GOVERNMENT OFFICE CENTER
MID-ATLANTIC U.S.

TECHNICAL ASSIGNMENT 3

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Construction Management
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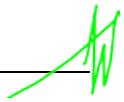

EXECUTIVE SUMMARY

This report is designed to identify areas of the Government Office Center renovation and modernization project that are strong candidates for research. After discussions at the PACE Roundtable and interviews with project team members, several key constructability challenges, schedule acceleration scenarios, value engineering topics, and critical industry issues were analyzed in relation to the Government Office Center project. As a result, four major areas were pinpointed for initial development of future research plans.

Constructability challenges for this project include the curtain wall, the requirements for continuous occupancy, and the site logistics constraints. Since the removal of the existing curtain wall would leave the interior spaces of the building exposed to the weather, the project team evaluated existing conditions and created a virtual mock-up of the planned temporary weather wall that would be used. Similarly, analysis of the existing conditions allowed for the development of an optimized tenant relocation plan and a site logistics plan that facilitates productivity while protecting building occupants with covered walkways and tenant emergency egress routes.

Schedule acceleration scenarios are largely centered on the curtain wall activities. Due to the repetitive nature of this scope of work, the activities that relate to the demolition and replacement of the curtain wall systems are conducive to a SIPS production model. Also, due to tenant complaints of noise and interruption of their work, some construction activities may be switched to a night shift, decreasing site congestion and potentially doubling daily production on the project.

Value engineering topics were limited for the purposes of this report. Alternates that were included in the project specifications, such as rain water collection, were not pursued for construction in almost every case. Because marginal added value to the curtain wall would be magnified extensively, the curtain wall was examined in great detail by the project team.

At the PACE Roundtable, the Process Innovation break-out sessions discussed some of the barriers to implementing integrated teams on a project, as well as the need for early involvement of specialty contractors for high performance retrofit projects. The insight of industry professionals into the importance of how people interact was a valuable lesson that seems to be often forgotten in the construction industry.

After analyzing these issues and discussing them with industry professionals and project team members, four major technical analysis options were identified. First, researching the implementation of BIM for use in the field and for facilities management purposes has value for both owners and construction management teams. Replacing the South curtain wall with a transparent photovoltaic system could financially benefit the owner of the Government Office Center. Identification of process and integration failures can keep collaborative teams on a pathway to successful project delivery. Finally, although the addition of a progressive collapse prevention system would increase cost and project duration, it would add an arguably immeasurable amount of value to the project by improving life safety for the building occupants.

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CONSTRUCTABILITY CHALLENGES

Curtain Wall

Perhaps the most substantial portion of the Government Office Center renovation project is the removal and replacement of the North and South façades of the building. Once the existing system has been removed, the interior spaces of the building would have no protection from the weather. In order to resolve this issue, a completely functional temporary weather barrier must be built inside the façade prior to the demolition of the existing system. This temporary wall will deliver additional benefits to the project, such as isolating construction activities from tenant activities, blocking dust and other debris from finding its way into the occupied spaces, and offering safety features to the construction workers.

To overcome this challenge, the project team worked from a strategy that required a complete understanding of the conditions around the interior perimeter of the building in order to properly design and implement a weather wall that is tight and secure. The project team created a virtual mock-up to demonstrate the step-by-step construction of this temporary weather wall. As shown in the images below, great effort has been taken to ensure that the temporary weather wall is structurally sound to resist loads caused by wind and construction activities, is insulated to maintain thermal comfort in conditioned spaces, and is sealed to prevent air and moisture from leaking through.

