EXECUTIVE SUMMARY

DOLPHIN MALL EXPANSION PROJECT HISTORY

The Dolphin Mall Expansion project is located at the intersection of the Dolphin Expressway and the Florida Turnpike in Miami Florida. The Dolphin Mall Expansion includes the demolition and preparation for a new Bass Pro Shop anchor store. Total construction costs for the mall building, boat storage and Bass Pro Certified Pad were $6,400,000.

VALUE ENGINEERING ANALYSIS

The permitting phase of the Dolphin Mall Expansion project restricted a great deal of construction. The general contractor needs to sit down with Miami-Dade's Building and Fire Departments, while also bringing on a team member with experience in the area from a local office in the future. A local architect would be valuable in the consultation of the drawing submission process. A permit expediter is essential to the permitting phase of the project. An experienced, schedule driven expediter will improve the buildings success rate every time. WASD needs to be consulted immediately to prevent permit lags later in the project.

The general contractor needs to mobilize quickly and without phases to create a smooth transition into construction. A focus on the selective demolition will allow major parts of the building to be removed to ensure a better flow of construction activities later in the schedule. A Structural Cage will be required to allow egress through the center of Entry #1. Without wings of egress, construction will suffer fewer stops/pauses in the flow of activities.

A commissioning agent will be a great improvement on the integration and installation of a mechanical system. System re-designs could potentially be downsized, or better planned for, based on the Commissioner's experience.

FIRE PROTECTION ISSUES

Sprinkler design, installation and operation are guided by NFPA 13. Properly designed and installed sprinkler systems are part of the fundamental fire protection envelope that is key to today's modern building design and construction.

An Ordinary Hazard Level 2, unobstructed rectangular area of 26'x45' will require 176gpm at 49psi to allow people to safely exit the building in the event of an emergency.

Sprinkler mainlines will not need to be relocated because of the Structural Cage, and an overall cost savings for sprinkler construction of the temporary egress work is roughly $30,000 dollars. The length of construction time will be decreased significantly.

STRUCTURAL CAGE ANALYSIS

The proposed Structural Cage design would lead egress through Entry #1 and not North and South of Entry #1 as previously done. Because the egress will go directly through Entry #1, it is my opinion as the Engineer of Record for the design that an impact cage is necessary.

Usage of the Structural Cage will improve activities such as the hurricane wall, the temporary egress corridor construction, sprinkler relocations, selective demolition, shell demolition, footing excavation and installation, masonry block wall construction and permanent corridor construction.

The cost of the structural cage is roughly $44,000 plus the cost of the temporary corridor running through it worth approximately $200,000. The total of $244,000 is significantly less then original cost of $750,000 for work that will stand for a matter of weeks before demolished.

CONSTRUCTIBILITY REVIEW

The new sequence of construction based on the use of the Structural Cage in place of the two temporary egress corridors will allow for mall reconfiguration earlier then previously scheduled. The problematic Column Line "A" will no longer inhibit the demolition or construction plans.

The structural cage will be located partially in Entry #1 and proceed through the 30'x16' opening into what will ultimately become Bass Pro Shop. Once panels are removed, Entry #1 will be demolished over the Structural Cage, and the masonry wall construction from both zones can be joined and finished. The schedule and ease of construction is improved significantly. With demolition complete, masonry wall excavation, footings and block-laying will be accomplished starting in the South zone and proceeding into the North zone. The permanent corridors will be placed upon masonry wall completion.

SCHEDULE REDUCTION

The schedule can be significantly reduced in multiple categories. The use of the Structural Cage and improved permit planning will allow for reductions in permitting, site-work, demolition and construction.

The permitting schedule reduction is 22 days starting with the original 222 day duration and decreasing it to a 200 day duration. The site-work schedule reduction is 23 days starting with the original 139 day duration and decreasing it to a 116 day duration. The Bass Pro Boat Storage schedule reduction is 14 days starting with the original 113 day duration and decreasing it to a 99 day duration. The demolition schedule reduction is 15 days starting with the original 50 day duration and decreasing it to a 35 day duration. The mall reconfiguration schedule reduction is 46 days starting with the original 137 day duration and decreasing it to a 91 day duration. Finally the info desk relocation schedule reduction is 52 days starting with the original 72 day duration and decreasing it to a 20 day duration.

COMMISSIONING RESEARCH

The Dolphin Mall Expansion did not utilize commissioning. The Mall contracted Skanska U.S.A. Building Inc. to prepare the mall for the addition of a Bass Pro Shop. The system integration between mall and expansion will be limited. The Mall should however have a member of their Operations and Management team familiar with all the systems installation and upgrades. While it may not be cost effective to commission limited systems, that is a decision best made after an estimate has been given by the CxA. The Mechanical Engineer on the project was constantly flying down to Miami during construction to verify that only the parts of the system that were supposed to be demolished were demolished. System performance for the Mall, as a whole, should be monitored by the Commissioning Agent. It would have been best if the Anchor store tenant was given direction to utilize their commissioning agent on the corridor MEP to guarantee the tenant space matches the Mall's system. Fit-outs/renovations are often over looked with respect to commissioning agents and the mall would have benefited from commissioning consultation, even if it was a limited, low cost system design review. The value added by getting a CxA's opinion during the preliminary stages can no longer be overlooked in mechanical design. Taubman Centers delivers billions of dollars in malls throughout the United States, there are few corporations around that could benefit more from a commissioning division and or Cx team utilization during construction every year.

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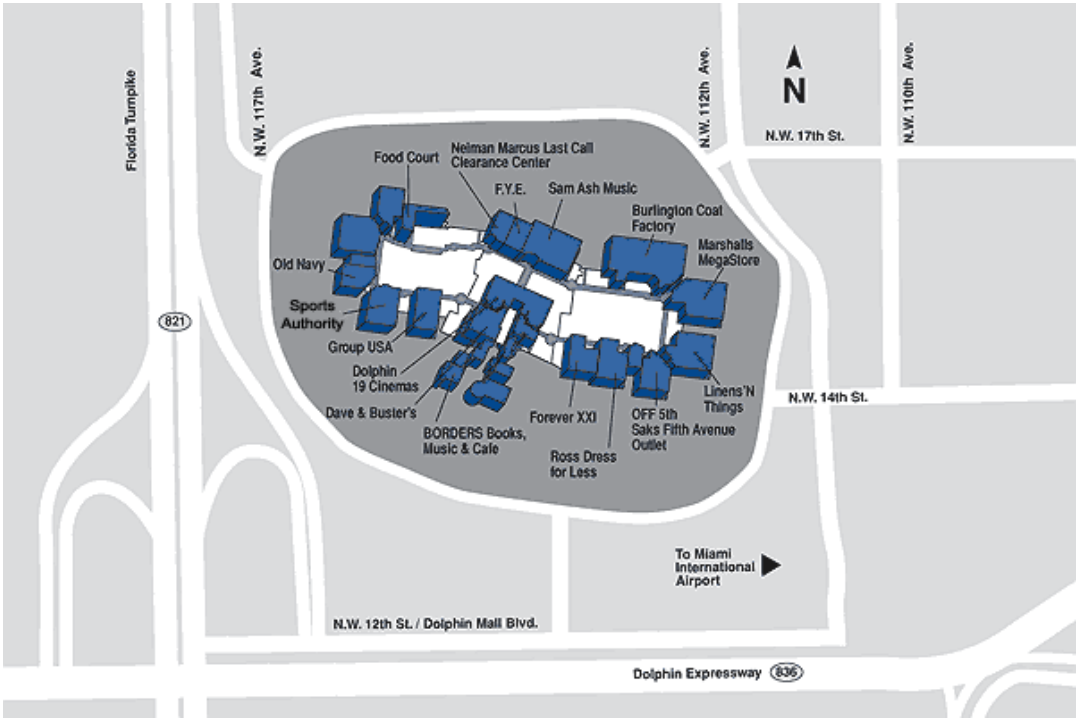
COMMISSIONING RESEARCH

DOLPHIN MALL EXPANSION PROJECT HISTORY

Dolphin Mall Location

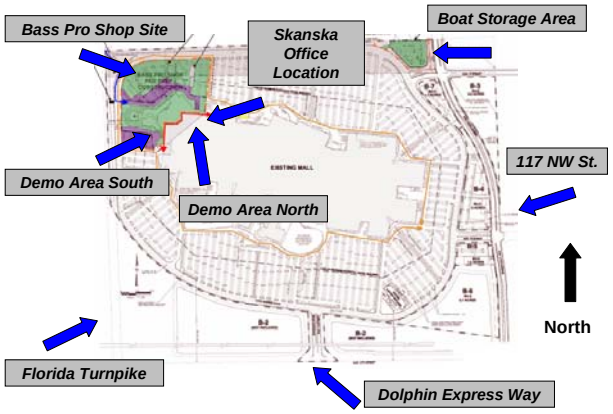
The Dolphin Mall Expansion project is located at the intersection of the Dolphin Expressway and the Florida Turnpike.



F1. Dolphin Mall Map (836-Turnpike)

Dolphin Mall Northwest Corner

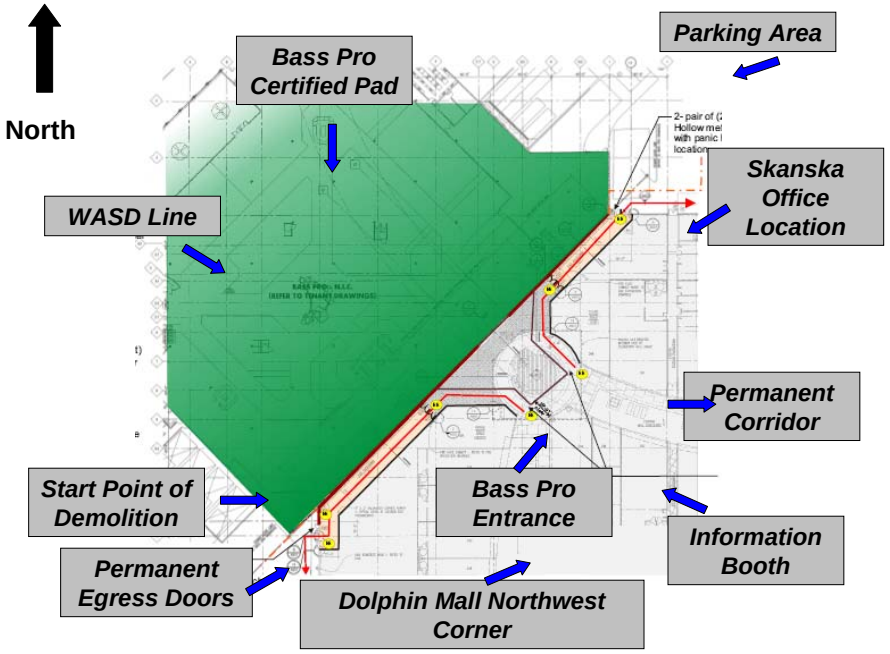
The Dolphin Mall Expansion is located in the Northwest corner of the mall. Parking, pedestrian flow and traffic have been blocked off between the food court (Parking Lot G8,) and Old Navy (Parking Lot A1-2.)



F2. Dolphin Mall Expansion Project Map

Corridor Construction Map

The permanent corridor runs parallel with Column Line "A." Skanska U.S.A. Building Inc.'s office remains inside the project area, and will ultimately become storage for the neighboring tenant space.



F3. Permanent Corridor Construction Map

WASD Line Through Pad

The WASD (Water and Sewer Department) line is shown in the graphic above. This line runs directly through the Bass Pro Pad. It is the only existing utility that was not removed from the project. All storm water lines are to be installed prior to grading. The green represents the future Bass Pro Shop footprint.

Schedule Summary

The Dolphin Mall Expansion is intended to be a five month, intensive construction project. There was a thirteen-month preconstruction/design period before Skanska U.S.A. Building Inc. mobilized to begin construction. Permitting was, and is a critical path activity on the Dolphin Mall Expansion, and is shown in the section of schedule below. The original schedule is included at the end of the history section. It is the intended schedule and not the actual schedule utilized. The actual schedule will be found at the end of the value engineering section.

ID	Task Name	Duration	Start
1	Bass Pro Shop Negotiation	1 day	Tue 6/21/05
2	Expansion Design	107 days	Wed 6/22/05
3	Submit Site Improvement Permit #1	1 day	Fri 11/18/05
4	Submit Building Permit #2	1 day	Wed 12/14/05
5	**Receive Site Improvement Permit #1**	1 day	Mon 4/3/06
6	**Skanska Site Mobilization**	1 day	Mon 5/22/06
7	Bass Pro Shop Site Work	57 days	Fri 6/2/06
8	Skanska Boat Storage Mobilization	1 day	Mon 6/5/06
9	**Receive Building Permit #2**	1 day	Fri 6/30/06
10	**Skanska Mall Building Mobilization**	1 day	Mon 7/10/06

F4. Original Schedule Permitting Process

Permitting

The Dolphin Mall Expansion project is located in the Miami-Dade Building Department jurisdiction. With an architect and engineer located in Michigan, correspondence was difficult. There are many location specific design demands placed on buildings located in the South Florida region. Neumann Smith and L&A Inc. were forced to learn and master the hurricane standards placed on all structural elements of the construction. Skanska needed to learn the complexities of Miami-Dade as well. Skanska was required to have all exterior door shop drawings approved by the building department before they could call in temporary wall inspections. All structural steel shop drawings must be approved by Miami-Dade before inspections for a number of disciplines may commence.

