

Architectural Engineering 2013 Senior Thesis
Technical Assignment 3

FOR

BLOCK 12

DEVELOPED BY

Josue Fernandez



[BLOCK 12]

ROCKVILLE, MD

Advisor: Dr. Dubler

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SECTION A: EXECUTIVE SUMMARY

This report will analyze the schedule acceleration scenarios and value engineering for Block 12, primarily from an interview of the project manager of Block 12. Critical issues from the construction industry will also be analyzed, from which potential research topics from industry professionals will be discussed for a technical analysis. A defined area of investigation will be developed for a thesis proposal.

Setting up a phone interview with the project manager was a bit time consuming due to the current schedule of the project and time coordination. During the phone interview we discussed potential ways to accelerate the schedule of the framing and millwork trades by increasing the manpower and working days to Saturday and Sunday. This procedure would add cost to the project, but save time on the schedule. Value engineering was also discussed and determined that it was implemented primarily during the schematic phase of the project.

During the 22nd Annual PACE Roundtable, current critical issues were discussed. Two of the roundtables I was a part of were the Information Management in the Workplace and the Criteria and Drivers for Effective Multi-trade prefabrication and Modularization. In the first session major topics were centered on presenting information and preventing reiterative rework. During the second session, previous experience with prefabricating multi-trade units was discussed. In between the sessions a guest speaker from SYSTRA came to talk about potential implementations of modularization to the construction industry from the railroad industry. At the conclusion of the roundtable, feedback was provided by an industry professional from Balfour Beatty to serve as a research topic for a technical analysis.

Block 12 is part of a new community development in the heart of Rockville, MD. The developed, Federal Realty Investment Trust, will own, operate, and manage the newly constructed building, which is intended to achieve LEED certified status. Within the structure's four total floors and two sublevels, various usage types will be incorporated. A parking garage will provide 163 spaces over 72,266 square feet spanning over 2 levels. In various locations across two levels, retail space will occupy 44,254 square feet and consist of 13 individual retail spaces. The residential space makes up 175,284 square feet of the building and includes 174 units, a fitness center for the tenants, and an outdoor courtyard with a swimming pool.

The existing conditions of Block 12 are ideal. Block 12 sits on a large open commercial lot. Existing stores include Starbucks, Bank of America, AC Moor, Chipotle, and Bally Total Fitness among others. As part of phase 1 of the overall project, Bally Total Fitness will be under demolition. The existing building does not affect Block 12's construction progress, but it does affect Block 10 and 11, which are the other 2 buildings being built adjacent. Utilities are readily accessible, but due to the high occupancy demands of the overall project, most of the utilities will have to be upsized. Construction traffic flow is of a concern due to the high car flow and accessibility issues on the two primary roads. Based on the geotechnical reports, Block 12 sits above 3 feet of the water level, facilitated with the drainage concerns during excavation.

The project schedule has a critical finish date of May 2014. Federal Realty Investment Trust plans on leasing the apartments to recent college graduates, whom seek a place to live after having accepted a job near the densely populated DC/Northern Virginia Area. The project is fast paced, with a construction schedule lasting only 20 months. This was achieved through prefabricating wood framing into sections. The production rate was increased by systematically

managing workflow and through effectively splitting the building into four sections as seen on Figure 1.2. The project had a 5 day delay due to Hurricane Sandy hitting the job site. The effect was mitigated by proactively planning accumulated water deposits within the excavation. The only activity in the schedule that lies on the critical path is close-out, which also marks the period of most workforce demand.

