11
A1040	Footer Excavation	6	18-Oct-11	25-Oct-11
A1050	Form Footers	6	25-Oct-11	01-Nov-11
A1060	Form Foundation Piers	6	25-Oct-11	01-Nov-11
A1070	Building Excavation	3	25-Oct-11	27-Oct-11
A1080	Footer Rebar	6	26-Oct-11	02-Nov-11
A1090	Foundation Pier Rebar	6	26-Oct-11	02-Nov-11
A1100	Pour Footers & Piers	6	27-Oct-11	03-Nov-11
A1110	Backfill Footers & Piers	2	03-Nov-11	04-Nov-11
A1120	Foundation Wall Forms	10	03-Nov-11	16-Nov-11
A1130	Underslab Rough-in	5	03-Nov-11	09-Nov-11
A1140	CMU Basement Shear Walls	10	03-Nov-11	16-Nov-11
A1150	Elevator Foundation Wall Form Work &	5	03-Nov-11	09-Nov-11
A1160	Foundation Wall Rebar	10	03-Nov-11	16-Nov-11
A1190	Strip Elevator Form	1	03-Nov-11	03-Nov-11
A1200	Backfill Elevator Pit	1	03-Nov-11	03-Nov-11
A1230	Lower Level Interior Wall Layout	2	03-Nov-11	04-Nov-11
A1170	Pour Foundation Wall	10	07-Nov-11	18-Nov-11
A1180	Pour Elevator Pit	1	09-Nov-11	09-Nov-11
A1210	Prepare SOG (Perimeter, Insulation, V:	2	21-Nov-11	22-Nov-11
A1220	Pour SOG	1	22-Nov-11	22-Nov-11
A1240	Temporary Tenting & Heating 1	8	05-Dec-11	14-Dec-11
A1350	Select Demolition	4	05-Dec-11	08-Dec-11
A1250	Below Grade Water Proofing	5	12-Dec-11	16-Dec-11
A1260	Foundation Drain / Filter Fabric	1	16-Dec-11	16-Dec-11
A1270	Backfill 4' of Foundation Wall	2	19-Dec-11	20-Dec-11
A1290	Set Interior Steel	3	19-Dec-11	21-Dec-11
A1330	Infill Concrete Openings	1	21-Dec-11	21-Dec-11
MEPF		191	12-Dec-11	10-Sep-12
Rough-ins		121	12-Dec-11	31-May-12
A1300	Below Slab Rough-Ins	10	12-Dec-11	23-Dec-11
A1310	Electrical Rough-Ins	10	14-Dec-11	28-Dec-11
A1430	MEP In-Wall Rough in	20	31-Jan-12	27-Feb-12
A1570	Lower Level MEP Above Ceiling Rough	25	01-Feb-12	06-Mar-12
A1630	Fire Protection System Rough-In	20	02-Apr-12	27-Apr-12
A1680	Above Ceiling Rough-Ins Ground Level	25	26-Apr-12	31-May-12
Distribution/Finishes		78	21-May-12	10-Sep-12