Mobilization

Skanska U.S.A. Building Inc. is a national constructor with offices in a multitude of states. The Dolphin Mall Expansion is a Taubman Centers account project. This account is held by the corporate headquarters of Skanska, and so a team was compiled primarily of Parsippany, New Jersey employees.

Selective Demolition

Dolphin Mall is one of Taubman Center's higher grossing malls. As an operating mall, all construction must be completed with the least interference possible concerning ongoing shopping and activities. With approximately 32,000 Square Feet of demolition to take place, a majority of demolition was to be completed without temporary egress. Relocation of sprinklers, electrical, plumbing and HVAC lines were done during non-operating hours. All demolition with the exception of structural element removal was to be completed selectively.

Temporary Egress Corridor

The temporary egress corridors proved to be one of the more severe critical path tasks of the project. The corridors were design-build and had many intricacies in their

erection and completion. Before any Pre-cast panels could be removed the temporary corridors had to have their certificate of occupancy.

Wall and Roof Demolition

Wall and roof demolition was to be completed with finesse to avoid destruction of the current tenant spaces. Once the temporary egress corridors were complete, all demolition of the Pre-cast panels and the roof was to take place in approximately three-weeks, in coordination with site work.

Footings

Because of schedule alterations, building footings were partially poured before demolition took place. Some footings could not be placed until Entry #1 was completely removed, but the majority of footings were excavated and poured before the roof was removed above them. This activity temporarily expedited the schedule, but created limitations to the demolition team as far as access to areas.

Storm Water Piping Relocation

South Florida will receive inches of rain in a short period of time. Because of the peak volume of water, all storm water piping and overflows are essential to the project. Both twelve and fifteen-inch storm water pipes were needed before, during, and after demolition.

HVAC Relocation and Installation

One roof top air handling unit was removed via crane pick in the early stages of selective demolition. The removed air handling unit is to be relocated and installed, along with a new air handling unit behind the demolition line (Bass Pro Shop tenant space line.)

Expansion Project Systems Summary

- Demolition of pre-cast wall panels was required on the West and North walls of "Demo area South," and the West and North walls of "Demo area North." Roof removal was done in a staggered fashion to maintain the girder lines. Entry #1 was removed and selective demolition was required throughout the Dolphin Mall Expansion Area.

- Structural Steel was scheduled to be erected. Columns, engineered joists and new metal roof decking were to be installed along Column Line "A." A truck mounted, 30-ton crane was used to erect the steel, starting in "Demo area South" and proceeding northeast along Column Line "A."

- Cast-in-place concrete will be used for the footings, slab and the roof system. Earthen and hand built formwork were used according to specifications.

- Pre-cast concrete was removed during demolition, but was not reinstalled in any locations. The new wall to be erected along column line "A" is composed of twelve-inch masonry block.

- The Dolphin Mall Expansion will utilize two rooftop air handling units. An existing Trane Voyager Series 8000 CFM unit will be relocated, and an additional Trane Voyager Series 4900 CFM unit will be installed. There are primarily 12x21-inch and 24x10-inch duct lines running through the demolition area. These lines will be capped, demolished and reconfigured throughout the space. New supply fans, a condenser, filters, evaporator coils, a refrigeration system, controls and smoke detectors all match existing mall HVAC equipment.

    - Supply Fans – Belt driven, self contained, airfoil blade, adjustable v-belt.
    - Outside Air – No more then 25 CFM leakage.
    - Condenser Section – 30 degree slope, aluminum fin, 10 degree Fahrenheit sub-cooling.
    - Filters – Two-inch thick, fiberglass, 30% efficiency.
    - Evaporator Coils – Copper tube with aluminum fins, equalizing type vertical tube.
    - Refrigeration System – Scroll type compressors, two stages of capacity control and isolated from base pan.
    - Controls – Self contained DDC Control System, VFD blower speed controller.

- Sprinkler mainlines were relocated and branch lines were removed and replaced throughout the space. White Pendent, Concealed, Brass Upright, Brass pendent and White Horizontal Sidewall heads were installed according to specifications. All signage was installed according to Miami-Dade Fire Department requirements.

- Electrical Systems were removed during demolition and replaced. 480/277 Volt, three phase electricity was supplied throughout the space with 480 Volt, 100 Amp disconnects located in multiple Mall locations, as well as at the Boat Storage Area.

- Masonry walls will be installed along Column Line “A,” and around the exterior of the boat storage area. Twelve-inch, reinforced block will be placed to create a roof-load bearing barrier between Dolphin Mall and the new Bass Pro Shop tenant space. Scaffolding will be placed on the mall side of the wall during installation to avoid interference with Bass Pro’s pad preparation. The scaffolding will be just west of the temporary hurricane wall, but east of the Bass Pro Entry.

- Excavation of footings were earthen supported and did not require additional support. Form work was placed in some of the footing locations for concrete pour. Boat storage required hand built formwork where soils could not be compacted to 95%. Site work excavation was stepped where necessary. Lime rock and Limestone are both adequate materials for excavation, and did not require shoring.

Dolphin Mall Expansion Project Cost

The Dolphin Mall Expansion actual construction costs for the mall building were $3,400,000/32,000SqFt. $106.25 per Square Foot. This number includes the demolition, temporary egress corridors and expansion preparation work.

The Dolphin Mall Expansion total construction costs for the mall building, boat storage and Bass Pro Certified Pad were $6,400,000. There is an additional $200,000 in miscellaneous work inclusive of the Information Booth relocation.

- Boat storage is $1,200,000/45,000SqFt. $26.67 per Square Foot.
- Bass Pro Site is $1,600,000/154,000SqFt. $10.39 per Square Foot.
- Total Construction cost based on 32,000SqFt of mall expansion would be $6,400,000/32,000SqFt. This equates to $200 per Square Foot.

Major Building System Costs

Demolition of 48,000SqFt – $760,000
- $15.84SqFt

Temporary Egress Corridors of 3,100SqFt – $750,000
- $241.94SqFt

Structural Steel of 32,000SqFt – $116,000
- $3.63SqFt

Roofing of 32,000SqFt – $128,000
- $4.00SqFt

Sprinklers of 32,000SqFt – $87,000
- $2.72SqFt

HVAC of 32,000SqFt – $425,000
- $13.29SqFt

Electrical of 32,000SqFt – $179,000
- $5.60SqFt

Local Conditions and Project Restraints

- Dolphin Mall, as previously stated, is one of Taubman's highest grossing malls. Because it is such a popular and successful enterprise, it has ample parking. The Dolphin Mall Expansion project is located in the northwest corner of the mall. Parking is available in lot G-8. Because this location previously did not contain an anchor store, it was predominantly the least attractive location to park. Skanska has been granted access to its own parking by fencing off lot G-8.

- There is a concerted attempt to keep concrete, metal and trash separate in dumpsters. All material removed from site is the responsibility of subcontractors and is recorded for Taubman's information.

- South Florida has numerous sub soil condition types. Eleven Standard Penetration Test (SPT) borings were completed. Three constant head exfiltration tests were performed in accordance with South Florida Water Management District (SFWMD) Permit Information Manual, Volume IV. The Dolphin Mall

Expansion project has Fill, Limerock at 0-5 feet, Silt and Sandy Silt at 5-6 feet, and Silty Limestone at 6-30 feet. The ground water level varies between 4.2 and 5.5 feet throughout the project site.

- No soil conditions resembling sinkhole activity were encountered. Severe weather impacts the site daily, and so storm water management is very important. All excavations require ground water pumping. Most storm water pipe installation was accomplished with workers standing in multiple feet of water.

- Foundation design requires 25,000 pounds per square foot bearing pressure soils. Lifts must be less then 12 inches at all times to obtain at least a 95 percent compaction, according to the modified proctor ASTM D-1557.

The original schedule is included to convey the intention of the owner, architect and contractor at the commencement of the project.

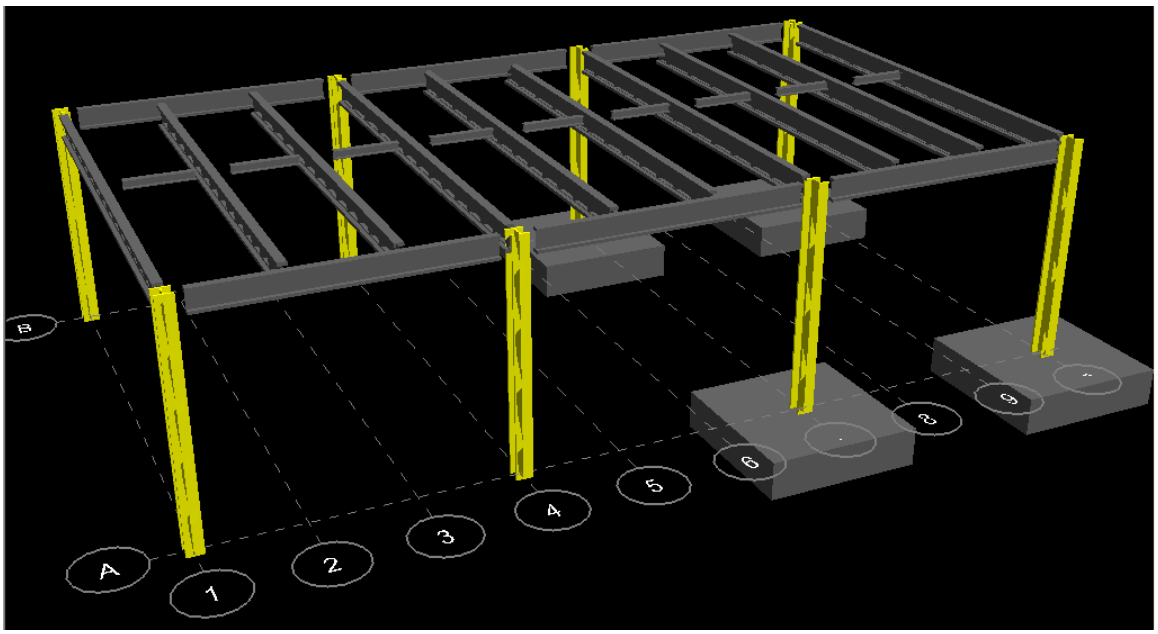
VALUE ENGINEERING ANALYSIS

Introduction

The Dolphin Mall Expansion Project has one major item that presents challenges to the project on multiple levels. The temporary egress corridors, connecting Entry #1 with the public is that challenge. Value engineering by definition is the alternate/ proposed changes, adds or deducts from exiting drawings or logistics to add value to the project. Value engineering is not cost-cutting.

Proposed Value Engineering

The Dolphin Mall Expansion project presents potential structural and fire protection technical analyses. A problem statement, proposed solution, research steps and expected outcomes will be addressed for a possible relocation of the temporary egress corridors to Entry #1 and all sprinkler and structural system alterations that will follow. In addition to these statements, solutions, steps and conclusions will be included. A proposal to utilize a commissioning process to tie-in to existing mechanical systems as well as install a new air handling unit and relocate other air handling unit has been proposed. $425,000 in HVAC is worth a Commissioner's attention.



F5. Structural Cage Value Engineering

Permitting V.E.

The Dolphin Mall Expansion project is located in the Miami-Dade Building Department jurisdiction. With an architect and engineer located in Michigan, correspondence was difficult. There are many location specific design demands placed on buildings located in the South Florida region. Neumann Smith and L&A Inc. were forced to learn and master the hurricane standards placed on all structural elements of the

construction. Skanska learned the complexities of Miami-Dade as well, at times at the expense of the schedule.

Permitting V.E. Solutions

Skanska needs to utilize communication between corporate offices. Some potential value engineering ideas to assist in the permit chaos are as follows:

1. Sit down with Miami Dade Building and Fire Departments prior to document submittal for permit.
2. Bring in a Miami-Dade experienced member of the Skanska Tampa office to consult the team on potential permitting issues such as
    a. Exterior door shop drawing submittals prior to any interior inspection. This is required for hurricane design reasons.
    b. Steel shop drawings submitted and approved prior to any steel inspection on-site.
    c. Exterior lighting and rolled/grass egress for all permanent and temporary egress from building.
3. Hire a local architect as a planning consultant to prevent permitting slowdown.
4. Hire an experienced Permitting expediter with a strong reputation for delivering the permits as scheduled.
5. Consult WASD before project commences to ensure permit will be ready when needed.