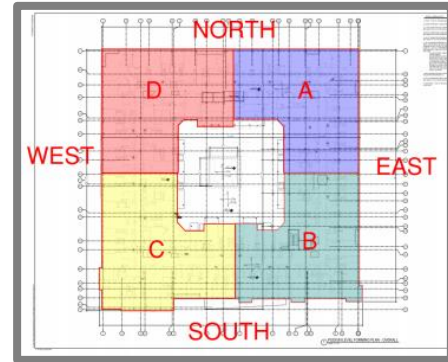


Figure 1.2: Wood framing sequence

The wood frame building sits on spread footing set 3 feet below the slab on grade level with two post tensioned concrete slabs. The cast-in-place concrete was pumped and poured using concrete barrels, to reach the building's extremes. The residential units will be heated by split system heat pumps and cooled with a cooling system. The mechanical equipment will primarily be located on the roof, including 2 RTU's. The parking garage will circulate air with 3 exhaust fans, which will be activated with CO₂ sensors. Active fire protection measures are taken by 2hr fire rated shafts and fire rated I-beams. Passive fire protection measures are additionally taken by a wet pipe system in the stairs & residential areas and a dry pipe system in the garage & retail slabs. The electrical system is a 3 phase 480/277V low voltage fed from one location to electrical closets on each level. The building will contain 1 diesel 250 KW generator for emergency power outages with an auto start specification of 10 seconds max and minimum fuel storage of 24 hours at rated load. Load bearing concrete masonry walls will house the stair shafts. The exterior retail space façade will primarily be composed of curtain walls, to be designed, furnished, and installed by the subcontractor. The systems to support excavation walls were steel soldier piles and wood lagging boards with tiebacks on the north, south, and east. The west side was laid back to facilitate truck flow traffic inside the excavation. Temporary pumps were used only used during excavation, due to the building sitting on 3 feet above the water line.

The patented system by SCA Consulting Engineers, Inc. was incorporated for faster production time installing drywall. Full sheets of drywall can be placed and drilled in place, compared to traditionally trimming the drywall to fit properly. Zip system sheathing and tape was used as a moisture resistant barrier to enclose the building and reduce air leakage. This system discards the need for house wrap and felt typically required. The owner is seeking LEED Accreditation through implementing a green roof, a waste management plan, and an indoor air quality management plan.

The project delivery system is a traditional Design-Bid-Build project delivery system with the CM at risk providing a GMP. This was the chosen method due to the owner feeling comfortable with the delivery method and by previous project's success. The owner settled on a price with the general contractor, The Whiting-Turner Construction Company, through a negotiation. The owner's representative is compensated through a cost by fee basis, while the architects, engineers, and subcontractor's contract types are lump sums. It is worth noting, even though the architect and construction manager do not have a contract, they have a strong communication for the success of this project. The construction contract terms are typical AIA language stating explicitly each party's responsibilities. The schedule to abide is attached and the consequences for delay or non-compliance are stated. The contractor was selected based on a good relationship with the owner.

Block 12 is one of three buildings under construction at the same time, with a team dedicated to site work, due to the heavy site work involvement. Ted Border is the Vice President overseeing all the work performed throughout the overall project. Adam Haubert is the Sr. Project Manager primarily in charge of scheduling. Luther Hildreth is the Senior Superintendent making sure everything runs smoothly in the field. Site work and Block 12 are structured similarly with a project engineer being under a superintendent under a project manager.

Federal Realty Investment Trust is a large realty investment trust, which focuses on development and redevelopment. They typically own, operate, and manage their buildings. Federal Realty is a privately funded company who focuses on obtaining a quality building at a feasible cost.

SECTION B: SCHEDULE ACCELERATION SCENARIOS

Critical Path Analysis and Acceleration Options

Due to the sequencing of work scheduled to be performed in Block 12, the critical path runs through the concrete and vertical construction of the prefabricated wood frame structure. The concrete work lies on the critical path, since the CMU shear wall and the start of framing the prefabricated wood trusses are dependent on the completion of the concrete retail level. This affects construction, since multiple crews must be brought in to complete the retail construction before starting the residential wood frame construction.

Framing the prefabricated wood trusses can be considered more critical than concrete, since it has a longer duration and because inspections and substantial completion activities are dependent on the completion of the construction tasks being done in these areas. The prefabricated wood framing could have been placed more productively with more crews. Since the framer only had enough workers to work on 2 sections consecutively (this equates to approximately 5 days per activity), the schedule was developed in a sequence to maximize productivity. The implied cost of bringing more crews in is hiring additional workers, which the framing company will have most likely not worked with before.

In general, as the retail level was being roughed-in, the residential level was being framed in a clockwise pattern, with finishes, and inspections following close. The schedule has some flexibility to account for unprecedented circumstances, which have definitely occurred in this project. The owner understands these unforeseen events and has agreed to pay for some of the costs incurred in overtime work to maintain the job to schedule.

Currently, drywall is being installed, which lies on the critical path. Unfortunately, there are some issues with inspection. The project was scheduled to allot time for one inspection, but Montgomery County requires 2 additional inspections, totaling to 3 inspections per unit. These inspections include shafts for interior insulation and the other two are typical close-in inspections. Additional delays were caused due to fire stopping. The inspector only checked initially for fire stopping, but if there were plumbing pipes half way in a shaft and half in the demising wall, it had to be completely encased with drywall to achieve the required fire rating.

Another acceleration option is to add a second crew or more to the interior cabinet millwork along with working Saturdays and Sundays. Additionally, overlapping the schedule more may accelerate the schedule even further. The cost savings would include those implied in the general conditions.

