Research Facility Core and Shell

2012

Final Proposal

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Executive Summary

The following proposal describes the four areas of analysis that will be pursued by this researcher for the spring semester AE Senior Thesis. The building under consideration is Research Facility Core and Shell (RFCS) which is a 127,000 square foot, $20 M, 4 story building with underground parking which houses both laboratory and office space. The four proposed areas that will be under investigation are: 1. Research into the Application of Prefabricated Wall Panels, 2. Utilization of SIPS for Exterior Façade, 3. Solar Panel Installation at Roof Level, and 4. Mobile Technology Integration-Tablets.

Analysis 1-A: Application of Prefabricated Wall Panels

The stick-built exterior façade was a critical path activity with a duration of 6 months. The proposed alternative to this approach is to erect prefabricated wall panels assembled at ground level on site. The proposed solution is intended to decrease the exterior façade duration and essentially decrease the overall schedule duration.

Analysis 1-B: Utilization of SIPS for Prefabricated, Panelized Exterior Façade

The erection of the prefabricated exterior wall panels at RFCS shows signs for excellent implementation of Short Interval Production Scheduling (SIPS) due to the highly repetitive nature of the activity and the already present need for early planning due to prefabrication. This analysis will provide a SIPS plan for the erection of the prefabricated exterior panels at RFCS. The intended purpose of analyzing the activity using SIPS is to decrease the duration and save overall project costs.

Analysis 2: Solar Panel Installation at Roof Level

Upon review by the USGBC, RFCS missed attaining LEED Gold Certification by only a few credits. The owner has tasked the team to find a way to achieve LEED Gold while refraining from "Point Chasing". This analysis proposes the installation of rooftop solar panels to meet both of the owner's goals. The analysis will document the construction impact, relationship ties, purchasing plan, and business model necessary to install these units. The rooftop solar panels are anticipated to gain the necessary points to attain LEED Gold certification while benefitting the sustainability of the building in the almost always sunny Southern California region.

Analysis 3: Mobile Technology Integration-Tablets

Mobile technology use in construction is becoming a top industry issue. More specifically, tablet use in the field is appearing at an escalating rate. The application of this technology is still new and remains questioned over its benefits and pitfalls. Through research into case studies documenting the use of tablets, this researcher plans to examine the benefits and pitfalls, and present them in a manner that owners can apply to their specific project. This document will be used to analyze the effectiveness of tablet use at RFCS and provide a detailed recommendation to the project team.

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Project Background

Figure 1: Exterior View of Research Facility Core and Shell

Research Facility Core and Shell (RFCS) was designed and built to serve the growth demands of the tenant, Faction, on their existing campus located in Southern California. Faction's main business involves research into new tools that can be used to study the human genome.

The building is four stories above grade with an underground parking garage. The gross square footage of the building is 130,000 SF and will operate as a mixed use facility comprised of both laboratory and office space. To find detailed descriptions of the systems used at RFCS please reference Appendix C- System Descriptions.

General Information

The construction of this project is planned to be completed in two phases under two contracts: a core and shell portion and a tenant improvement portion to follow. The General Contractor for the project is DPR construction contracted under a GMP and delivered as a design-bid-build. The area of study for this thesis proposal is the core and shell portion of the project which includes the structural system, the building enclosure, heavy mechanical and electrical equipment, and site work. Under current plans Research Facility Core and Shell is estimated to cost $20 M and take 18 months to complete from design through substantial completion. The breakdown of the main costs and schedule durations can be found in *Table 1: Major Project Costs* and *Table 2: Major Schedule Durations*.