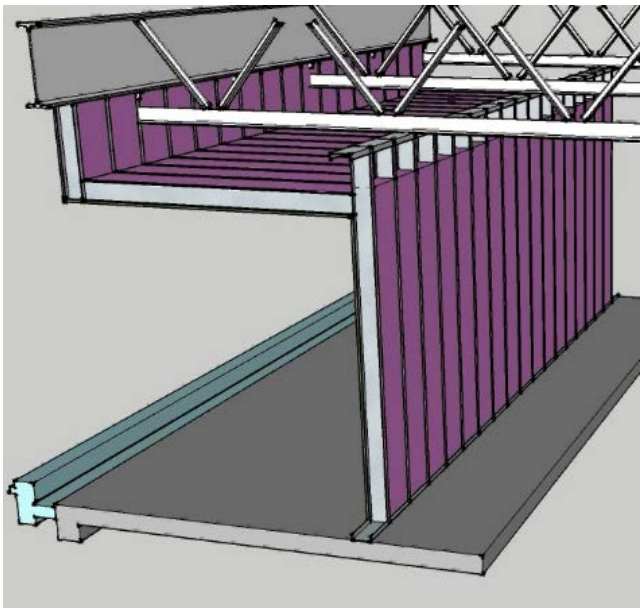


Figure 1: View of Temporary Weather Wall Under Construction

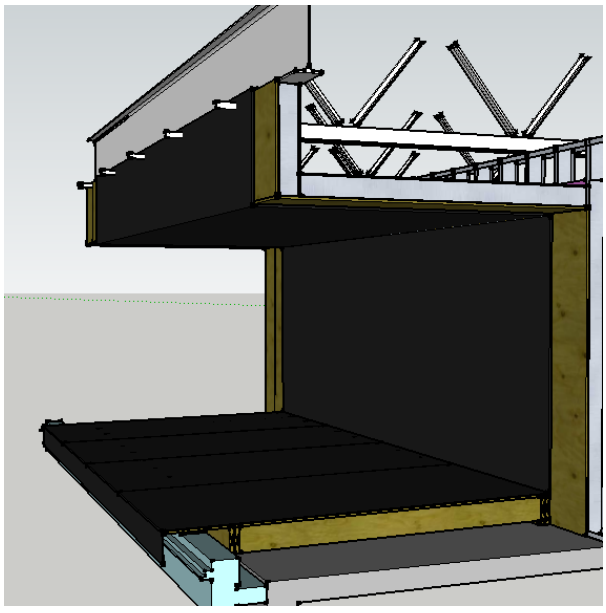
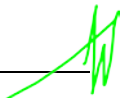


Figure 2: Virtual Mockup of Completed TWW Segment

A major factor of this constructability challenge that is currently affecting the project team is a constant wind at the North face of the building, which often produces powerful gusts. The wind is strong enough to affect work activities during the demolition of the existing curtain wall and the installation of its replacement on the North façade. Pre-fabricated panels for the new curtain wall will be hoisted from the ground into place, but excessive winds will force installation efforts to stop due to safety concerns and the risk of damage to the panels.



The project team for the Government Office Center renovation project is currently developing a strategy to handle this challenge. Potential solutions for this issue involve modifying how or when panels are delivered to their respective floors. For example, rather than hoist the panels from the ground directly into place, panels could be brought up to their intended floors by using the material hoist on site. Another similar option involves staging panels on their respective floors during periods of calmer winds.

Due to the strong winds affecting the North façade of the building, the temporary weather wall must be built to a high level of quality in order to ensure occupant comfort is maintained. Leaks in the weather wall will result in drafts when subjected to these windy conditions, creating the need for these walls to be checked thoroughly for quality and performance standards until replacement panels are installed.

The most fundamental solution to this challenge is to complete the installation of one floor of the curtain wall system as quickly as possible once the existing curtain wall system has been demolished on that floor. Unfortunately, the winds also present a challenge to the installation process, as discussed above. As a result, this seemingly obvious solution to the weather wall performance concerns may not be the most practical solution available.

Continuous Occupancy

Because the building must remain occupied throughout the construction process, the project team must ensure that demolition and construction activities do not impact the occupants of the Government Office Center. The safety of the tenants and the public throughout the construction process is of highest importance. Unfortunately, most construction activities for this project cannot be performed in occupied spaces, resulting in the need for some tenants to be relocated within the building while construction activities are taking place.