Schedule Risks

Long lead items are always a concern for project completion along with major design changes. Long lead items, which lie on the critical path, include transfer switches, the switchboard, generator, and elevator to name a few. Fortunately, there were no major design changes which caused a potential schedule delay.

Currently, there are some issues with coordinating the connections of all the utilities connecting to the building. This includes the roads, pavement, etc. This is a major concern since, without utilities or pavements, the building will not be considered occupiable and substantially complete, thus making it ineligible for payment.

Another concern for Block 12 is the RFI response time from the architect and engineers. The RFI response time is currently taking 60-200 days, which should typically only take 14 days. There are no requests for payment due to delays, since the construction managers did not let any of the RFI's get to the point where it caused delays.

SECTION C: VALUE ENGINEERING

Value Engineering

There were several value engineering efforts dedicated to the construction and design of Block 12. While the private owner wanted to maintain the high quality of work performed, they were also concerned to maintaining the original budget. The value engineering effort was devoted heavily during the schematic design process of Block 12.

Some of the components which were considered for value engineering were wallpaper, flooring, and interior finishes naming a few. By providing equal quality products with a reduction in cost, this maintained the owner's vision. Due to the familiarity of the building owner with having built similar projects, the owner was very comfortable with expressing what he desired and how he wished the construction to go. Having allotted value engineering efforts in the early phase of the project, the schematic phase, there was a lot of value added to the project with little to no major changes. The value of such implementations can be seen in the use of several systems, like the use of CPVC for fire protection, aluminum cabling for power rather than copper, and a zip system sheathing and tape to act as an air barrier to keep moisture out and reduce air leakage.

Some potential opportunities for value engineering during the construction phase of Block 12 include replacing the non-load bearing walls with metal studs. This will reduce the cost, while maintaining the quality of the end product. Another opportunity for value engineering is potentially replacing the granite counter tops for example a Venetian Gold Granite as seen in Figure 3.1, with less expensive quartz laminate countertops as seen in Figure 3.2. The final end product will have a similar aesthetic appeal as that of granite, but it will be much more cost effective.

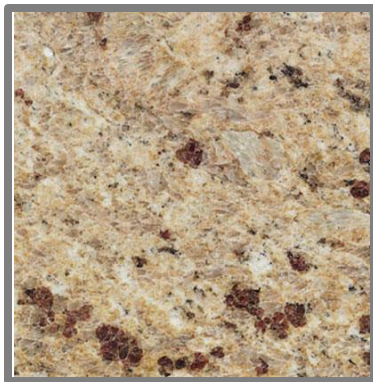


Figure 3.1: Venetian Gold Granite



Figure 3.1: Milano Quartz Laminate by Wilsonart

SECTION D: CRITICAL INDUSTRY ISSUES

The Partnership for Achieving Construction Excellence (PACE) holds a conference every year in early November to discuss current issues and brainstorm how to best address critical industry issues. The 22nd Annual PACE Roundtable conference highlighted the three major themes of sustainability, information technology, and integrated processes. The integrated processes topic was interesting, due to Block 12 containing prefabricated wood trusses. Most of the discussions in the roundtable were primarily based on collaboration and system information exchange. There were two industry contacts I got a hold of that may potentially be of invaluable help for my Block 12 project, which include David Maser of Gilbane Inc. and Jason Reece of Balfour Beatty.

Information Management for the Workforce

This meeting session's discussions primarily focused on information exchange standards and systems integration. There were discussions on how there should be a focus on information standards. The idea was centered around "letting designers design," so more time can be spent on design and less on documentation. This is a major concern in the industry since most projects suffer from missing information and design discrepancies. If the designers spent more time on ensuring the quality of their designs, the information exchanged to the other parties would be much more effective.

Integration among different tools and software was also discussed. This pertained to various companies utilizing different software, some even highly customizing their own in house software to suit their needs. The potential downfall to this issue is the exchange of information. Once the information is transferred, if the next party down the line does not utilize the same compatible software, the potential to utilize the information is lost. Partial lost in this process may be common, since at times not all the information may be critical, but there is a monetary issue. Work has to be redone. For example, if a mechanical contractor is given a 3D model in different software than what it utilizes to prefabricate, it is forced to redo its own model. This inefficient process not only adds time to the process, but it also adds cost. There should be a greater emphasis on communicating an exchanged model's reliability of geometry and information. It was interesting to me that the industry members stayed on topic during this session and were not afraid to discuss details of successes and shortcomings some project had to other competitors.