Table 1: Major Project Costs

Major Costs for Research Facility Core and Shell		
	Construction Cost	**Cost/SF**
Actual Building Construction	$16,031,402	$125.86
Total Project	$20,035,000	$157.29
Mechanical System	$1,574,261	$12.36
Electrical System	$1,014,666	$7.97
Plumbing System	$662,250	$5.20
Fire Protection	$298,462	$2.34
Structural System	$5,238,945	$41.13
Exterior Skin	$4,089,261	$32.10

Table 2: Major Schedule Durations

Schedule Overview	
Phase	**Timeframe**
Notice to Proceed	January 24, 2011
Design/Preconstruction	January 24, 2011 – June 26, 2011
Substructure	June 27, 2011 – September 30, 2011
Superstructure	October 12, 2011 – November 30, 2011
Exterior Envelope	December 15, 2011 – June 29, 2012
Core MEP Rough-in	March 20th 2012 – April 30, 2012
Core Interior Finishes	May 1, 2012 – June 21, 2012
Commissioning	March 20, 2012 – August 27, 2012
Substantial Completion	August 28, 2012

Planned Facility Use at RFCS

As previously noted, Research Facility Core and Shell was designed and built to serve the research and office growth demands of the client, Faction. *Table 3: Building Use Description* gives a breakdown of the planned use for each floor at RFCS. The garage will house the main electrical and elevator machine rooms as well as parking while floors 1-4 will serve the main office and laboratory needs. The roof will house the large mechanical equipment necessary to serve the HVAC needs of the building.

Table 3: Building Use Description

Level	Size	Use
Underground Parking Garage	31,197 SF	Parking, UPS Room, Electrical Room, Elevator Machine Rooms
First Floor	31,850 SF	Lobby, Laboratory Space
Second Floor	31,850 SF	Offices, Laboratory Rooms
Third Floor	31,850 SF	Offices, Laboratory Rooms
Fourth Floor	31,850 SF	Offices
Roof	31,850 SF	Large Mechanical Equipment

Project Considerations

The construction of RFCS has been successful thus far and the team has delivered on all facets of the project promised to the owner. While many of these decisions proved to be successful, some areas of design and construction caused difficulties and show areas that could increase the value to the owner. Of initial concern is the 6 month critical path duration of the exterior façade. The exterior façade proved to be a challenging area for the team as it caused congestion on the site and drove the critical path for a 3rd of the entire project duration. Another consideration to be made is the alternating facades that exist at RFCS. Throughout the entire exterior the curtain wall and masonry veneer facades alternate which caused the team various difficulties with connection points.

Besides the architectural difficulties described above, the LEED Certification of RFCS missed LEED Gold Certification by a few credits. The owner has expressed interest in achieving LEED Gold and the team is working to develop a solution that will not simply entail "Point Chasing". Discussions have led towards the consideration of installing rooftop solar panels to achieve LEED credits as well as serve the building in an appropriately sustainable manner to the Southern California Region.

Analysis 1-A: Application of Prefabricated Wall Panels

Problem Identification

A primary concern for the exterior enclosure at RFCS was the stick-built metal stud wall with sheathing and masonry veneer that accounted for the majority of the enclosure. This portion of the exterior enclosure drove the schedule as a critical path item for 6 months of the 18 month total schedule and created the majority of congestion on the site. With scaffolding erected on entire sides of the building at a time and crews and materials creating confusion on the ground, the on-site stick-built nature of the design proved to be expensive and time consuming for the team at RFCS.

Adding to the on-site troubles was the reliance the exterior enclosure had on the steel structure. Work on the exterior enclosure could not begin until the steel contractor had finished erecting "Sequence 1" which consisted of levels 1 and 2 steel framing. This meant that if the exterior skin contractor was ready to begin work at an earlier stage, they could not, adding time to the final schedule.

Proposed Solution

The proposed alternative to this approach will be to implement a prefabricated wall panel system for the exterior enclosure of RFCS. The process would involve prefabricating the wall as panels, at a controlled location on site at ground level, and raising the panels into place with a crane.

Solution Method/ Background Research

Prefabricated wall panels are becoming more and more prevalent as prefabrication efforts are increasingly standardized; the design and installation of prefabricated panels are better understood; and the safety, quality, and logistical benefits are further brought to light. Suiting prefabrication to the correct situation is essential to success. According to a member of Forester Construction who spoke during a discussion at the Penn State University- PACE Roundtable; prefabrication is best suited for projects that do not have many variations in the design. The enclosure at RFCS appears to be fitting for such efforts in principle.

According to an interview with a Project Manager at DPR Construction, many ways of prefabrication would be possible for this building. The Project Manager prescribed that the best way to prefabricate these wall panels would be to panelize the walls in tall thin sections and then infill between them with smaller panels. His knowledge will be valuable to this analysis topic.