Therefore, a comprehensive study was performed to analyze tenant relocation requirements in order to minimize disruption to the building occupants while allowing for the efficient flow of construction efforts around them. For the purposes of evaluating and communicating this tenant relocation plan, the project team developed a 4D model that clearly illustrates how specific zones of the Government Office Center will be affected by the construction process.

However, even though significant planning went into preventing disturbances to the tenants, there have been complaints about noise from the demolition and construction activities, as well as interruptions to the day-to-day activities of the building occupants. In order to please the tenants, the project team will most likely begin performing work on occupied floors during night shifts.

Also, in order to complete the construction activities required for the renovation of the interior spaces of the Government Office Center while maintaining the building as a workspace for the tenants, a substantial number of file cabinets must be temporarily relocated to the 9^{th}-12^{th} floors. However, these floors were not originally designed to support the loads that the relocated file

cabinets will add. As a result, the project team must reinforce the existing trusses with steel plates to achieve the required safety factor.

Site Logistics

Site constraints at the Government Office Center heavily dictate the means and methods that can be used in the construction process. The project team faces the challenge of ensuring that the site and the environment surrounding the building must promote the productivity of the work associated with the renovation without compromising public and building occupant safety. Space on site is limited as well, due to the fact that a minimum level of available parking is required on site for tenant use. As a result, the project team must work within tight site conditions to locate trailers, temporary air handlers, and material laydown and storage areas needed to maintain appropriate production levels.

In preparation for this challenge, the project team engaged in an extremely thorough evaluation of the site to document existing conditions. Based on the findings of this evaluation process, the team created a plan for working productively on site while maintaining public and building occupant safety. The project management team then met with the designers and owner to review this plan, which included 3D models to allow for easy visualization and communication of the key aspects of the plan, such as tenant emergency egress and covered walkways that passed through construction zones.

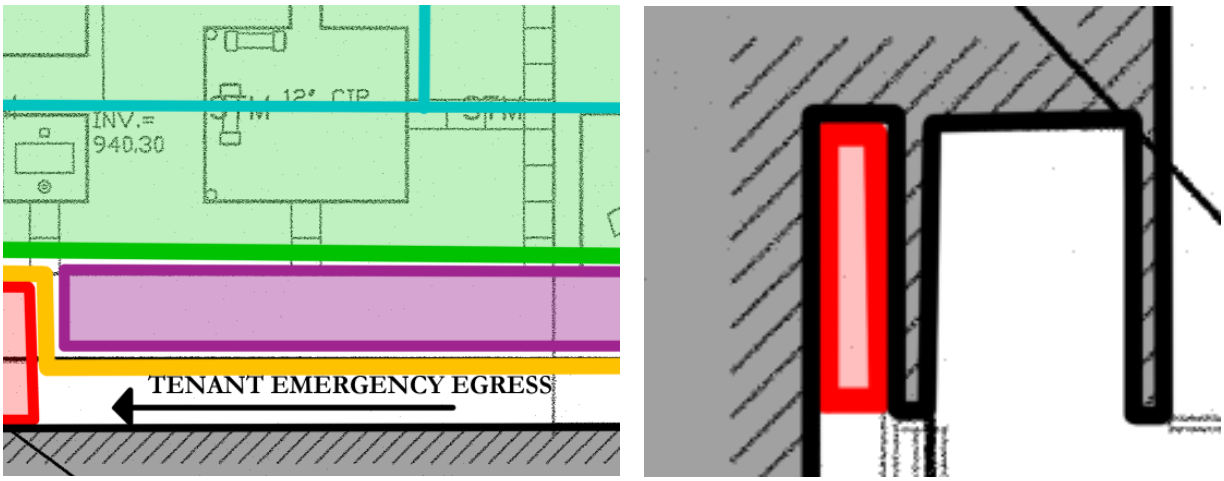
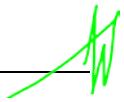


Figure 3: Cropped Views of the Site Logistics Plan Showing Tenant Emergency Egress and Covered Walkways



SCHEDULE ACCELERATION SCENARIOS

The critical path of the project schedule is primarily focused around the curtain wall activities. Demolition and installation activities for the North and South curtain wall areas all fall into the critical path of the project schedule, with significant overlaps between the demolition and construction work in an effort to minimize the overall duration of the project. Prior to the demolition of the existing curtain wall systems, installation of temporary dust partitions and weather walls also lie on the critical path. Other critical path activities include erection of the material hoist and trash chute, the relocation of the filing cabinets, and renovation of the mechanical room on Level 14.