Transporting Systems Integration of Rail Projects to Building Design & Construction

Patrick Harrison of SYSTRA gave a presentation on systems integration for metro-rail work and the opportunities in building systems. Mr. Harrison's past experience includes systems integration, engineering, construction, start-up and commissioning of all railroad and facility systems for the project. His current role is with SYSTRA's New York City headquarters, where with more than 36 years of experience, he manages complex engineering, design and construction projects.

"Bringing together systems to function like a system," is how Mr. Harrison described the definition of integration. He walked about how critical it was to understand that definition, in order to implement the correct system. He described the railroad industry as having one of the greatest potentials for modularization and system integration due to the repeated amount of

work over a linear path. The stresses the importance of checking the integration system and making sure the process is smooth. All the responsibilities and processes should be proactively accounted for at the start of the project with minimal changes during construction. He displayed various 3D models of Grand Central Station, where he showed the power of color coding and visualizing how various complex systems integrated. Mr. Harrison concluded his presentation with stressing that modularization is possible in the construction industry with great planning before hand and a systematic sequence.

Multi-trade Prefabrication

The second break out session in the integrated processes topic investigated criteria and drivers for effective multi-trade prefabrication and modularization. The discussions were primarily on considerations that should be taken when prefabricating multi-trade units. Building tolerance was discussed as being a prevailing issue that should be taken into account from the start of design. Once all the units are assembled, they are very difficult to coordinate and set into place.

Pre-fabrication was discussed as a positive, as long as there was a local fabricator which would reduce on the associated travel cost to the site. Building off site is not only safer and faster, but it is as industry members put it “an organized chaos.” This makes sense, since there is more space to coordinate logistics and more crews available to work on concentrated tasks. If space permits, on site fabrication should be a choice, since it cuts on transportation and coordination.

Starting a prefabricated job does not only require a lot of proactive thought, but it also requires money upfront. Since there are multiple trades involved, there should be a plan of action on who has custody of the units and up to what point. This simple task allows for insurance companies, lenders, and other institutions to understand the amount of risk each party is carrying.

SECTION E: FEEDBACK FROM INDUSTRY ROUNDTABLE

The final session of the 22nd Annual PACE Roundtable culminated with forming focus groups for discussing student research topics with industry members. The industry member I was fortunate enough to join was Jason Reece of Balfour Beatty. Balfour Beatty is a multinational infrastructure group with professional services and construction services to name a few. With the help of Jason's on field experience and expertise on the construction industry, he requested some ideal topics to further look into, based on the provided details of the scope of Block 12.

Key Feedback

Delivery of a project is always critical and a cost savings option, so Jason requested that I look into potentially speeding the schedule of delivery thru phasing Block 12. He suggested that there may be value in delivering one side of the floor earlier than the other. This is a tempting topic, but the value will be dependent on the compensation offered on the contract documents.

The second potential topic he suggested was analyzing the time and expense lost due to rework of clashes in the prefabricated trusses with the MEP shafts and mechanical work caused by not coordinating in a 3D model before installation. The effects of remodeling on the general conditions would be the primary focus. He provided me with a rough calculation to use, in order to calculate the actual costs of rework to the company. The equation was the base salary time a 2.1-2.3 multiplier factor, would yield the amount per hour it costs the company for a change order. Other topics Jason provided to other students, which I was also interested in potentially investigating to Block 12 include implementing a SIPS analysis and analysis incorporating light shelves for energy savings.

SECTION O: ATTACHMENTS

1. **Project Manager Interview: Jim Nelson** [FROM SECTION B]
2. **Project Engineer Questions: Steven Rogers** [FROM SECTION B]
3. **PACE Roundtable- Information Management for the Workforce** [FROM SECTION D]
4. **PACE Roundtable- Multi-trade Prefabrication** [FROM SECTION D]
5. **PACE Roundtable- Research Ideas Worksheet** [FROM SECTION D]
6. **PACE Roundtable- Industry Member Feedback and Resources Worksheet** [FROM SECTION E]

Project Manager Interview: Jim Nelson (The Whiting-Turner Contracting Company)