Another source for study is present at UHS Temecula Valley Hospital located in Temecula Valley, CA. On this job DPR Construction and DPR Drywall were able to work together to prefabricate the exterior panels on site and install them using a crane in a matter of days. This case study will be valuable to this analysis as the job is located in a similar area and will provide the design requirements necessary for loads such as seismic. Raw data is also available and was tracked throughout the entire process which offers valuable comparison information.

Methodology

(1) Consult Project Manager of DPR Construction and determine most appropriate way of paneling the building.
(2) Document actual construction values and rates at RFCS using the stick-built method of construction.
(3) Design 4 alternative approaches to prefabricate panels for exterior enclosure.
(4) Locate area on site appropriate for prefabrication and staging.
(5) Investigate off-site prefabrication and staging.
(6) Determine sequencing of panel erection.
(7) Attain values and rates of prefabricated wall panel erection from case study at UHS Temecula Valley Hospital located in Temecula Valley, CA.
(8) Run comparisons on cost, schedule, quality, and safety between proposed prefabricated wall panels and original stick-built system.
(9) Propose the most appropriate solution.

Expected Outcome

This alternative should decrease the overall schedule duration at RFCS. The alternative allows the exterior skin contractor to begin work at an earlier date assembling the panels on the ground in anticipation of the structural steel contractor completing "Sequence 1". Once the structure is erected the panels can be placed and tied in at a faster pace than the original stick-built plan was built. By mobilizing the exterior skin contractor at an earlier date, final completion of the skin should move ahead of schedule thus shortening the overall schedule since the exterior skin is on the critical path.

The proposed alternative should also decrease scaffolding and material needs directly near building construction and in turn decrease the congestion at the building. This would benefit quality and safety concerns as the crews would be working in a less stressful environment with more room to work.

Analysis 1-B: Utilization of SIPS for Prefabricated, Panelized Exterior Facade

Problem Identification

The installation of the exterior façade at RFCS spanned nearly 6 months. This is a matter of concern as RFCS is only four stories and has a footprint of about 32,000 SF. With researchers beginning to overcrowd the other buildings on campus and waiting to move into the new spaces, schedule savings could prove to be a significant benefit created and planned by the GC.

Analysis 1-A in this report looks into prefabricating the exterior into panels on site and then hoisting them into place. This will essentially turn the exterior wall installation into a repetitive task, raising one panel after the other. To be able to see success in using an approach like this, early planning is essential. All of these factors seem to culminate into a problem that can see significant benefit by finding an approach that is successful for buildings that can afford the time for early planning and which highlight a repetitive task.

Proposed Solution

The proposed approach to decreasing the schedule duration for the exterior façade is utilizing the Short Interval Production Scheduling (SIPS) method. The SIPS method will contribute to the early planning necessary to see success in raising the prefabricated panels by breaking down the repetitive task into steps that can be studied and worked through by the project team, design team, and the crews on site.

Solution Method/ Background Research

SIPS is an interesting scheduling technique in which schedule drives the activity duration rather than the activity driving schedule. The main topic of study regarding SIPS that we have studied thus far at Penn State concerned the MGM Grand Hotel in Las Vegas, Nevada. This case study should prove to be an important resource for how to correctly use SIPS. Though RFCS is not nearly as big as this building, it is an ample starting point for understanding the process and the keys necessary for success.

More resources that have given rise to this analysis include conversations with a Project Manager and Assistant Superintendent at DPR Construction. The Project Manager holds many years of experience with planning the installation of prefabricated panels and the Assistant Superintendent has spent the past few months implementing SIPS on a hospital project in Southern California which used prefabricated wall panels. Both parties voiced concerns over the size of this building but still stated that the repetitive nature and high need for planning could contribute to a successful implementation of SIPS at RFCS.

Methodology

(1) Interview Professor Dubler regarding the necessary steps required to use MGM Grand as a case study which will give appropriate comparisons.