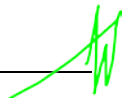
The biggest risks to the project completion date are the successful and timely demolition of the existing curtain wall systems and the installation of the replacement systems. If there are unforeseen delays, or if the assumptions made when determining the timeline for this systematic construction process were flawed, these activities would require more time to complete, directly impacting the substantial completion date of the Government Office Center renovation project.

A key to minimizing the risk of schedule overruns due to the curtain wall construction activities is to establish an in-depth understanding of the process prior to beginning the work. Since the new curtain wall consists of highly repetitive unitized panels, this thorough understanding of the construction process helps the construction crews to establish a routine that allows for quick installation of the curtain wall system.

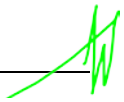
Another substantial risk to the project completion date is the renovation of the mechanical systems within the Government Office Center, due to potential productivity losses that arise from working in an existing building as opposed to new construction. This risk can be minimized by involving the mechanical contractor in the planning process and allowing them to begin work as early in the project schedule as possible.

Because the project team will likely be using the night shift to perform construction activities on occupied floors, the team has the ability to accelerate the schedule by having crews work the typical day shift while other crews work at night. This strategy can effectively allow for two days of work to be accomplished throughout most of the building in a single workday. While there is most likely an added cost associated with running crews during night shifts, the magnitude of this cost is currently undefined.

Other means to accelerate the schedule include the implementation of production management processes such as Short Interval Production Scheduling (SIPS). For activities that are consistent and repeatable, such as the demolition and replacement of the curtain wall systems, SIPS can be employed to provide a detailed plan for incremental progress. In this case, a SIPS program could be implemented such that the temporary weather wall for one floor would be completed, followed by the demolition of the exiting curtain wall on the same floor, followed by the installation of the new curtain wall on that floor, and then followed by other activities such as demolition of the temporary weather wall and completion of finishes. Each activity would be planned such that a consistent time period, such as a day or a week, would define all intervals in the process.



However, since the construction activities have only recently begun, implementing techniques like these are more strategic planning than they are schedule acceleration. As a result, there is no added cost associated with them, although they may differ from other methods in terms of cost. Using more or larger crews, more hours, more work shifts, and other similar schedule acceleration techniques would add direct labor costs as well as potential overtime costs and surcharges from subcontractors who are required to work outside of their planned schedule.

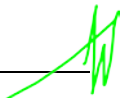


VALUE ENGINEERING TOPICS

Due to the nature of the Government Office Center renovation project, significant design and planning efforts drove the project in its early stages. Because this project is a modernization of an existing building, the design team was able to use data collected from the original mechanical and enclosure systems in order to properly design the replacement systems. While value engineering was most likely employed in this phase, the details are unknown at the time of this report.

The specifications for this project call for nine alternates that had potential to be included in the scope of the construction work. However, most of these alternates were not pursued in the construction phase due to value engineering efforts that indicated low value to cost ratios. For example, rain water collection could have earned additional LEED points for the project, but the cost of including this system outweighed both the true sustainability purpose of the rain water collection system and its contribution toward the LEED accreditation goal of the project. The value engineering that eliminated this alternate reduced the potential cost of the Government Office Center renovation project while detracting slightly from the LEED goals of the owner.

Because of the substantial and repetitive nature of the curtain wall system, the project team spent considerable time and effort evaluating the construction process in order to eliminate wasteful steps. In this case, value engineering was applied to nearly all aspects of the unitized curtain wall system, since any marginal added value or cost savings would be amplified on an extensive scale.