Mobilization V.E.

Skanska U.S.A. Building Inc. is a national constructor with offices in a multitude of states. The Dolphin Mall Expansion is a Taubman Centers account project. This account is held by the corporate headquarters of Skanska, and so a team was compiled primarily of Parsippany, New Jersey employees unfamiliar with South Florida.

Mobilization V.E. Solutions

Skanska could provide a non-phased mobilization with emphasis on getting team members acquainted with contractors and the location quickly. Utilizing local personnel, Skanska should have selected members of the team that were intimately familiar with the area to be on-site first to cut down on knowledge acquisition lag. Because of the short project duration, team members were forced to learn about the project and local conditions in the heat of battle and not prior to the swift increase in project activity. The lag in project knowledge, especially with the building department, created small preventable errors that impacted the schedule.

Selective Demolition V.E.

Dolphin Mall is one of Taubman Center's higher grossing malls. As an operating mall, all construction must be completed with the least interference possible concerning ongoing shopping and activities. With approximately 32,000 Square Feet of demolition to take place, a majority of demolition was to be completed without temporary egress. Relocation of sprinklers, electrical, plumbing and HVAC lines were done during non-operating hours. All demolition with the exception of structural element removal was to be completed selectively.

Selective Demolition V.E. Solutions

Selective demolition was done with poor communication. Subcontractor difficulty prevented Skanska from removing key elements in the way of temporary egress corridor construction. The sequencing of selective demolition was flawed and created havoc as corridors were being put up. Potential methods to extract material to ultimately better the sequencing of the project is as follows:

1. Increase demolition team size to accomplish task in three weeks or less, not the actual ten as done.
2. Remove all material South of the future Column Line "A." Material will be directly in the way of corridor construction and difficult to access.
    a. 3-5 man team increased to 8-10 man Demolition crew.
    b. Material will be directly in the way of corridor construction and difficult to access after the column line is cut open.
3. All storm water piping must be removed starting South and proceeding North.
4. HVAC should be removed early to prevent a potential hazard over the work area of Column Line "A"
5. Remove all equipment located by Entry #1 immediately to prevent Site Work slowdown because of congestion.
    a. Late August both Site contractor and Demo contractor met at same location causing delay.

Temporary Egress Corridor V.E.

The temporary egress corridors proved to be one of the more severe critical path tasks of the project. The corridors were design-build and had many intricacies in their erection and completion. Before any pre-cast panels could be removed the temporary corridors had to have their certificate of occupancy.

Temporary Egress Corridor V.E. Solutions

Temporary corridor egress was the keystone to the schedule failure of the Dolphin Mall Expansion project. Potential corrective actions are as follows:

1. Write schedule penalties into subcontractor contract.
    a. Schedule was not a priority for subcontractors because of little threat of penalty.
2. Demand increase in man power.
    a. Crews of 4-6 showed up to accomplish tasks that a 20 man crew would be pressed to accomplish without reprimand.
3. Order hurricane rated exterior doors for corridor through general conditions.
    a. Doors ordered late through subs
    b. Doors ordered without proper hardware
    c. Doors marked to save were partially thrown away and did not match hardware when actually saved
        i. Disregard all save door plans
4. Re-Route egress through Entry #1
    a. Less construction time required
    b. Less impact on construction and demolition

c. Requires same exterior accommodations that wings of egress would have required
d. Place through permanent masonry wall opening for ease of construction and zero impact on permanent corridor
e. Demolition can commence earlier because temporary egress will be available earlier
f. Remain with site-work schedule to keep storm water work complete in new egress location
g. No need for door installations for temporary corridors
    i. Doors and hardware were major schedule impactors

Wall and Roof Demolition V.E.

Wall and roof demolition was to be completed with finesse to avoid destruction of the current tenant spaces. Once the temporary egress corridors were complete, all demolition of the Pre-cast panels and the roof was to take place in approximately three-weeks, in coordination with site work.

Wall and Roof Demolition V.E. Solutions

Re-sequence work through Entry #1 to prevent damage of joist drops on temporary egress corridor. With no egress restrictions, drop exterior panels of North and West walls first. Pre-cast panels to fall away from Entry #1 once North and West walls are removed.

Acquire a commitment from roofing contractor early in project.

1. Murton Roofing contracted far too late in process (Last contract signed)
    a. Delayed roof mark-out for demolition cut by Demo contractor.

Footings V.E.

Because of schedule alterations, building footings were partially poured before demolition took place. Some footings could not be placed until Entry #1 was completely removed, but the majority of footings were excavated and poured before the roof was removed above them.

Footings V.E. Solutions

By re-sequencing, the egress corridor footings will have less impact from the corridors, but still need to be sequenced. The permanent footing located along Column Line “A” at Entry #1 must be poured prior to the Structural Cage construction. Working South and North from Entry #1, footings will be prepared after demolition has taken place. Rebar was damaged during demolition when the footings were poured prior to roof removal.

HVAC Relocation and Installation V.E.

One roof top air handling unit was removed via crane pick in the early stages of selective demolition. The removed air handling unit is to be relocated and installed, along with a new air handling unit behind the demolition line (Bass Pro Shop tenant space line.)

HVAC Relocation and Installation V.E. Solutions

System tie-in after removal and relocation should be consulted on by a Commissioning Agent.

1. Neighboring tenants constantly complained about HVAC malfunctions because of inaccurate cut and removals.
2. System re-designs could potentially be downsized, or better planned for, based on Commissioner's experience.
3. System integration with Johnson Control's would be more accurate if the design through final testing was planned for by a Commissioner with acute experience of system integration, as opposed to new construction.
4. Utilize the Bass Pro Shop contract to share a commissioner to cut on costs, as well as allow for a more smooth transition from mall to new tenant space.

V.E. Solutions Conclusion

The permitting phase of the Dolphin Mall Expansion project restricted a great deal of construction. The general contractor needed to sit down with Miami-Dade's Building and Fire Departments, while also bringing on a team member with experience in the area from a local office. A local architect would be valuable in the consultation of the drawing submission process. A permit expediter is essential to the permitting phase of the project. An experienced, schedule driven expediter will improve the building's success rate every time. WASD needs to be consulted immediately to prevent permit lags later in the project.

The general contractor needs to mobilize quickly and without phases to create a smooth transition into construction. A focus on the selective demolition will allow major parts of the building to be removed to ensure a better flow of construction activities later in the schedule. A Structural Cage will be required to allow egress through the center of Entry #1. Without wings of egress, construction will suffer fewer stops/pauses in the flow of activities.

A commissioning agent will be a great improvement on the integration and installation of a mechanical system. System re-designs could potentially be downsized, or better planned for, based on the Commissioner's experience.

The actual schedule is included to convey the project lags and delays that are open for value engineering and schedule reductions.

FIRE PROTECTION ISSUES

Problem Statement

- Remove temporary egress corridors from the project and install one egress corridor through the future opening for Bass Pro Shop at Entry #1. It is no longer necessary for the mainline relocation of sprinklers but the Cage will require a branch to sprinkle the proposed corridor. A tap located off the Northeast corner of Entry #1 at Column Line "A" will supply adequate pressure and flow for new temporary corridor sprinklers

Proposed Solution

- Tie sprinkler line into branch line located at gridline H.5 or gridline 6.
  - A 4" branch of mainline located at Entry #1 and Column Line "A"
- Do not relocate any six-inch mainlines for temporary egress corridors, but proceed with branch line demolition as scheduled.

Research Steps Utilized

- Consulted the Miami Dade Bldg. Dept. / Arfran II's approved sprinkler plan and specifications for the Dolphin Mall. Layout will be required to match existing mall conditions regardless of "temporary" title.
  - Informed of ability to apply for variance to drop hazard level for sprinkled area from Ordinary Level 2 to Ordinary Level 1.
- Consulted Skanska U.S.A. Bldg. Inc. on-site personnel for additional assistance in addressing a redesign.
- Designed according to NFPA 13 code requirements.
- Consulted and discussed all designs with Dr. Haight of The Pennsylvania State University's Industrial Health and Safety department.

Expected vs. Actual Outcomes

- Less relocation of existing piping will be required. The "hurricane" wall will now run along the exterior of the existing sprinkler mainlines which will allow for a deletion of the multiple relocations for the six-inch mainlines.
- Additional sprinkler line installation to accommodate the new sprinkled path. Existing corridors dropped a line and tied into the branches feeding the demo areas. A new egress path through Entry #1 would require a new line installed through Entry #1 wall.
- Time and money will be saved on avoiding the relocation of the mainlines, however a comparison of the tie-in to the existing branch will have to be analyzed against the drops located at the extents of Column Line "A" as previously performed. Lineal footage will be substantially decreased and heads will be reduced.

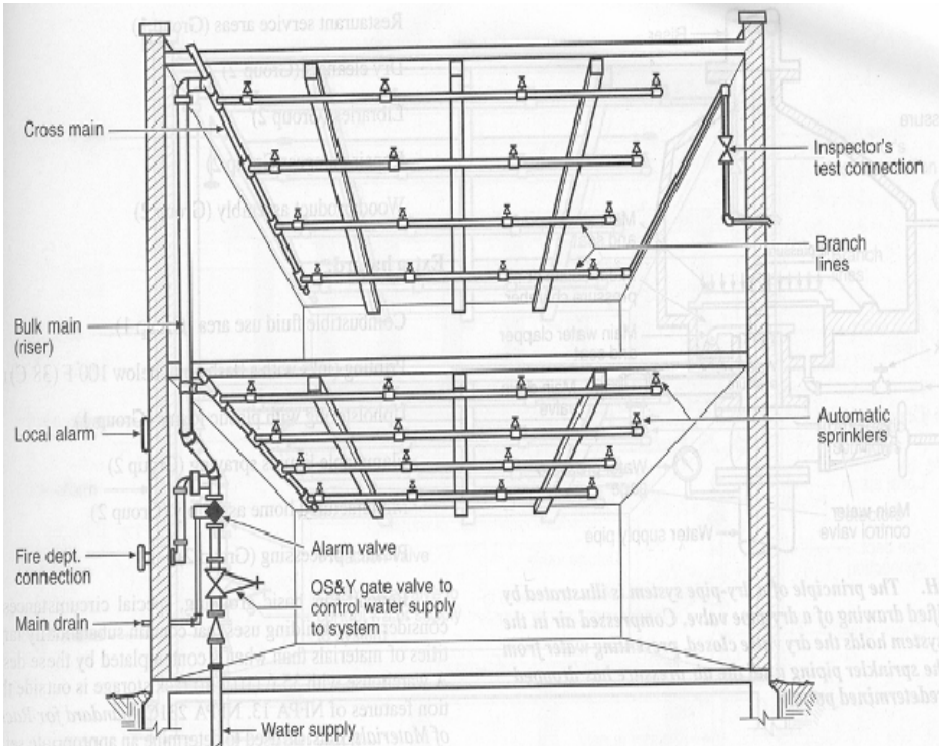
Sprinkler Background

Sprinkler design, installation and operation are guided by NFPA 13. Properly designed and installed sprinkler systems are part of the fundamental fire protection

envelope that is key to today's modern building design and construction. Compartmentalization, detection and suppression are the key features that allow buildings of certain heights to be constructed. System design is reliant on the importance of knowing what sprinklers can and can not do.

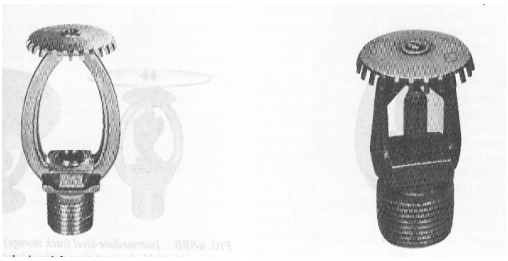
System Selected

The wet-pipe is the most common, easiest to design and maintain system in use, especially for temporary needs. Water is up to sprinkler heads at all times and fast acting, but a danger to freezing. The Miami-Dade location deletes any worry of freezing in sprinkler pipes and can be ignored.



F6. Typical Wet Pipe Sprinkler Layout

Head selection for the temporary egress corridor was done based on stock availability of Arfran II, the sprinkler subcontractor for the Dolphin Mall Expansion project. A standard ½" upright was selected as shown below.