(2) Develop the list of required documents and outputs which will provide the necessary information to implement SIPS at RFCS.
(3) Interview the project team at RFCS to determine the level of involvement foreman have in planning.
(4) Interview Project Manager at DPR regarding the planning necessary for the installation of prefabricated wall panels and how it will overlap with a SIPS approach.
(5) Integrate the interview with the Project Manager at DPR with an interview of the Assistant Superintendent at DPR to properly apply SIPS to prefabricated wall panels.
(6) Analyze which parties must be involved in the planning process.
(7) Perform SIPS analysis on the erection and installation of the prefabricated panels.
(8) Create 3-D Model of one interval of the SIPS for ease in potential coordination meetings.
(9) Assemble research and SIPS analysis
(10) Report whether SIPS is appropriate at RFCS

Expected Outcome

The expected outcome of this analysis is to show that through proper planning with SIPS, the GC can significantly reduce the schedule duration of the exterior façade which is a critical path item on the overall schedule. Analysis 1-B is expected to contribute to Analysis 1-A by combining the repetitive prefabricated panel erection with the techniques consistent with SIPS.

Documents that will afford this outcome include providing insights from the project team and specific interviews, providing models of the SIPS sequence, detailing the significant parties to be involved, and producing the actual SIPS sequence with crew loading and time frames.

Analysis 2: Solar Panel Installation at Roof Level

Problem Identification

Recent calculations on LEED credits have left the team at RFCS quite happy with their performance but have also given rise to a question of how they can do better. The owner's original request was for RFCS to receive LEED Silver Certification. As time progressed, the team found out that the building met LEED Silver by a large margin and was actually only a few credits short of achieving LEED Gold. They met with the owner to inform them of the results and were surprised when the owner told them to find a way to get the building to LEED Gold standards.

This left the team with an important question; how do we gain the necessary credits for LEED Gold without simply point chasing? They did not want to add bike racks or items of this nature which would gain credits but would ignore the actual desires of the owner to improve sustainability. Currently the project team is looking into the appropriate solution to this problem and has voiced strong opinions that rooftop solar panels could be the best choice.

Proposed Solution

The proposed solution to this problem is the installation of rooftop photovoltaic panels at RFCS. The installation of rooftop solar panels would provide the necessary credits for RFCS to achieve LEED Gold while maintaining the interests of the owner and chasing sustainability, not points. The almost always sunny environment of Southern California provides a great opportunity for harvesting the sun's energy.

Solution Method/ Background Research

To gain a better understanding of the impacts that rooftop solar panels would have at RFCS, I contacted members of the team on site, specifically the Project Manager. The Project Manager informed me of the requests of the owner and said that the team is currently looking into using solar panels as their solution too. They are in the planning and design phase but have already been given the initial "ok" by the design teams as far as feasibility. The Project Manager will be a valuable resource to interview regarding the impacts the solar panels will have on construction, relationships between the trades, purchasing, and the business model that should be used.

Other resources that will complement the interviews with the Project Manager at RFCS, and the project specific relationships, include research into solar panel cost and lifecycle modeling as well as case studies with nearby buildings. The project team expressed that there are a few buildings nearby that are using solar panels which will provide essential comparison values.

Methodology

(1) Interview Project Manager on bi-weekly basis during spring semester to report on project specific gains and losses due to owner's desire for solar panels.

(2) Conduct project specific research regarding the contract ties, relationships, benefactors of the installation, constraints, and supports for the solar panels.
(3) Reach out to owners of nearby buildings as a means of case study comparisons.
(4) Calculate lifecycle costs and energy use.
(5) Document construction issues such as schedule impacts, purchasing requirements, and sequencing.
(6) Determine type, proper placement and amount of solar panels to install.
(7) Model roof with and without panels.
(8) Complete electrical analysis to determine installation requirements.
(9) Determine and present whether rooftop solar panels are appropriate for RFCS.

Expected Outcome

The expected outcome of this analysis will be a comprehensive report detailing the project specific benefits and constraints related to installing rooftop solar panels at RFCS. The report is expected to evaluate all of the steps described above in the “Methodology” portion of this section and give a final recommendation to the owner regarding whether rooftop solar panels are appropriate for RFCS.