CRITICAL INDUSTRY ISSUES

The 20th Annual PACE Roundtable was held on November 8-9th, 2011 at The Pennsylvania State University. With the theme of "Building Innovation into Practice: Keeping What Works," discussion topics at the Roundtable included Sustainability/Green Building, Process Innovation, and Technology. Although Sustainability and Technology are undoubtedly important in the industry today, the impact of Process Innovation on successful project delivery is tremendous.

During the first break-out session, the Process Innovation group discussed the topic of "Assembling/Procuring an Integrated Team." A major focus of this session was the identification of the barriers to the implementation of an integrated team project delivery model. For example, the owner must be willing to pursue an integrated team over more traditional models. In order to help the owner take that first step, participants in the discussion suggested that teams could educate the owner on the benefits of an integrated approach and offer a case history backed by financial data.

Also, trust issues between the general contractor or construction manager, AE firms, and owners must be alleviated in order to overcome challenges related to risk sharing. Behavioral challenges can promote these trust issues between project entities, often requiring cultural shifts within organizations to spark much-needed change in how these organizations interact.

There were several points of interest in this discussion session that can be applied to the Government Office Center renovation project. For example, one industry member suggested that integrated team efforts could be inserted into key points or scopes of the project. Since the curtain wall replacement is a major aspect of this project, the implementation of an integrated team effort for the design, manufacture, and construction of this key scope could have had significant impact on the success of the Government Office Center renovation project.

During the second break-out session, the Process Innovation group discussed "Integrated Decisions for High Performance Retrofit Projects." The need for early involvement of key team members was discussed throughout the session. For example, a project team might hire a balancer at the onset of the project to measure the performance of the existing systems. This early effort could identify areas where specific systems components could be replaced, rather than replacing the entire system, ultimately producing a financial savings for the owner and the project team.

Another key discussion point during this session related the Last Planner principles to the design phase of a project. By meeting in a single location, teams can identify which team members need to know what information, and more importantly determine when these team members need to know the information in order to appropriately influence the decision. This concept aims to optimize the design process by eliminating negative iterations.

Because the Government Office Center project is a major renovation that is intended to update and modernize the existing mechanical and enclosure systems in the building, the discussion during this break-out session is directly applicable to points of interest for potential analyses. For example, it would be beneficial to analyze how early involvement of specialty subcontractors would improve the delivery of the project. In the case of the replacement curtain wall system, strategic integrated teaming could have allowed for detailed design efforts coordinated with the manufacturers of these engineered products, resulting in a customized system that exceeds expectations in terms of constructability, cost, and performance.

All industry professionals in attendance had some level of valuable insight into the discussion topics. In particular, roundtable attendees such as Bill Moyer from Davis Construction, Amanda Goolsby and Mark Konchar from Balfour Beatty Construction, and Chuck Tomasco from Truland would be able to provide guidance in the area of Process Innovation in the construction industry. The variety of companies represented at the PACE Roundtable will offer substantial support during future research efforts.

TECHNICAL ANALYSIS OPTIONS

After review of the Government Office Center renovation project, discussions with members of the project team, and interactions with industry members at the PACE Roundtable, several potentially problematic aspects of this project were identified for analysis as part of future research.

Technical Analysis 1: Implementation of Building Information Modeling

The uses for Building Information Modeling (BIM) in the construction industry continue to rapidly expand to meet the needs of designers, builders, and owners. For the purposes of the Government Office Center project at its current phase, it would be highly beneficial to examine options for implementing BIM use on site. With quality control and punchlist systems like Vela available for the iPad, construction management teams are confirming the value of bringing technology to the jobsite. Models created for design and coordination should be leveraged for use in the field, allowing the construction team to have quick access to information. In order to analyze the benefits of bringing BIM into the field, research will be needed to identify potential uses and examine cases where project teams have implemented the field use of BIM in some fashion. Afterwards, analysis can be performed with the help of construction management firms and software developers to define the needs of project teams on site and to quantify the benefits associated with meeting these needs.