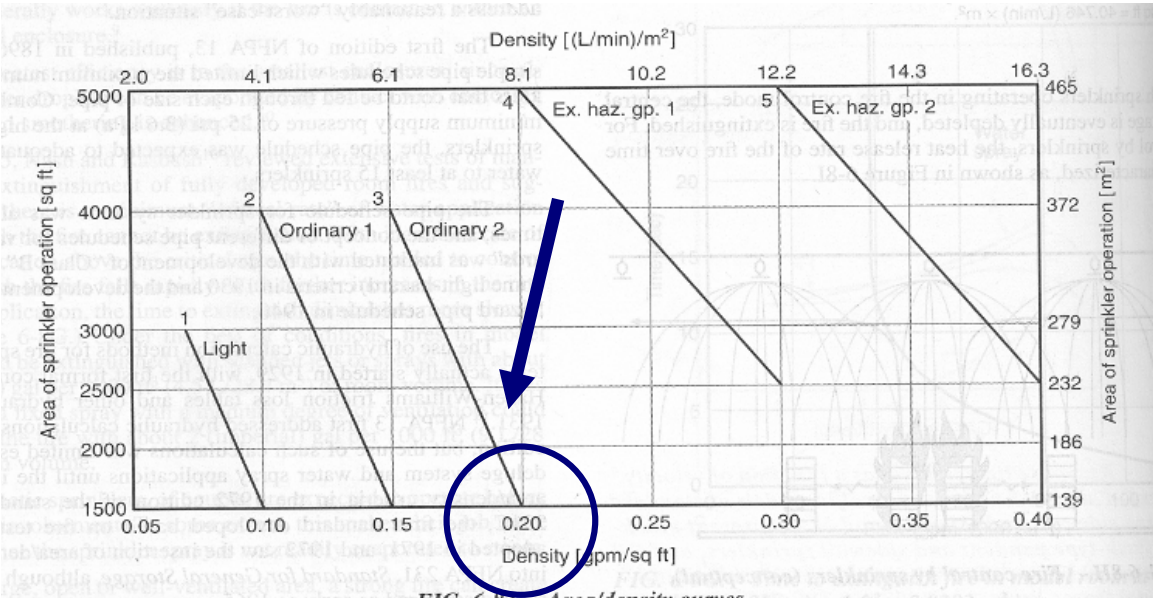


F7. Standard ½" Upright Sprinkler Heads

Hazard Level

The type of system required depends on the fundamental hazard level. There are three primary hazard levels to select from:

1. Light – office buildings, schools, residential, public assembly
2. Ordinary – electronics plants, restaurants, dry cleaners, libraries, repair garages, wood product assembly
3. Extra – combustible liquids use areas, printing, upholstering with foam, flammable liquids spraying, manufactured home assembly



F8. Hazard and Density Selection Chart

Obstruction Level

The level of obstruction will determine the number of heads required in the system. There are two primary obstruction levels to select from:

1. Obstructed construction – members impede heat flow or water distribution in a manner that materially affects the ability of the sprinklers to control or suppress a fire.

2. Unobstructed construction – heat flow and water distribution are not affected. To meet this definition;
   - Openings in the member must be at least 70% of the cross-sectional area;
   - Depth of the member does not exceed the least dimension of openings;
   - Members are spaced more than 7.5’ on center.

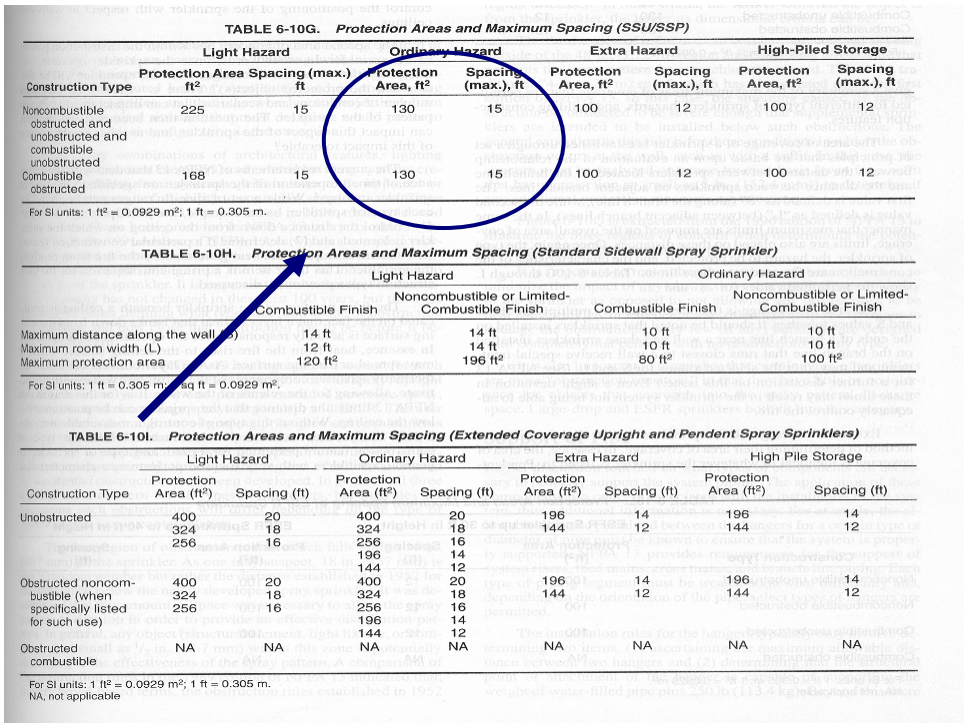


TABLE 6-10G. *Protection Areas and Maximum Spacing (SSU/SSP)*

Construction Type	Light Hazard Protection Area, ft²	Light Hazard Spacing (max.) ft	Ordinary Hazard Protection Area, ft²	Ordinary Hazard Spacing (max.), ft	Extra Hazard Protection Area, ft²	Extra Hazard Spacing (max.), ft	High-Piled Storage Protection Area, ft²	High-Piled Storage Spacing (max.), ft
Noncombustible obstructed and unobstructed and combustible unobstructed	225	15	130	15	100	12	100	12
Combustible obstructed	168	15	130	15	100	12	100	12

For SI units: 1 ft² = 0.0929 m²; 1 ft = 0.305 m.

TABLE 6-10H. *Protection Areas and Maximum Spacing (Standard Sidewall Spray Sprinkler)*

	Light Hazard		Ordinary Hazard	
	Combustible Finish	Noncombustible or Limited-Combustible Finish	Combustible Finish	Noncombustible or Limited-Combustible Finish
Maximum distance along the wall (S)	14 ft	14 ft	10 ft	10 ft
Maximum room width (L)	12 ft	14 ft	10 ft	10 ft
Maximum protection area	120 ft²	196 ft²	80 ft²	100 ft²

For SI units: 1 ft = 0.305 m; sq ft = 0.0929 m².

TABLE 6-10I. *Protection Areas and Maximum Spacing (Extended Coverage Upright and Pendent Spray Sprinklers)*

Construction Type	Light Hazard Protection Area (ft²)	Light Hazard Spacing (ft)	Ordinary Hazard Protection Area (ft²)	Ordinary Hazard Spacing (ft)	Extra Hazard Protection Area (ft²)	Extra Hazard Spacing (ft)	High Pile Storage Protection Area (ft²)	High Pile Storage Spacing (ft)
Unobstructed	400	20	400	20	196	14	196	14
	324	18	324	18	144	12	144	12
	256	16	256	16				
			196	14				
			144	12				
Obstructed noncombustible (when specifically listed for such use)	400	20	400	20	196	14	196	14
	324	18	324	18	144	12	144	12
	256	16	256	16				
			196	14				
			144	12				
Obstructed combustible	NA	NA	NA	NA	NA	NA	NA	NA

For SI units: 1 ft² = 0.0929 m²; 1 ft = 0.305 m.
NA, not applicable

F9. Obstruction Level Selection Chart

Sprinkler Design Calculations

- Step 1:
  - Ordinary 2 Hazard Level – 1500 ft. ^{2} minimum coverage area – required water density – 0.2 gpm / ft. ^{2}
- Step 2:
  - Standard spray upright/standard spray pendant, next determine protection area per sprinkler head and maximum spacing between sprinkler heads.
  - If noncombustible, unobstructed construction and SSU/SSP sprinkler heads, then 130 gpm/sprinkler head is required and maximum 15 feet spacing between heads.
- Step 3:
  - Number of sprinkler heads required (SH) = 1500 ft. ^{2} / 130 ft. ^{2}/sprinkler head
  - SH = 12 sprinkler heads
- Step 4:
  - SH/Br = 1.2 $\sqrt{1500}$ ft. ^{2}/ 15 ft.
    SH/Br = 3 sprinkler heads per branch
  - This means that in the layout for this 1,170 sqft. Area, 12 sprinkler heads must be distributed in 4 branches with 3 sprinkler heads per branch.
- Step 5:
  - Determine flow and pressure requirements for each sprinkler head starting with the most hydraulically remote head in the system.
  - Q_1 = (130 ft. ^{2}) (0.2 gpm/ft. ^{2})

- **Q_1 = 26 gpm** (gallons per minute)
- $Q_1 = k \sqrt{\rho}$ (assume ½" orifice sprinkler head – k = 5.3-5.8, so choose middle value ~ 5.5)
- $\rho = (Q_1 / k)^2$
- $\rho = (26 \text{ gpm}/5.5)^2$
- **ρ = 22.4 psi** (pounds per square inch)
- Required flow and pressure at most remote sprinkler head is 26 gpm at 22.4 psi

- Step 6
  - Determine flow and pressure requirement for next four hydraulically remote sprinkler heads accounting for pipe friction loss.

The branch line must be capable of delivering at least **176 gpm at 49 psi.** Dolphin Mall is equipped with up to 1000 gpm in branch lines if required. Temporary egress is well under any water requirement the mall can provide. Spacing of 6.5' east-west between heads and 9' north-south between heads will be utilized for the twelve heads in the temporary egress corridor.

Hand Version of Sprinkler Design Calculations Page 1

STEP 1
HALL CORRIDOR = ORDINARY 2
VARIANCE FOR ORDINARY 1

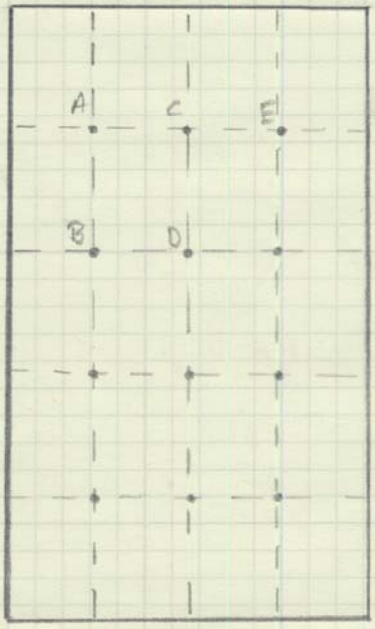
NO STORAGE OBSTRUCTIONS PERM FUEL SOURCE

$45 \times 26 = 1170 ft^2$ MIN COVERAGE AREA WALL FINISH
$1170 \approx 1500$ MIN FOR ORD 2
.20 GPM/SQFT DENSITY REQ.D

STEP 2
SSU/QRP SPRINKLER HEADS
$130 ft^2$ COVERAGE 15' MAX SPACE

STEP 3
SH = 1,170 $\Rightarrow$ 1500 $\therefore$ $1500/130 = 11.5 \approx 12$

STEP 4
SH/BR = $1.2\sqrt{1500}/15 = 3$ HEADS
4 BRANCHES @ 3 HEADS



STAEDTLER® No. 937 811E Engineer's Computation Pad

Hand Version of Sprinkler Design Calculations Page 2

STEP 5

$Q_1 = 130 ft^2 \times 0.2 GPM/ft^2$

$Q_1 = 26$ gpm ½" STANDARD HEAD

$Q = K\sqrt{P}$ K = 5.3-5.8

$P = (26/5.5)^2 = 22.4$ PSI

STEP 6 A-B

FRICTION LOSS TO KICK OFF 5 HEADS

26 GPM 1" LINE = .211 PSI/LINEAL FT

.211 x 9 = 1.899 PSI FRICTION LOSS

22.4 + 1.899 = 24.3 PSI NEEDED FOR

$Q_2 = 5.5\sqrt{24.3} = 27.2$ gpm "A" TO OPERATE

A-C

26 GPM 1" LINE = .211 PSI/LINEAL FT

.211 x 6.5 = 1.37 PSI FRICTION LOSS

22.4 + 1.37 = 23.8 PSI NEEDED FOR

$Q_2 = 5.5\sqrt{23.8} = 26.8$ gpm "A" TO OPERATE

B-D

27.2 gpm 1" LINE = .232 PSI/LINEAL FT

.232 x 6.5 = 1.508 PSI FRICTION LOSS

24.3 + 1.508 = 25.8 PSI NEEDED FOR

$Q_2 = 5.5\sqrt{25.8} = 27.9$ GPM "B" TO OPERATE

C-D

26.8 gm 1" LINE = .223 PSI/LINEAL FT

.223 x 9 = 2.01 PSI FRICTION LOSS

23.8 + 2.01 = 25.81 PSI NEEDED FOR

$Q_2 = 5.5\sqrt{25.81} = 27.9$ GPM "C" TO OPERATE

Hand Version of Sprinkler Design Calculations Page 3

C-E

26.9 gpm 1" LINE = .223 PSI/LINEAL FT

.223 x 6.5 = 1.45 PSI FRICTION LOSS

23.8 + 1.45 = 25.25 PSI NEEDED FOR

$Q_2 = 5.5\sqrt{25.25}$ = 27.63 GPM "E" TO OPERATE

Q_T = 27.2 + 26.8 + 27.9 + 27.9 + 27.7 = 137.5 GPM

PIPE RUN BACK TO BRANCH (NO PUMP)

CAN BE ROUTED 3 WAYS SO ASSUME

50 GPM/LINE x 32 (MAX DIST)

50 GPM 1" LINE = .709 PSI FRICTION LOSS

.709 x 32 = 22.68 psi

25.91 + 22.68 = 49 PSI $Q_2 = 5\sqrt{49}$ = 38.5

137.5 + 38.5 = 176 GPM ⇒ 176 GPM REQ'D @ 49 PSI

Decrease in Material and Cost

Two wings at roughly 215 lineal feet will be replaced with a rectangular area of 26'x45.' Relocation of 6" mainlines will no longer be required, and the lineal footage of 1" pipe is decreased as well as the number of heads and all associated hardware, hangers and fittings. The material and cost savings are included in the graphic below.