Analysis 3: Mobile Technology Integration- Tablets

Problem Identification

While the interest in using mobile technology in construction is increasing, many owners are not yet convinced by its benefits, leaving available and efficient technology in the background. This has contributed to engineers and crews utilizing archaic approaches to on-site problem solving and documentation. Communicating field issues, documenting RFI's, searching for the necessary drawing, and completing punch lists are a few of the main contributors to what makes up a project engineer's day. By underutilizing the technology available to on-site engineers, these tasks are inefficient, taking more time and creating more confusion than necessary when compared to the new programs and processes available. The comparative increase in engineer's time by ignoring the mobile technology available contributes to higher General Condition's costs based on the need for either more engineers or overtime requirements.

Proposed Solution

The proposed solution to this problem is to present information regarding the benefits, costs, applications, and required scenarios for success associated with mobile technology integration; more specifically, the use of tablet computers. Such solution would accrue information for use by industry professionals, in particular the team at RFCS, for decision making in regards to the implementation of tablets on their jobsite.

Solution Method/ Background Research

Mobile technology integration is a trending issue within the construction industry in recent years. Many companies and owners are racing towards a solution that will save their respective companies money and lower their bottom line. At the forefront of this search is a team at DPR Construction known as the Innovation Department. This researcher had the opportunity to work for the Innovation Department at DPR Construction over summer 2012 and was able to see mobile tablet integration first hand.

The Innovation Department consulted with project teams at DPR and distributed numerous tablets in hopes of determining what technology, interfaces, and applications are suited to construction. The Innovation Department then tracked rates and project team comments regarding the benefits and concerns of such technologies which should prove to be essential to this analysis topic.

Another source for information regarding mobile tablet integration will be consultations and reports generated by companies associated with their experiences thus far. Once such source will be a webinar presented on June 6th, 2012 by ENR titled "Field Guide to Mobile Apps in Construction". During this webinar industry professionals present raw data regarding the use of mobile technology during the construction and renovation at DFW Airport in Dallas, TX. These values will help to create a better sampling for data as opposed to using simply one company's reports.

Methodology

(1) Gather and Report information from case studies obtained from Innovation Team at DPR Construction on mobile technology.
(2) Study and document mobile tablet integration at DFW Airport in Dallas, TX.
(3) Research articles, essays, and journals referencing mobile technology to obtain facts and figures from sources such as ASCE Database and ENR.
(4) Find appropriate case studies that did not use tablets for comparison.
(5) Apply rates, values, benefits, and pitfalls to the situation at RFCS.
(6) Present information a template business case that industry professionals can use to determine whether tablet use is appropriate for their project.
(7) Determine whether utilizing mobile tablets is appropriate for RFCS.

Expected Outcome

The expected outcome of this solution will be a document compiling case studies and research regarding mobile technology integration. The document will focus mainly on the integration of tablets at the jobsite. This information should allow owners to make an educated decision on whether mobile technology would be the correct choice for their project. By studying and gaining a better understanding of the uses and pitfalls of tablets, as well as the project based variables that exist; this proposed solution could break ground on an area that interests many in the industry but remains controversial.

Along with documenting the outcomes of integrating mobile technology, the final outcome will also help guide this researcher towards determining to what affect mobile technology integration is appropriate for RFCS. A final proposal to the team will complement the research documentation giving a project specific analysis.

Conclusions

Analysis Weight Matrix

Table 4: Analysis Weight Matrix describes and details the expected level of time that will be spent in the spring semester performing each analysis. To give a further breakdown, the time spent on the four core areas of construction investigation are defined for each analysis topic.

Table 4: Analysis Weight Matrix

Analysis Description	Critical Issue Research	Value Engineering	Constructability Review	Schedule Acceleration	Total
Application of Prefabricated Wall Panels	**-**	**10%**	**10%**	**10%**	**30%**
Utilization of SIPS for Exterior Façade	**-**	**5%**	**10%**	**15%**	**30%**
Solar Panel Installation at Roof Level	**-**	**5%**	**15%**	**-**	**20%**
Mobile Technology Integration	**15%**	**5%**	**-**	**-**	**20%**
Total	**15%**	**25%**	**35%**	**25%**	**100%**

Preliminary Schedule

The preliminary schedule notes important milestones as well as a detailed breakdown of the timeframes that activities must be performed to ensure that the final thesis is submitted complete and on-time. The Preliminary Spring Semester Timetable is located in Appendix B shows this breakdown.