Question:	Response:
Schedule Acceleration Scenarios:	
Describe the critical path of the project schedule.	After the notice to proceed was acquired, we began excavating the perimeter. Then came the foundation and consequently the concrete parking lot was formed and poured. As the retail level was being roughed-in, the residential level was being framed in a clockwise pattern, with finishes, and inspections following close. The schedule has some flexibility due to unprecedented circumstances, which have definitely occurred in this project. The owner understands these events and has agreed to pay for some of the costs incurred in overtime work to maintain the job to schedule.
	Drywall is being installed and lies on the critical path. There are some issues with inspection. The project was scheduled to a lot time for one inspection, but Montgomery County requires 3 inspections per unit. These inspections include shafts for interior insulation and the other two are typical close-in inspections.
	No major delays have caused delays.
	Framing crew is limited, but a sequence was developed to maximize productivity.
What are the biggest risks to the project completion date?	Long lead items are always a concern for project completion along with major design changes.
	There were no major design lags.
	Site work coordination of all utilities connecting to the building (roads, pavements, ect.). RFI response time takes 60-200 days, which is typically only 14 days. Not requesting payment for delay, just working thru it.
What are key areas that have potential to accelerate the schedule if needed?	Adding a second crew or more to the cabinet interior millwork has the potential to accelerate the schedule along with working Saturdays and Sundays. Also, overlapping the schedule more may accelerate the schedule.
What would be the cost and technique?	Saving would include those implied in the general conditions.
Value Engineering Topics:	
Describe key areas of value engineering that were implemented on the project.	Honestly, no value engineering was implemented in this project.
How did these correlate/ detract from the goals of the owner?	The owner has built similar buildings locally, so the owner has preferred systems and equipment.
What ideas for value engineering were considered but not implemented?	No value engineering, but there was a LEED consultant for this project.
Notes:	
General notes from conversation.	Water closets were bought locally due to 1.6 gallon equipment.
	Building is LEED Certified.
	Incentive for 1 month early completion is \$25,000 per floor.

Session 1-B:

Information Management for the Workforce

Facilitator: Messner

Room 211

Questions

- What information does the workforce need, in hand?
- What techniques have you seen to efficiently deliver this information?
- Is "too much" information or technology causing inefficiencies?
- What are differences in information delivery in the shop vs in the field? (format, content, scale)
- How much design information is generated but never used?
- What opportunities or strategies exist to streamline the information production and delivery process?

Notes

- Focus on information standards
 - + let designers design
 - + more time on design & less on documentation
- Integration among different tools & software
- Mechanical contractors → to pre fabricate, have to redraw in Navisworks
 - + Adds cost to project & time.
- Added cost or redrawing (South Halls)
 - + DB project
- Scope of engineering work & impact on project.
- user interface for BIM implementation → links within regions to cross reference
- Reverse mentoring foreman & Project Engineers.
- Communicating model reliability (geometry & information)

Session ends at 10:30 am

- Incentives vs. duties of trades
- Building Integration & Building Automation & touchscreens
 - > \$10 → BIM
 - < \$10 → Depends on complexity
- BFI Tags
- Technology Deployment Plan.

Session 2-C:

Multi-trade Prefabrication

Facilitator: Messner / Sowers
219

Room

Questions

- What examples do you have or have you seen of multi-trade prefab or modularization?
- How did its use impact the project?
- How was it designed, delivered, and installed?
- What are the common criteria for systems and assemblies to prefabricate?
- What other concerns drive the decision to fabricate offsite, or pre-assemble on site?

Notes

- Building tolerances for pods
- local fabricator, less travel cost
- organized chaos
- who has custody of multi-trade components?
- prefabricating shafts w/ ducts & pipes
- CMA certification - code compliant
- cashflow in prefabrication
 - + lending institutes do not lend money up front
- 3 months to design & 6 months to prefabricate
- On site prefabrication

Session ends at 2:30 pm

Student Name Jose Fernandez

Session 1: Topic: Information Management for the Workforce

Research Ideas:

- 1) Managing model reliability (geometry & information)
- 2) Defining incentives vs. duties of trades

Session 2: Topic: Transporting Systems Integration of Rail Projects to Building Design & Construction

Research Ideas:

- 1) Integrating modularized systems in repetitive construction
- 2) Efficient use of managing responsibility

Session 3: Topic: Multi-trade Prefabrication

Research Ideas:

- 1) Establishing best practices for building tolerances for prefabricating systems or modularization.
- 2) Managing custody of multi-trade components.

The 22nd Annual PACE Roundtable

Industry Member: Jason Reece (Balfour Beatty)

Key Feedback:

Which research topic is most relevant to industry? What is the scope of the

1) Speed schedule delivery thru phasing (early delivery on one side)

2) Time & expense lost to redo work

+ effects on general conditions

+ re-modeling

+ use to calculate cost \rightarrow salary \cdot (2.1-2.3) = _____ \$/HR

others:

- SIPS
- light shelves \rightarrow energy savings
- geathermel
- tilt-up

Suggested Resources:

What industry contacts are needed? Is the information available?

- David Moser (Ailbena) VDC
- Jason Reece (Balfour Beatty) \rightarrow jreece@balfourbeattyus.com