Dolphin Mall Expansion Project

A Sprinkler Design Material Estimate Prepared by Travis Anderson Smith

Item	Quantity	Weight	Length	$ Cost Per Unit	Unit	Total Cost
Main Line Relocation					**Total Cost**	**$ 8,000.00**
6" relocation by Arfran II	4.0	n/a	100	20.00	Lineal Feet	$ 8,000.00
New Pipe					**Total Cost**	**$ 9,472.00**
6" Sch 10 Blk Steel Pipe Grooved	4.0	n/a	100.00	23.68	Lineal Feet	$ 9,472.00
Relocation					**Total Cost**	**$ 17,472.00**
Retail Light Hazard Material Quote					**Total Cost**	**$ 17,648.64**
1" Sch 10 Blk Steel Pipe	1		326	8.39	Lineal Feet	$ 2,735.14
1" Sch 10 Blk Steel Pipe 10% waste	1		14.4	8.39	Lineal Feet	$ 120.82
Fittings, Hangers, 1/2" Heads	46	n/a	n/a	321.58	Each Installed	$ 14,792.68
Original Sprinklers					**Total Cost**	**$ 17,648.64**
Retail Light Hazard Material Quote					**Total Cost**	**$ 5,187.94**
1" Sch 10 Blk Steel Pipe east-west	1		81	8.39	Lineal Feet	$ 679.59
1" Sch 10 Blk Steel Pipe north-south	1		63	8.39	Lineal Feet	$ 528.57
1" Sch 10 Blk Steel Pipe 10% waste	1		14.4	8.39	Lineal Feet	$ 120.82
Fittings, Hangers, 1/2" Heads	12	n/a	n/a	321.58	Each Installed	$ 3,858.96
Modified Sprinklers					**Total Cost**	**$ 5,187.94**
Total Sprinkler System Savings						**$ 29,932.70**

F10. Sprinkler Savings Breakout

Sprinkler Analysis Conclusion

Sprinkler design, installation and operation are guided by NFPA 13. Properly designed and installed sprinkler systems are part of the fundamental fire protection envelope that is key to today's modern building design and construction.

An Ordinary Hazard Level 2, unobstructed rectangular area of 26'x45' will require 176gpm at 49psi to allow people to safely exit the building in the event of an emergency.

Sprinkler mainlines will not need to be relocated because of the Structural Cage, and an overall cost savings for sprinkler construction of the temporary egress work is roughly $30,000 dollars. The length of construction time will be decreased significantly.

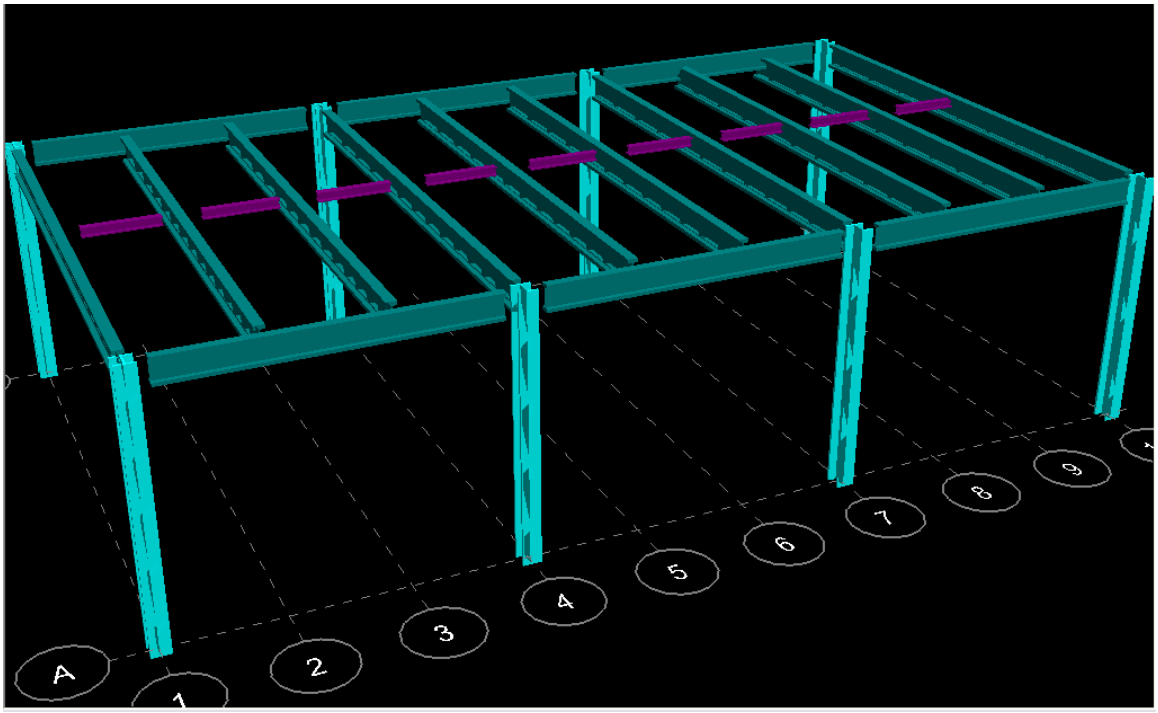
STRUCTURAL CAGE ANALYSIS

Problem Statement

- Remove temporary egress corridors from the project and install one egress corridor through the future opening for Bass Pro Shop at Entry #1. Determine the structural requirements to proceed with egress through a demolition area.

Proposed Solution

- Do not proceed with egress corridors a previously planned. Place one egress corridor through the opening for Bass Pro Shop at Entry #1. Structure should fit through 16'x30' opening to allow for permanent masonry wall construction over temporary egress corridor.
- Structurally reinforce the egress corridor for overhead demolition.
    - Structural Cage capable of handling impact located around the egress corridor.



F11. Proposed Cage with Bracing

Research Steps Utilized

- Consulted the Miami Dade Bldg. Dept. / Lotspeich (corridor Design-Builder) / LRFD.
- Utilized The Pennsylvania State University's Architectural Engineering Structural personnel for brainstorming on redesign.
- Consulted Skanska U.S.A. Bldg. Inc. on-site personnel for additional assistance in addressing a redesign.

Material Reduction

The reduction of total material is significant but an additional Structural Cage will be necessary. The temporary egress corridor lineal footage deletion is comprised of:

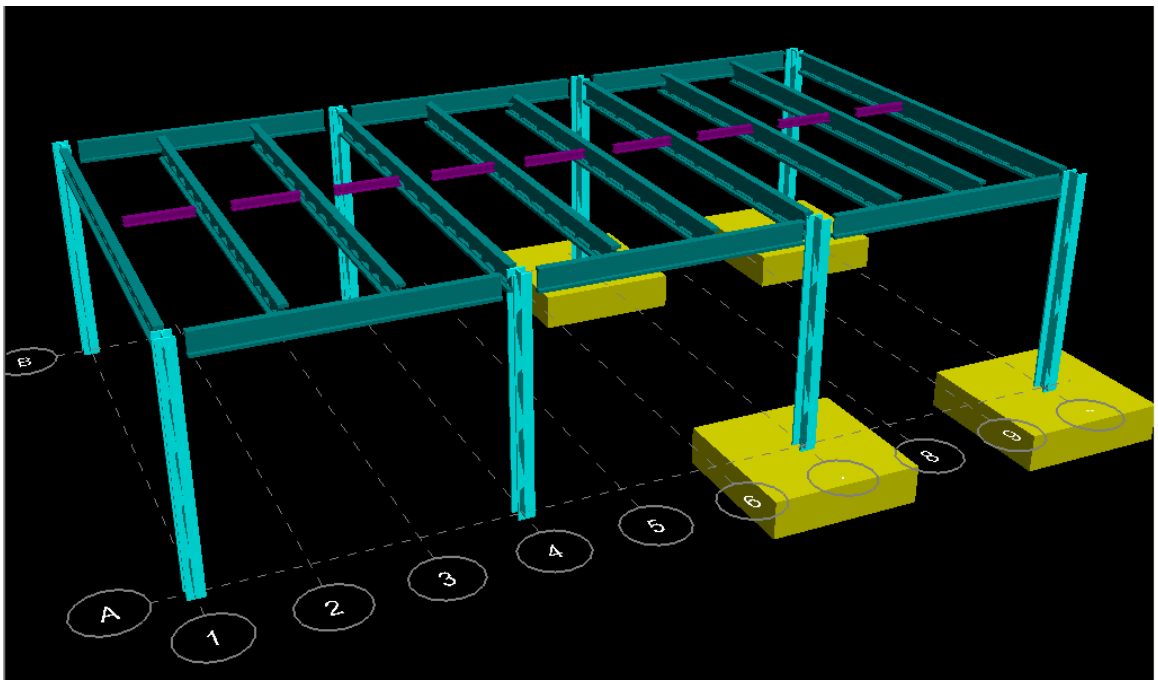
- 8" x 18 Ga. horizontal joists at 24" O.C.
- 3 5/8" x 18 Ga. vertical studs at 16" O.C.
- 3 5/8" x 14 Ga. continuous track
- 12" x 2" 12 Ga. vertical hurricane stud 24" O.C
- 12" x 14 Ga. continuous track
- 5/8" type X fire rated gypsum board sheathing
- Roofing felt on ¾" plywood sheathing w/ #8 screws at 4" O.C. hurricane wall exterior
- Sand bags, flashing and waterproof floor joint.

New Temporary Egress Corridor Cost

The original temporary egress corridor totaled 210 linear feet including both the thirteen foot wide North and South wings of the temporary egress corridor. One temporary egress corridor out Entry #1 will be 45 linear feet a decrease of 165 linear feet. The services of Lotspeich were all-inclusive at $750,000 for the temporary egress corridors at a lengthy schedule. The cost per linear footage is $3,572 per linear foot. The new cost for the 45 linear feet at that price would be $160,715 plus the cost of the Structural Cage at $43,715. The corridor is now twice as wide as before for the 45 feet of cage, and therefore a number of approximately $200,000 plus the cost of the cage would be more exact. The cost reduction is sizeable, but the schedule reduction is the primary objective of the temporary egress corridor re-design. Taubman can live with minor cost escalations but not unhappy anchor store owners.

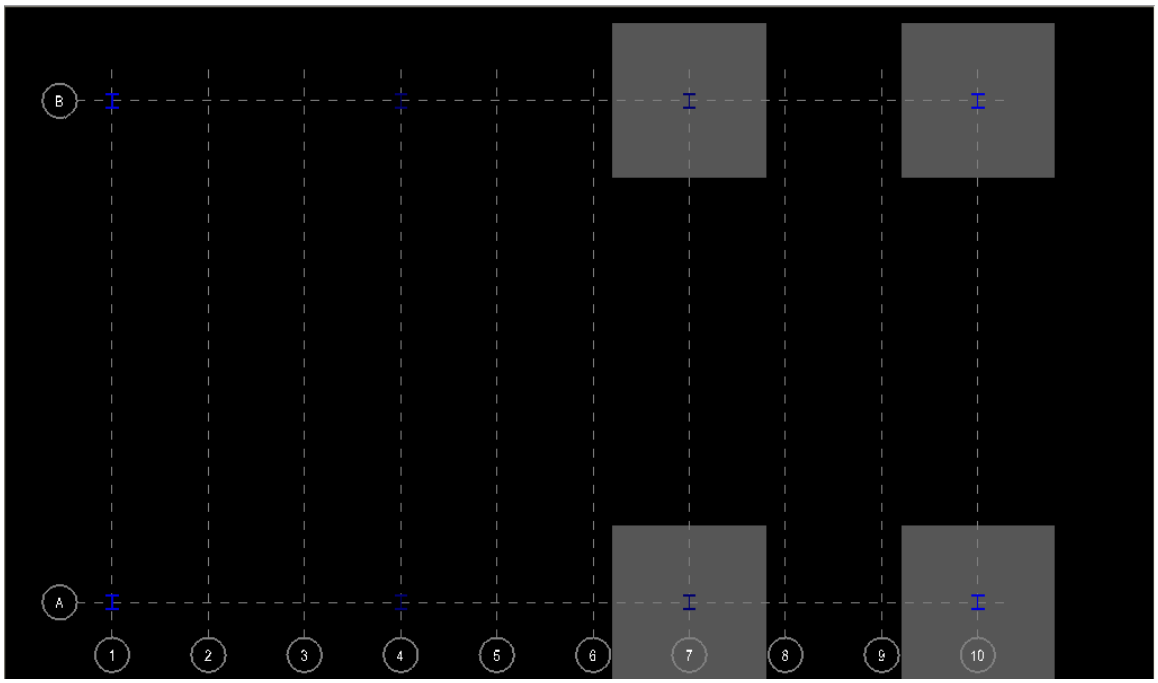
Structural Load and Protection

There are a vast number of items that benefit from the usage of the Structural Cage. The type of construction for the temporary egress corridor will not be altered, but the location will. Because the location of the egress will now be through the center of Entry #1, the development of the Structural Cage allows an increased comfort level in the event of a collapse.