Overall Conclusion

The four areas of analysis detailed in this report are intended to provide a comprehensive final thesis submission which offers valuable solutions to the project team at RFCS. First, the application of prefabricated wall panels is intended to reduce the schedule while maintaining the quality seen with stick-built construction. Complimenting this analysis, utilizing SIPS for the prefabricated wall panels is intended to decrease the schedule duration of the exterior façade. Third, rooftop solar panels are anticipated to meet the LEED Gold credit requirement while providing a beneficial sustainable solution. Lastly, the exploration into mobile technology could prove to benefit owners and more specifically, the project team at RFCS. All of these analysis topics will culminate into a final thesis presentation that encompasses the majority of the systems at RFCS.

Appendix A- Breadth Topics

Demonstration Breadth Topics

Structural Breadth

Contributes to Analysis 1: Application of Prefabricated Wall Panels

The proposed solution to the stick-built exterior enclosure at RFCS is prefabricated wall panels built on site and erected panel by panel. Installing such panels causes considerable changes in the load calculations and connections necessary for structural support. Investigation into the required systems to support these prefabricated panels will be essential to the feasibility study of installation at RFCS. By researching, performing calculations, designing, and speaking with industry professionals and faculty; this proposal will delve into the structural requirements necessary to accomplish a prefabricated exterior enclosure.

Electrical Breadth

Contributes to Analysis 3: Solar Panel Installation at Roof Level

To solve the owners request for LEED Gold Certification while avoiding "Point Chasing", rooftop solar panel installation will be investigated in Analysis 3. Installing these panels will impact the electrical system in regards to the way it is properly connected and the impact it has on the energy production requirements of the main power sources. This breadth will delve into the specific electrical requirements of installing solar panels. It will also consider the accompanying power systems and the impact solar panels would have on them.

Appendix B- Preliminary Spring Semester Timetable

		1/28/13 Milestone 1			2/11/13 Milestone 2		3/1/13 Milestone 3				3/25/13 Milestone 4	Timothy Maffett Dr. Messner Construction Management			

Proposed Schedule for Spring Thesis (Project: Research Facility Core and Shell)

January 2013-April 2013

Jan-7-13	Jan-14-13	Jan-21-13	Jan-28-13	Feb-4-13	Feb-11-13	Feb-18-13	Feb-25-13	Mar-(3-9)-13	Mar-11-13	Mar-18-13	Mar-25-13	Apr-3-13	Apr-8-13	Apr-16-13	Apr-24-13
								Spring Break				Final Report April 3rd	Faculty Jury Presentation April 8-12		Senior Banquet April 26th
Gather Comparison Information on Stick-Built Approach															
		Design Prefabricated Panels and Panelling Scheme													
			Analyze Cost/ Schedule of Panels												
				Run Comparison Checks											
			Interviews and Research												
					Construct SIPS Plan										
						Model SIPS Plan									
			Interview Prj. Team/ Research RFCS												
						Case Study Documentation									
							Calculate Lifecycle Costs								
								Detail Placement/ Amount of Panels							
									Electrical Breadth						
		Gather Information from DPR Innovation													
								Perform Case Study Analysis							
										Produce Final Comparison					
												Finalize Report			
													Jury Presentations		
														Update CPEP and Report	

Milestone		
1	Info from DPR for Mobile Tech/ Design Prefab Panels	Depth 1-A: Application of Prefabricated Wall Panels
2	Finalize Prefab Plan and Detail Background on SIPS	Depth 1-B: Utilization of SIPS for Exterior Façade
3	Complete D 1-A/1-B and Begin Life-cycle Costs	Depth 2: Solar Panel Installation at Roof Level
4	Complete D #2 and Majority of D #3	Depth 3: Mobile Technology Integration- Tablets
		Submission

Appendix C- System Descriptions

Systems Descriptions

Structural System

The structural system used for RFCS consists of structural steel resting on 42 spread footings sized mainly at 11'x11' supporting the structure with a CMU wall running the perimeter of the basement bearing the load from the soil. The design is straight forward following a redundant bay scheme. Composite metal deck rests on the steel beams topped with 3 ½" normal-weight concrete. *Figure 2: Typical Structural Bay Scheme* shows the typical layout of the structural steel beams.