Activity ID	Activity Name	Activity Duration	Start	Finish
A2120	System Pressure Testing	45	21-May-12	24-Jul-12
A1830	MEP Trim & Devices	20	05-Jul-12	01-Aug-12
A1920	Set Plumbing Fixtures	10	03-Aug-12	16-Aug-12
A1960	Drop Sprinkler Heads	12	13-Aug-12	28-Aug-12
A1970	Toilet Compartments	10	20-Aug-12	31-Aug-12
A2030	Toilet Assessories	5	04-Sep-12	10-Sep-12
Structure		88	12-Dec-11	13-Apr-12
A1280	CMU Elevator Tower	10	12-Dec-11	23-Dec-11
A1320	Building Interior Wall Layout	1	28-Dec-11	28-Dec-11
A1360	Set Steel	10	09-Jan-12	20-Jan-12
A1370	Set Pre-Cast Planking	2	20-Jan-12	23-Jan-12
A1380	Grout Pre-Cast	2	23-Jan-12	24-Jan-12
A1390	Temporary Tenting & Heating	5	23-Jan-12	27-Jan-12
A1420	Lower Level Metal Stud Framing	5	24-Jan-12	30-Jan-12
A1400	Remove Temp. Tenting & Heating 1	5	30-Jan-12	03-Feb-12
A1440	Blocking - In Wall	15	31-Jan-12	20-Feb-12
A1450	Temporary Tenting & Heating 2	5	01-Feb-12	07-Feb-12
A1340	Metal Studs	3	03-Feb-12	07-Feb-12
A1470	Glulam	5	28-Feb-12	05-Mar-12
A1540	Metal Pan Stairs	5	28-Feb-12	05-Mar-12
A1480	LVL's	15	05-Mar-12	23-Mar-12
A1460	Temporary Tenting & Heating 3	5	12-Mar-12	16-Mar-12
A1550	Door & Window Blocking	25	12-Mar-12	13-Apr-12
A1490	Concrete Bond Beam	8	26-Mar-12	04-Apr-12
A1590	Temporary Tenting & Heating 4	5	04-Apr-12	10-Apr-12
Enclosure		59	06-Feb-12	26-Apr-12
A1410	CMU Exterior Walls	20	06-Feb-12	02-Mar-12
A1580	Exterior Overhang & Canopy Framing	15	05-Mar-12	23-Mar-12
A1520	Fluid Applied Air Barrier	20	12-Mar-12	06-Apr-12
A1500	Roof Blocking	15	26-Mar-12	13-Apr-12
A1510	Roof Sheathing	15	26-Mar-12	13-Apr-12
A1610	Rubber Roof System	15	02-Apr-12	20-Apr-12
A1650	Dry In Building	0		26-Apr-12
Exterior		69	04-Apr-12	11-Jul-12
A1560	LH.O Signage for Canopy Bracket	0	04-Apr-12	
A1530	Brick Veneer	25	09-Apr-12	11-May-12
A1620	Zinc Trim, Coping, Fascia and Soffit	20	23-Apr-12	18-May-12
A1710	Exterior Wood Doors	4	04-Jun-12	07-Jun-12
A1780	Gutter & Downspout	5	02-Jul-12	09-Jul-12
A1790	Louvers	3	09-Jul-12	11-Jul-12
Ground Level		120	26-Apr-12	15-Oct-12
A1660	Spray Foam Insulation	10	26-Apr-12	09-May-12
A1720	Wood Windows/Clear Stories	20	07-May-12	04-Jun-12
A1690	Wood Ceiling Blocking	10	29-May-12	11-Jun-12