In addition, models generated during design and construction should ultimately flow downstream to produce a useful facilities management tool for owners. As-built models are more frequently being delivered to owners, but product data and installation details are rarely included. Therefore, research into feasible methods for delivering this information within as-built models can directly benefit owners and construction management teams seeking to differentiate themselves. Discussions with owners of substantial property can uncover challenges that facilities management staff face due to difficulties in locating information. Analysis can then be performed in order to more efficiently improve the flow of information through BIM from concept to turnover.

Technical Analysis 2: Building-Integrated Photovoltaics

With a large, south-facing glazed curtain wall system being replaced as part of the Government Office Center renovation project, the opportunity to incorporate building-integrated photovoltaics will never be better. Because the existing system will already be replaced as part of the modernization plan, only the marginal cost of the transparent or translucent solar array needs to be financially justified by its electricity production. Switching from the curtain wall system that will be installed to a transparent or translucent photovoltaic system can have a variety of effects on the building, including changes to the amount of daylight passing through the enclosure, solar thermal gains, and system weight. The magnitude of these differences could require or allow for a resizing of mechanical systems and structural supports.

To produce a useful analysis, available options that would be applicable to the Government Office Center renovation project must be researched. Once a system has been selected, it should

be compared against the glazing that will be used in the actual construction project to determine how daylighting, solar thermal gains, and system weight are impacted. Any significant impacts should be addressed by modifying lighting fixtures, mechanical equipment, or structural supports as needed. Schedule impacts should also be addressed, as the curtain wall installation falls on the critical path of the project timeline. Finally, the proposed changes should be incorporated into a financial analysis that demonstrates whether the photovoltaic curtain wall can be justified for this project.

Technical Analysis 3: Integrated Processes

The construction industry is slowly beginning to trend toward more integrated solutions to project delivery challenges. Designers, contractors, and owners are forming teams in order to improve value while reducing wasted time and money along the way. For the greatest chance of success, owners must be fully engaged in the process from concept to turnover. However, it is difficult to define what an engaged owner truly looks like. All members of a project team stand to benefit from the identification of the traits that define an engaged owner that positively contributes to integrated team efforts. Research efforts for this topic would involve discussions with owners and other members of integrated teams to begin to isolate recurring traits of engaged owners that lead to successful delivery of collaborative solutions.

Similarly, integrated teams would also benefit from the identification of process and integration failures that can be encountered on this type of project. By leveraging previous research performed by the Penn State Department of Architectural Engineering, discussions with members of integrated teams can point to the root causes of these failures. As it relates to the Government Office Center, high performance retrofit project teams can help to define the delivery processes associated with disciplines like envelope and mechanical systems that are critical to their success.

Disengaged owners may be one of the process and integration failures identified by this analysis. These failures have the potential to add cost or schedule time to the project, or even result in solutions that do not meet or exceed the expectations of the owner. As a result, these failures reduce value for the client. Conversely, awareness of potential failures in addition to previously researched critical success factors can prevent value loss while promoting the benefits of an integrated teaming arrangement.

Technical Analysis 4: Progressive Collapse

The federal government implemented progressive collapse prevention requirements for government buildings decades after the original construction of the Government Office Center. As a result, the building will eventually require structural upgrades to meet these regulations. Considering the need to maintain continuous occupancy during the current renovation project, it can be assumed that the installation of the progressive collapse prevention mechanisms will face the same constraints. Although these constraints would likely impact the cost and time needed to complete the work, the impact could perhaps be mitigated if this system is installed as part of the scope of the current renovation project.

Research for this topic would require gaining a working knowledge of the basics of progressive collapse prevention methods used in retrofits. Based on this research, analysis would include the design of a theoretical section, such as a column or bay, followed by simple extrapolation to determine total material and labor requirements. Further analysis would examine whether the installation of this system would benefit from being included in the current renovation project, as well as the impact on the current project schedule and budget if the progressive collapse prevention system were included in the scope of work.