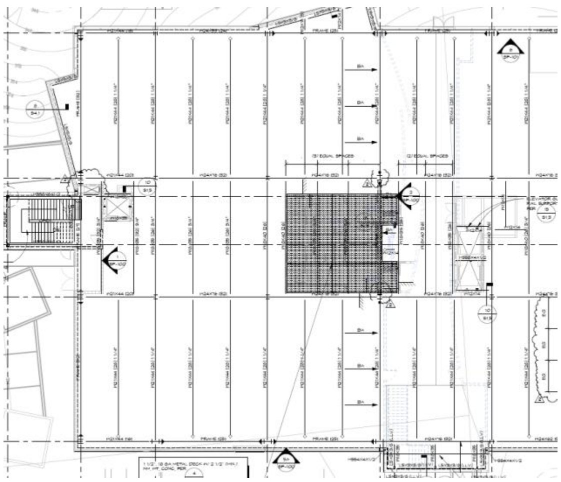

Figure 2: Typical Structural Bay Scheme

Mechanical System

The core portion of the HVAC system is comprised of 4 rooftop air handling units utilizing central chilled water via a main plant on the Faction campus and will service hot water via two 4-ton rooftop boilers. A smaller mechanical/utility room is located at the garage level but most of the service will occur at the rooftop level. A large vertical chase runs from the rooftop to the garage allowing for an organized flow of ductwork and piping. This chase is located at the center of the building next to the restrooms.

Electrical System

Three transformers (3000KVA, (2) 1500KVA) are planned to serve the electrical needs of the building. The power travels from the transformers to a 4000 A switchgear and a 2500 A switchgear that are located in the main electrical room at the garage level.

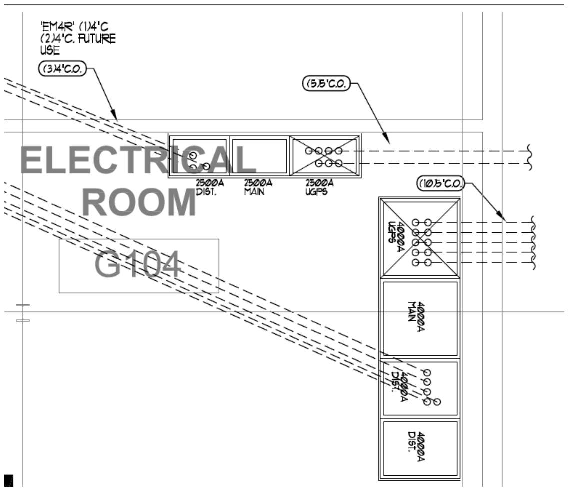

Figure 3: Main Electrical Room

Enclosure

The enclosure at RFCS consists of both a stick built masonry façade as well as a curtain wall system. The masonry facades consisted of a metal stud wall assembly with sheathing and waterproofing and a masonry veneer finish. The windows of this portion were punch windows that were prefabricated offsite and raised into place. The curtain wall consisted of steel mullions that supported windows that were mainly 4'x8' and were composed of clear blue "vision" glass. The curtain walls were built on the ground in larger sections and raised as panels. Once raised, they were tied into the structure at connection points on each floor.

Appendix D- References

References

Dubler, C. (2012). The Pennsylvania State University, AE Department. (T. Maffett, Interviewer)

"Field Guide to Mobile Apps in Construction." Review. Audio blog post. *ENR*. Mcgraw-Hill Construction, 6 June 2012. Web. 6 June 2012.

Helland, S. (2012, December 5). DPR Construction. (T. Maffett, Interviewer)

O'Dwyer, C. (2012, December 6). DPR Construction. (T. Maffett, Interviewer)

Pyka, I. (2012, November 27th). DPR Construction. (T. Maffett, Interviewer)