F12. Cage Footings Located at Exterior

Small footings have been designed to hold the cage in place outside of the mall exterior. The columns inside the mall will simply be anchor bolted into the 6” slab via Hilti Epoxy bolts.



F13. Cage Footing Plan View

Protection

During the demolition of the Dolphin Mall's "Demo Area North" and "Demo Area South" debris was dropped on a section of the temporary egress corridor located South of Entry #1. The joist caused damage to the corridor that had to be immediately corrected. The potential of a joist to injure anyone is limited, especially because temporary egress from the building would take place in the event of a fire or mandatory evacuation. It is safe to assume that construction would be halted in either of those cases. Therefore, there would never be a time where the joist being removed from the demo areas would truly have the ability to strike a human in the temporary egress corridor.

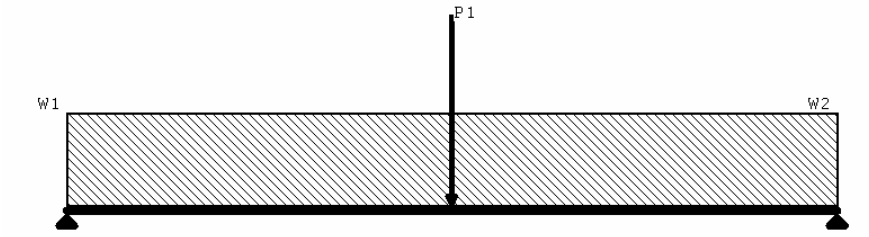
The proposed Structural Cage design would lead egress through Entry #1 and not North and South of it as previously done. Because the egress will go directly through Entry #1 it is my opinion as the Engineer of Record for the design that an impact cage is necessary.

Loading

The current design does not take impact of potential joist drops into account. Upon consultation from The Pennsylvania State University Architectural Engineering Departments Structural personnel, the decision to account for an impact load on each of the main load carrying members of the cage was calculated.

Beam Design

The heaviest joist located on the project weighed in at 860 lbs. The joist would not hit the Structural Cage located at Entry #1 but was used as a conservative baseline for design. A 1720 lb point load factored at 160 percent, because of its live load status was placed at the center of the horizontal beams to mimic a load at the greatest moment creating location.



Load	Dist	DL	LL+	LL-	Max Tot
	ft	kips	kips	kips	kips
P1	13.000	0.000	2.752	0.000	2.752
	ft	k/ft	k/ft	k/ft	k/ft
W1	0.000	0.211	0.680	0.000	0.891
W2	26.000	0.211	0.680	0.000	0.891

F14. RAM STEEL Beam Calculation

Beams are designed to account for:

- 45psf Construction Live Load
- 40psf Personnel Live Load
- 10psf Non-Composite Steel Decking Dead Load
- 20psf Wood Skin Dead Load

The loads are calculated at the conclusion of this section to spot check the values obtained through RAM STEEL.

STEEL BEAM DESIGN SUMMARY:

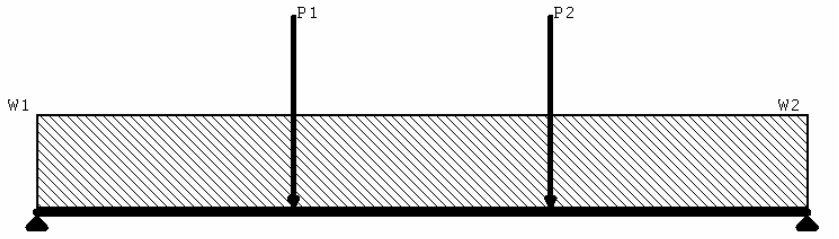
Floor Type: Gound

Bm #	Length ft	+M kip-ft	-M kip-ft	Seff in3	Fy ksi	Beam Size
1	26.00	63.7	0.0	38.4	50.0	W16X26
10	15.00	67.8	0.0	29.0	50.0	W14X22
5	15.00	67.8	0.0	29.0	50.0	W14X22
11	26.00	93.2	0.0	47.2	50.0	W16X31
12	26.00	93.2	0.0	47.2	50.0	W16X31
2	26.00	93.2	0.0	47.2	50.0	W16X31
9	15.00	67.8	0.0	29.0	50.0	W14X22
6	15.00	67.8	0.0	29.0	50.0	W14X22
13	26.00	93.2	0.0	47.2	50.0	W16X31
14	26.00	93.2	0.0	47.2	50.0	W16X31
3	26.00	93.2	0.0	47.2	50.0	W16X31
8	15.00	67.8	0.0	29.0	50.0	W14X22
7	15.00	67.8	0.0	29.0	50.0	W14X22
15	26.00	93.2	0.0	47.2	50.0	W16X31
16	26.00	93.2	0.0	47.2	50.0	W16X31
4	26.00	63.7	0.0	38.4	50.0	W16X26

F15. RAM STEEL Beam Selections

Column Design

The column selection is a W10x33, which is oversized. The actual load expected of each column is only 25,200 lbs. A W10x33 will carry up to 276,000 lbs under the expected conditions for design. The W10x33 is the smallest available column in the LRFD but can but sized smaller utilizing other standards. For the purpose of this design East Coast Metal Deck was contacted for a quote and gave a price of $2.46 per pound regardless of which sizing was selected. A smaller pound per foot would simply save additional money.



Load	Dist ft	DL kips	LL+ kips	LL- kips	Max Tot kips
P1	5.000	2.744	10.216	0.000	12.960
P2	10.000	2.744	10.216	0.000	12.960
	ft	k/ft	k/ft	k/ft	k/ft
W1	0.000	0.040	0.068	0.000	0.108
W2	15.000	0.040	0.068	0.000	0.108

F16. RAM STEEL Girder Calculations

RAM STEEL confirms the selection of the W10x33. Column spacing is located at 15 ft. long with a 26 ft. span.

Column Line 1 - A

Level	P	Mx	My	LC	Interaction Eq.	Angle	Fy	Size
Ground floor	22.6	5.2	7.4	1	0.43 Eq H1-3	90.0	50	W10X33

Column Line 1 - B

Level	P	Mx	My	LC	Interaction Eq.	Angle	Fy	Size
Ground floor	22.6	5.2	7.4	1	0.43 Eq H1-3	90.0	50	W10X33

Column Line 4 - A

Level	P	Mx	My	LC	Interaction Eq.	Angle	Fy	Size
Ground floor	30.2	8.0	5.8	6	0.40 Eq H1-2	90.0	50	W10X33

Column Line 4 - B

Level	P	Mx	My	LC	Interaction Eq.	Angle	Fy	Size
Ground floor	30.2	8.0	5.8	6	0.40 Eq H1-2	90.0	50	W10X33

Column Line 7 - A

Level	P	Mx	My	LC	Interaction Eq.	Angle	Fy	Size
Ground floor	30.2	8.0	5.8	6	0.40 Eq H1-2	90.0	50	W10X33

Column Line 7 - B

Level	P	Mx	My	LC	Interaction Eq.	Angle	Fy	Size
Ground floor	30.2	8.0	5.8	6	0.40 Eq H1-2	90.0	50	W10X33

Column Line 10 - A

Level	P	Mx	My	LC	Interaction Eq.	Angle	Fy	Size
Ground floor	22.6	5.2	7.4	1	0.43 Eq H1-3	90.0	50	W10X33

Column Line 10 - B

Level	P	Mx	My	LC	Interaction Eq.	Angle	Fy	Size
Ground floor	22.6	5.2	7.4	1	0.43 Eq H1-3	90.0	50	W10X33

F17. RAM STEEL Column Selections

Wood Planking for Joist Drop

Wooden planking, as seen over covered walkways for construction, will be placed on the metal decking that is welded to the top of the Structural Cage. Plywood will be placed in opposing orientations over the planks to act as a skin for the Structural Cage in the event of a joist fall from roof height.

Cost of Structural Cage

The cost for the proposed Structural Cage is as follows:

Dolphin Mall Expansion Project

A Structural Cage Material Estimate Prepared by Travis Anderson Smith

Item	Quantity	Weight	Length	Total Weight	$ Cost Per Unit	Unit	Total Cost
Concrete						**Total Cost**	$ 165.31
3'x3'x1' w/ 10% waste	Four	n/a	n/a	n/a	113.85	Cubic Yard	$ 165.31
Rebar						**Total Cost**	$ 53.20
18' #5 w/ 15% waste (1 ea)	n/a	1.04	72.00	75.10	0.71	Pounds	$ 53.20
Baseplates+Anchorbolts						**ECMD Quote**	$ 500.00
Substructure						**Total Cost**	$ 718.51
Columns						**Total Cost**	$ 7,801.20
W10x33	8.0	33.0	12.0	3168.00	2.46	Pounds	$ 7,801.20
Beams						**Total Cost**	$ 24,723.50
W16x31	10.0	31.0	26.0	8060.00	2.46	Pounds	$ 19,847.75
W10x22	6.0	22.0	15.0	1980.00	2.46	Pounds	$ 4,875.75
Roof						**Total Cost**	$ 10,471.50
3" 20 Guage Metal Roof Deck	1170	2.34	n/a	2737.80	1.95	Square Foot	$ 2,281.50
Planks	1170				3.00	Square Foot	$ 3,510.00
Plywood	2340	n/a	n/a	n/a	2.00	Square Foot	$ 4,680.00
Superstructure						**Total Cost**	$ 42,996.20
Total Structural Steel Cost							$ 43,714.71

F18. Structural Cage Cost Breakout

Decreased Impact on Construction

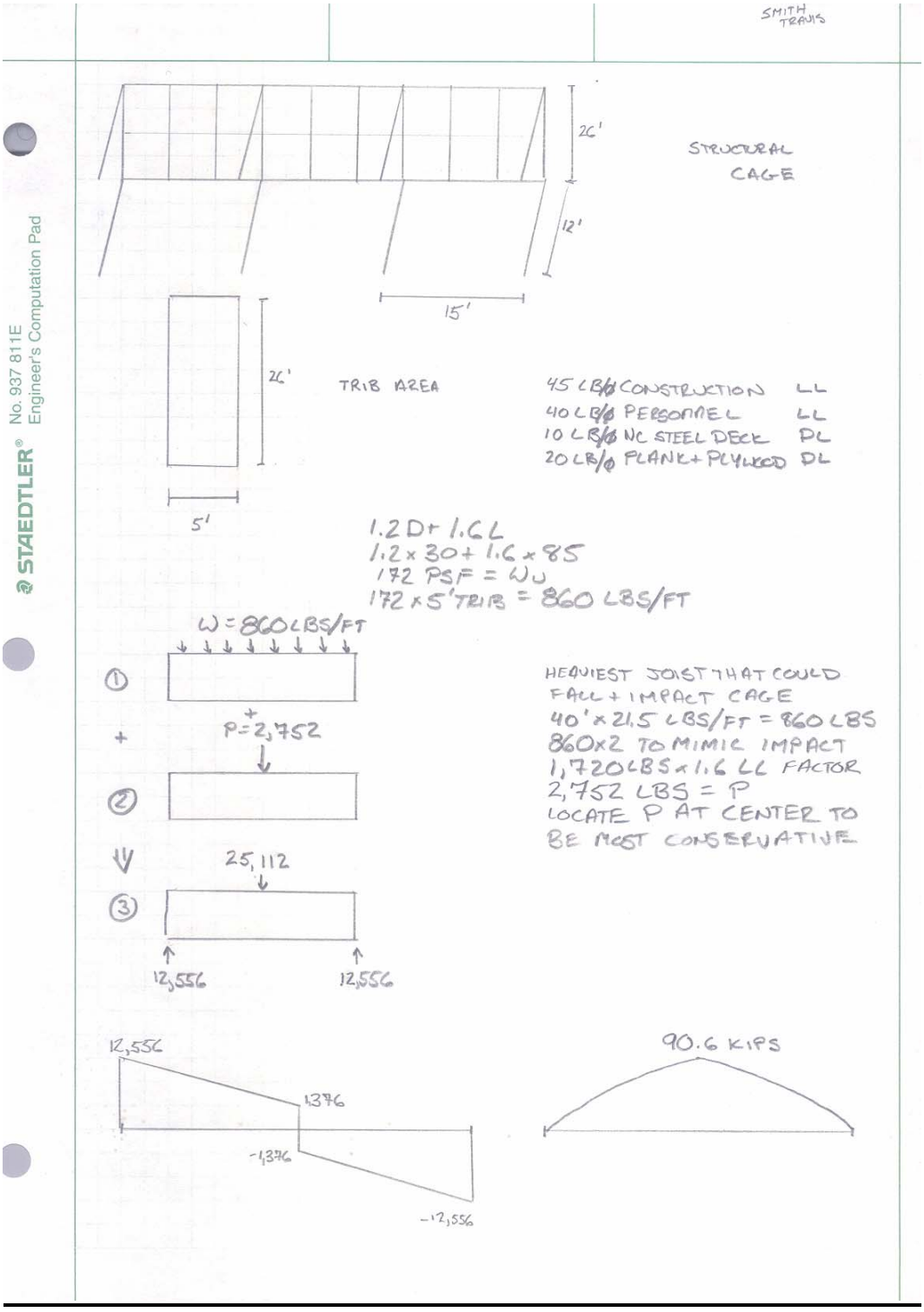
The following construction activities will greatly benefit from the use of the new Structural Cage:

1. Hurricane wall
   - The hurricane wall is the 146 mile per hour exterior of the temporary egress corridor.
   - Wall will now be constructed at exterior of tenant walls and mall space instead of the exterior of the temporary egress corridor. The wall will not interfere with the permanent egress corridor construction.
2. Temporary egress corridors
   - The decrease to the amount of construction required for the egress corridor is the driver to utilizing this value engineering idea.
   - Corridors will no longer be required along the joist line of demolition from North and South of Entry #1 to the North and West walls.
3. Sprinkler relocation
   - Sprinkler tie-in will now take place at Entry #1 and not at the North and West walls.
   - Total sprinkler amount required will no longer be as large.
   - Benefit because of Arfran II limited man power and schedule availability.
4. Selective demolition
   - Selective demo will need to be sequenced, but will have substantially less impact from the egress corridor.

- Location of previous design greatly restricted the selective demolition of both "Demo area North" and "Demo area South"

5. Shell demolition
   - Shell can not be demolished until temporary egress is available for the project.
   - Entry #1 will be ready for demolition significantly quicker then the previous design due to less construction time required.
6. Footing Installation
   - Footings at Entry #1 will need to be placed prior to Structural Cage but the remaining footings along Column Line "A" will no longer be restricted.
   - No restriction on pouring all footings outside of Entry #1.
   - Actual footing pour can take place after demolition, not before demolition as done previously.
     - Will prevent damage to footings and reinforcements.
7. Masonry block wall installation
   - Block wall will be completed quicker then previously planned.
   - Damage to the wall from debris and machines during demo will no longer be an issue.
   - Wall will be built in unison, and not require selective placement to compliment demolition and corridor construction.

Structural Cage Calculation Page 1



Structural Cage Calculations Page 2

SMITH TRAVIS

$\frac{WL^2}{8} + \frac{PL}{4} \Rightarrow \frac{860 \times 26^2}{8} + \frac{2752 \times 26}{4} \Rightarrow 90,558 =$ AREA UNDER CURVE

5-162 + 5-164 LRFD

USE 90.6 = ϕM_N CHART ⇒ TRY W16x31 / W12x26

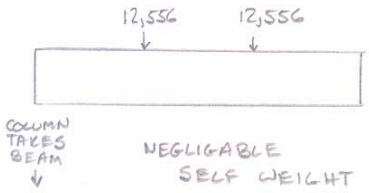
$\frac{PL^3}{48EI}$ + $\frac{5WL^4}{384EI}$

POINT DIST

W16x31 I = 375 = .648 IN

W12x26 I = 204 = 1.18 IN

USE W16x31 CONFIRMED BY RAM



COLUMN TAKES BEAM

NEGLIGABLE SELF WEIGHT

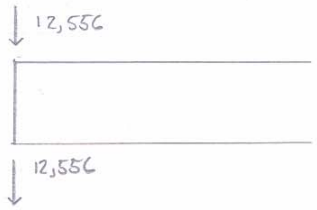
$M_{MAX} = P_A = 12,556 \times 5 = 62,780$ LBS ≈ 63 KIPS

Pg 5-101 LRFD USE $\frac{\ell}{360} = 1"$ FOR TEMP DESIGN

W10x22 I = 118

$\frac{Pa}{24EI}(3L^2 - 4a^2) \Rightarrow \frac{12,556 \times 5}{24 \times 29,000 \times 118}(3 \times 15^2 - 4 \times 5^2) \Rightarrow .440$ ✓

USE W 10x22 RAM CONFIRMS WEIGHT



KL = 12'

W10x33 CARRIES UP TO 276 KIPS

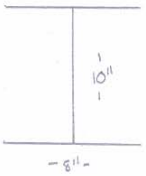
RAM CONFIRMS W10x33 BASED ON LRFD

SMALLER SIZE COULD BE USED.

STAEDTLER® No. 937 811E Engineer's Computation Pad

Structural Cage Anchor Bolt Calculations

SMITH TRAVIS



$P_U = 26$ KIPS

W10x33 COLUMN

APPROX 3'x3' FTG

$F'C = 3000$ PSI

$A_2 \geq 4A_1$ ASSUME

$26^K \leq .6 \times .85 \times 3000\,PSI \times A_1 \times 2$

$A_1 \geq 8.5\,IN^2$ VERY SMALL LOAD ∴ SMALL BR REQ. MUST BE LARGE ENOUGH FOR COLUMN + BOLTS

$D = 9.73$ $B_F = 7.96$

$\Delta = \frac{.95 \times 9.73 - .8 \times 7.96}{2} = 1.44"$

$N = \sqrt{8.5} + 1.44 = 4.36"$ ∴ DISREGARD SMALL MIN USE USE 14" OBVIOUSLY CONSERVATIVE BUT MUST FIT COLUMN

$A_1 = 14" \times 14" = 196\,IN^2$

$36/14 = 2.6$

$A_2 = 36" \times 2.6 \times 14 = 1311\,IN^2$

$A_2 = 1311\,IN^2 \geq 4A_1 = 4 \times 196 = 784\,IN^2$ OK ✓

$M = \frac{14" - .95(9.73)}{2} = 2.4"$

$n = \frac{14" - .8(7.96)}{2} = 3.9"$

$n' = \frac{\sqrt{(9.73)(7.96)}}{4} = 4.4"$

$\ell = 4.4"$

$t_p \geq 4.4" \sqrt{\frac{2 \times 26^k}{.9 \times 50\,KSI \times 196\,IN^2}} \Rightarrow .34"$ COULD USE 3/8 BUT 1/2" TO BE CONSERVATIVE AND ONLY A COUPLE $ MORE

$14" - 9.73/2 = 2.135$ COULD BE TIGHT SO USE 16"x16"

$A_2 = 36 \times 2.25 \times 16 = 1440 \geq 4 \times 256 = 1024\,IN^2$ OK ✓

16"x16" BASE PLATE

Structural Cage Footing Calculations

FOOTING DESIGN USE 3000 PSI, 28 DAY STRENGTH
SOIL REPORT SHOWS LIMEROCK AND SILTY LIMESTONE W/ BEARING WELL OVER 3000 PSI BUT BEING CONSERVATIVE IN CALCULATIONS

$P = 26^k$

$q_A \geq \frac{P}{A}$

$3 KSF \geq \frac{26^k}{B^2}$

$B \geq 2.94$

$q = \frac{26}{3^2} \Rightarrow 2.89 KSF = 2,890 PSF / 144 = 20 PSI$

$V_c = \phi 4 \sqrt{F'c}$

$0.75 \times 4 \times \sqrt{3000 PSI} \Rightarrow 164 PSI$

2WAY SHEAR

$d^2(164PSI + \frac{20PSI}{4}) + d(164PSI + \frac{20PSI}{2})(16") = \frac{20PSI}{4}[36^2 - 16^2]$

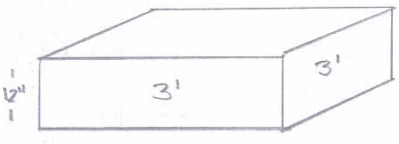
$169d^2 + 2,784d = 5200$

$D = 1.69"$ $H = d + 3" + d6$

$H = 1.69 + 3 + 0.625"$

$H = 5.315 \approx 12"$

EASIER FOR CONSTRUCTION + CONSERVATIVE TO THROW SOME #5's IN BOTTOM



Structural Cage Analysis Conclusion

The proposed Structural Cage design would lead egress through Entry #1 and not North and South of Entry #1 as previously done. Because the egress will go directly through Entry #1, it is my opinion as the Engineer of Record for the design that an impact cage is necessary.

Usage of the Structural Cage will improve activities such as the hurricane wall, the temporary egress corridor construction, sprinkler relocations, selective demolition, shell demolition, footing excavation and installation, masonry block wall construction and permanent corridor construction.

The cost of the structural cage is roughly $44,000 plus the cost of the temporary corridor running through it worth approximately $200,000. The total of $244,000 is significantly less then original cost of $750,000 for work that will stand for a matter of weeks before demolished.

CONSTRUCTABILITY REVIEW

Constructability Introduction

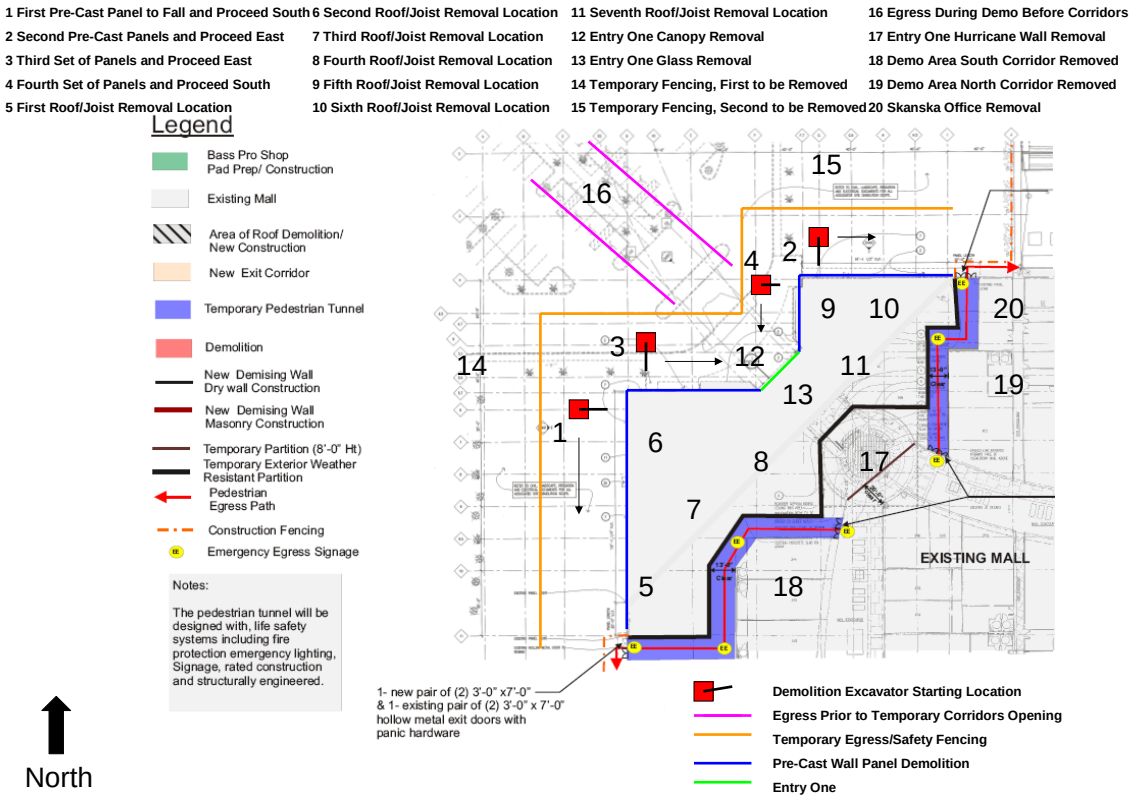
The Dolphin Mall Expansion project's temporary corridors control the schedule, and that leaves the constructability for the project with room for improvement. The temporary egress corridors, connecting Entry #1 with the public have proven troublesome for items such as demolition, foundations and block wall installation.