Activity ID	Activity Name	Activity Duration	Start	Finish
A1730	Gyp Board Systems Ground Level	20	04-Jun-12	29-Jun-12
A1820	Interior Wood Window Systems	15	05-Jul-12	25-Jul-12
A1840	Paint - Prime and 1st Coat Ground Lev	10	09-Jul-12	20-Jul-12
A1870	Catering Kitchen Casework	10	27-Jul-12	09-Aug-12
A1880	Folding Glass Door	3	30-Jul-12	01-Aug-12
A1890	Wood Plank Accoustical Ceiling	10	30-Jul-12	10-Aug-12
A1900	2" Toppin Slab & Saw Cut	3	30-Jul-12	01-Aug-12
A1910	Interior Wall Layout - Ground Level	2	02-Aug-12	03-Aug-12
A1930	Metal Stud Framing - Ground Level	10	03-Aug-12	16-Aug-12
A1940	ACT Tile	15	03-Aug-12	23-Aug-12
A1950	Bookstore Casework	15	06-Aug-12	24-Aug-12
A1980	Workroom - Casework	8	23-Aug-12	04-Sep-12
A1990	Sound Absorbing Wall Panel	5	28-Aug-12	04-Sep-12
A2000	Resilient Flooring	15	28-Aug-12	18-Sep-12
A2010	Library Wood Panels & Trim	4	28-Aug-12	31-Aug-12
A2020	Circulation Desk & Reading Room Cas	12	28-Aug-12	13-Sep-12
A2050	Concrete Stained	5	04-Sep-12	10-Sep-12
A2060	Carpet	20	18-Sep-12	15-Oct-12
A2070	Paint - Cut and Roll Final Coat	20	18-Sep-12	15-Oct-12
A2080	Protection Board - Stained Concrete Fl	3	18-Sep-12	20-Sep-12
A2090	Reception Desk	5	18-Sep-12	24-Sep-12
Lower Level		61	30-Apr-12	25-Jul-12
A1640	Gypsum Board Systems	15	30-Apr-12	18-May-12
A1670	Paint - Prime & First Coat	20	18-May-12	15-Jun-12
A1700	Rigid Insulation	2	18-May-12	21-May-12
A1740	Wood Doors	10	07-Jun-12	20-Jun-12
A1600	Elevator Pit Water Proofing	4	11-Jun-12	14-Jun-12
A1750	Special Collections Room Casework	20	11-Jun-12	09-Jul-12
A1760	Board Paneling Ceiling	20	13-Jun-12	11-Jul-12
A1770	Ceramic Tile	25	13-Jun-12	18-Jul-12
A1800	Door Hardware	1	02-Jul-12	02-Jul-12
A1810	ACT Grid	15	05-Jul-12	25-Jul-12
Commissioning		97	18-Jun-12	01-Nov-12
A2140	Pre-Installation Checks	45	18-Jun-12	20-Aug-12
A2130	Building System Commissioning	0	18-Jun-12	
A1850	Elevator	15	18-Jul-12	07-Aug-12
A2150	Bumb Systems	20	18-Jul-12	14-Aug-12
A2160	In Place Commissioning	50	18-Jul-12	26-Sep-12
A1860	Building Commissioning	50	23-Jul-12	01-Oct-12
A2040	LEED Commissioning	20	04-Sep-12	01-Oct-12
A2170	Air System Ballancing	10	17-Sep-12	28-Sep-12
A2180	Building Air Blowdown	10	05-Oct-12	18-Oct-12
A2100	Punchlist	10	15-Oct-12	26-Oct-12
A2110	Final Inspections	5	26-Oct-12	01-Nov-12
A2190	Final Completion	0		01-Nov-12



APPENDIX D: BIM GOALS

PRIORITY (HIGH/MED/LOW)	GOAL DESCRIPTION	POTENTIAL BIM USES
High	Ensure building is operating to sustainable standards	Building systems Analysis
Medium	Ensure building is operating to specified design	Building systems Analysis
High	Identify opportunities to modify system operations to improve performance	Building systems Analysis
Medium	Increase the efficiency of transition planning and management	Space management & tracking
High	Proficiently track the use of current and space and resources	Space management & tracking
High	Assist in planning future space needs for the facility	Space management & tracking
Medium	Improve the effectiveness of Emergency response	Disaster Planning
Medium	Minimize risks to responders	Disaster Planning
High	Accurately evaluate site layout for safety concerns	Site Utilization Planning
Medium	Effectively communicate construction sequence and layout to all interested parties	Site Utilization Planning
High	Minimize the amount of time spent performing site utilization planning	Site Utilization Planning
Medium	Increase constructability of a complex building system	Construction System Design (Virtual Mockup), 3D Coordination
High	Increase construction productivity, Phase Planning (4D Modeling)	Construction System Design (Virtual Mockup),
Medium	Decrease language barriers	Construction System Design (Virtual Mockup), 3D Control and Planning (Digital Layout)
High	Ensure quality of information	Digital Fabrication
Low	Reduce lead time	Digital Fabrication
Medium	Decrease layout errors by linking model with real world coordinates	3D Control and Planning (Digital Layout)
Low	Reduce rework because control points are received directly from the model	3D Control and Planning (Digital Layout)
High	Reduce and eliminate field conflicts	3D Coordination
High	Reduce construction cost	3D Coordination, Phase Planning (4D Modeling), Cost Estimation
High	Decrease construction time	3D Coordination, Phase Planning (4D Modeling)
High	Better control and quality control of design, cost and schedule	Design Authoring, Sustainability (LEED) Evaluation, Design Reviews
High	Achieve optimum, energy-efficient design solution by applying various rigorous analyses	Engineering Analysis, Facility Energy Analysis
Low	Automate analysis, saving time and cost	Engineering Analysis, Facility Energy Analysis
Medium	Early and reliable evaluation of design alternatives.	Sustainability (LEED) Evaluation, Design Reviews
High	Reduce operational costs of the facility due to the energy performance of the project	Sustainability (LEED) Evaluation
Low	Reduced turnaround time	Code Validation
High	Space and workspace conflicts identified and resolved ahead of the construction process	Phase Planning (4D Modeling)
Medium	Monitor procurement status of project materials	Phase Planning (4D Modeling)
High	Identification of schedule, sequencing or phasing issues	Phase Planning (4D Modeling)

APPENDIX E: BIM USE ANALYSIS

BIM USE	VALUE TO PROJECT	RESPONSIBLE PARTY	VALUE TO RESP PARTY	CAPABILITY RATING			ADDITIONAL RESOURCES/COMPETANCIES REQUIRED TO IMPLEMENT	PROCEED WITH USE
	HIGH/ MED/ LOW		HIGH/ MED/ LOW	SCALE 1-3 (1=LOW)				YES/NO/ MAYBE
				Resources	Competency	Experience		
Building systems Analysis	High	Architect	Medium	3	3	3	Building Systems Analysis Software, Record Model	Yes
		MEPF Engineer	High	3	2	2		
		Contractor	High	2	2	2		
Space management & tracking	High	Owner	High	2	3	3	Bi-Directional 3D Model Manipulation	Yes
Disaster Planning	Medium	Contractor	Medium	1	3	3	Record Model	Maybe
Site Utilization Planning	High	Contractor	High	3	3	3		Yes
Construction System Design (Virtual Mockup)	High	Architect	High	3	2	2		Yes
		MEPF Engineer	High	3	3	2		
		Structural Engineer	Medium	3	3	2		
Digital Fabrication	Low	Structural Engineer	Low	2	2	1		No
		Contractor	Low	3	3	2		
		Fabricator	Medium	3	3	3		
3D Control and Planning (Digital Layout)	Low	Architect	Low	2	2	1		No
		MEPF Engineer	Low	3	3	3		
		Contractor	Medium	2	3	2		
		Subcontractors	Low	1	2	1		
3D Coordination	High	Architect	High	3	3	3	Teach Subcontractors	Yes
		MEPF Engineer	High	3	3	3		
		Contractor	High	2	3	3		
		Subcontractors	Medium	1	2	1		
		Structural Engineer	High	3	2	2		
Code Validation	Low	Contractor	Low	3	2	2		No
Phase Planning (4D Modeling)	High	Contractor	High	3	3	3	Teach Subcontractors	Yes
		Subcontractors	Medium	1	3	1		
Design Reviews	Low	Architect	Medium	3	2	2		No
		Owner	Low	2	1	1		
Facility Energy Analysis	Medium	Architect	Medium	3	2	3		No
		MEPF Engineer	High	3	2	3		
		Contractor	Medium	2	2	1		
Sustainability (LEED) Evaluation	High	Contractor	High	2	2	1	Knowledge of up-to-date LEED information	Maybe
		Owner	High	2	2	1		
		Architect	High	3	2	3		
Cost Estimation	Low	Architect	Low	2	1	2		No
		Contractor	Medium	3	3	3		
Design Authoring	Low	Architect	Medium	2	2	1		No
		Owner	Low	2	1	1		
		Structural Engineer	Low	2	2	2		
Engineering Analysis	Medium	Architect	Medium	2	2	1	Engineering analysis software	Maybe
		MEPF Engineer	High	3	3	3		
		Structural Engineer	Medium	3	3	3		
	Medium	Contractor	Medium	2	2	1		Maybe
		Facility Manager	Low	2	1	1		
		Architect	Low	2	1	1		

APPENDIX G: BIM LEVEL-1 PROCESS MAP