Demolition

The demolition for the project centered on Entry #1. Because of a delay in the temporary egress corridors, roof demolition was done with surgical precision to avoid destruction of any area that would be in conflict with egress. Selective demolition was done for approximately six-weeks to allow for schedule continuance while the "hurricane wall" was not installed. Without the "hurricane wall" exterior shell demolition could not continue.

Site Layout for Original Demolition

The Dolphin Mall Expansion project includes demolition. The demolition of the Northwest corner of Dolphin Mall must be completed in preparation for the addition of a new anchor store, Bass Pro Shop.



F19. Original Demolition Plan Layout

Original Demolition Sequence Without Structural Cage Egress

Dolphin Mall is one of the highest grossing malls in the country. Because operations can not be shut down, much of the demolition required had to be accomplished without interference with the mall. Two weeks of selective demolition were utilized to remove all existing interior mechanical, electrical, plumbing and fire protection materials.

Items 1-4 on the demolition plan consisted of the burning of the clips and joists, and dropping the panels at joints. Panels were saw-cut once on the ground and removed from site.

F20. First Panel Removed on West Wall.

Items 5-11 involved the removal of the roof system. A lightweight concrete roof system supported by engineered joists was removed in 40'x40' bays.

F21. Roof System Removal after Columns & Joists Were Burned

Item 12 & 13 are the awning and Glass entrance located at Entry #1. Because of egress requirements these two stages had to be accomplished after the installation of the

temporary egress corridors, listed as the temporary pedestrian tunnel in the graphic on the previous page.

Items 14 & 15 are temporary fencing moved throughout demolition to best suit site work utility installation.

Item 16 is the 30-foot wide egress through the heart of site work. The Miami-Dade Fire Department requires the 30-foot egress be rolled with no obstructions or change of elevation. Daily maintenance of the egress path was necessary.

Item 17 is the removal of Entry #1. After a temporary hurricane wall was constructed, the awning and glass entrance were removed.

Items 18 & 19 are the temporary egress corridors. The corridors were removed upon the competition of the permanent corridor located parallel to column line "A." Column line "A" becomes the interior tenant line for Bass Pro Shop.

Item 20 is the trailer location for Skanska's construction management team. The team is to be located in this position until close-out has been completed. Dolphin Mall will ultimately turn this location into "back-of-house" storage.

Foundations

The demolition of the exterior walls was done after Column Line "A" footings were installed. Constructability was flawed because with footings installed, demolition still had to occur on both sides of Column Line "A." Machines are therefore required to cross the footings, damaging rebar dowels as well as dropping roof debris on the newly installed footings and first two courses of block.

Masonry Block Wall

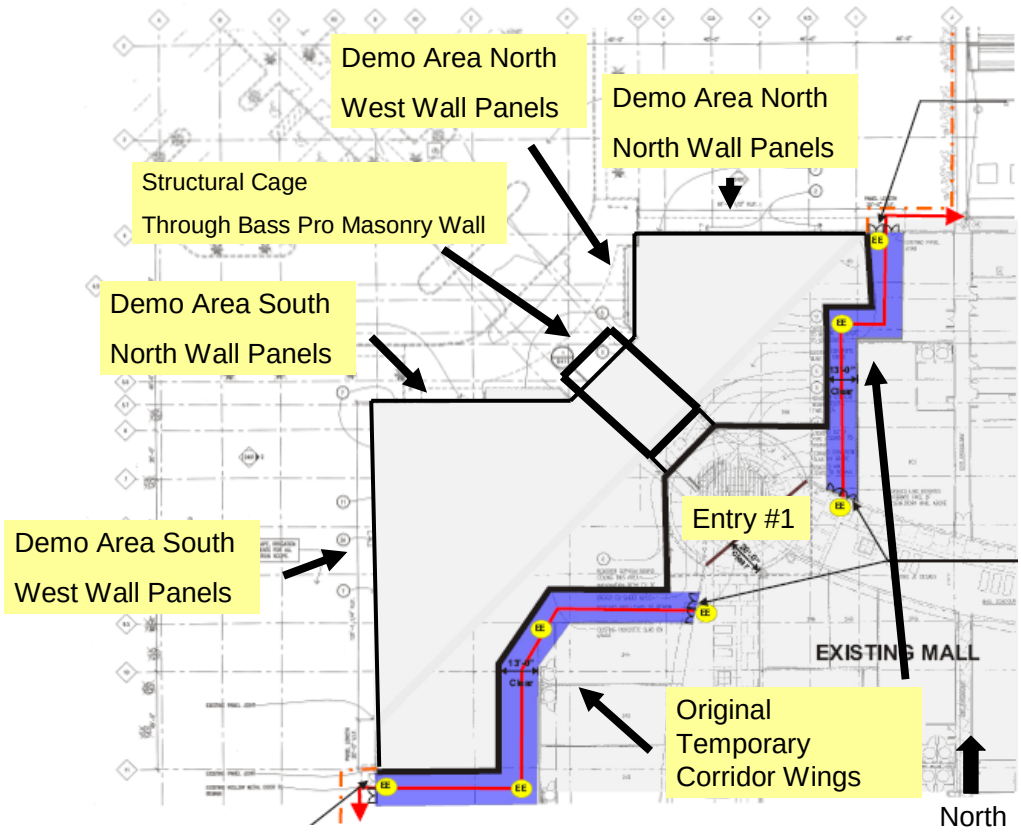
Masonry block was started upon competition of the footings along Column Line "A." Column line "A" was not completed in close proximity to Entry #1 because Entry #1 sat on 2 of the to-be footings. If egress is rerouted, the wall could be completed at one time, avoiding stepped, partial installation with less quality control. If schedule sequencing is altered, the masonry block wall will be substantially more constructible.

New Logistics Plans

The new sequence of construction based on the use of the Structural Cage in place of the two temporary egress corridors will allow for mall reconfiguration earlier then previously scheduled. The problematic Column Line "A" will no longer inhibit the demolition or construction plans.

Structural Cage Location

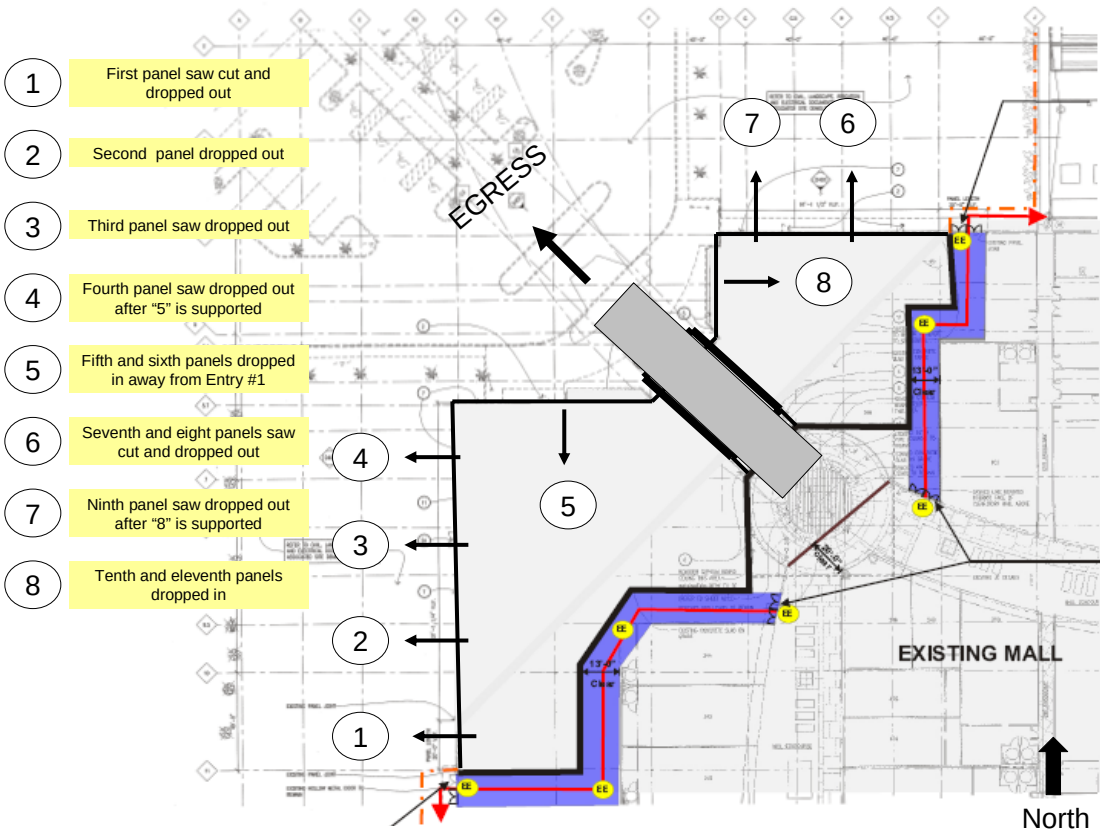
The structural cage will be located partially in Entry #1 and proceed through the 30'x16' opening into what will ultimately become Bass Pro Shop as seen below.



F22. Demolition Zone Breakdown

Exterior Panel Demolition

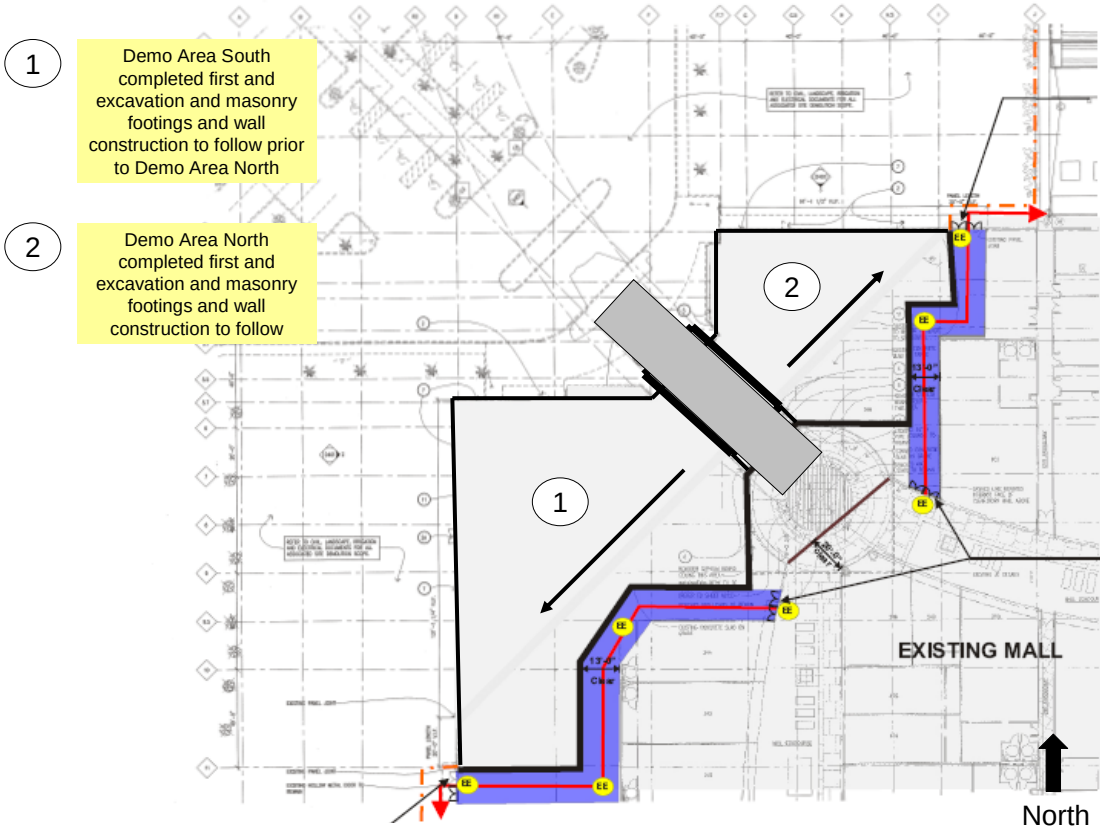
The exterior panels will no longer be dropped in an erratic fashion to best suit the exposed Column Line "A." Panels will be cut loose and dropped starting at "1" up to Entry #1. The panels located at "5" will be dropped into the demolition zone to avoid conflict with the egress. Panels at "5" will be shored up prior to demo after the dropping of panels along the West wall. A similar style of demolition will take place in Demo Area North. Because of the lag in demolition, excavation and construction can commence in the South zone while the North is demolished. Once panels are removed, Entry #1 will be demolished over the Structural Cage, and the masonry wall construction from both zones can be joined and finished. The schedule and ease of construction is improved significantly as shown below.



F23. Panel Locations and Demo Plan

Wall Construction

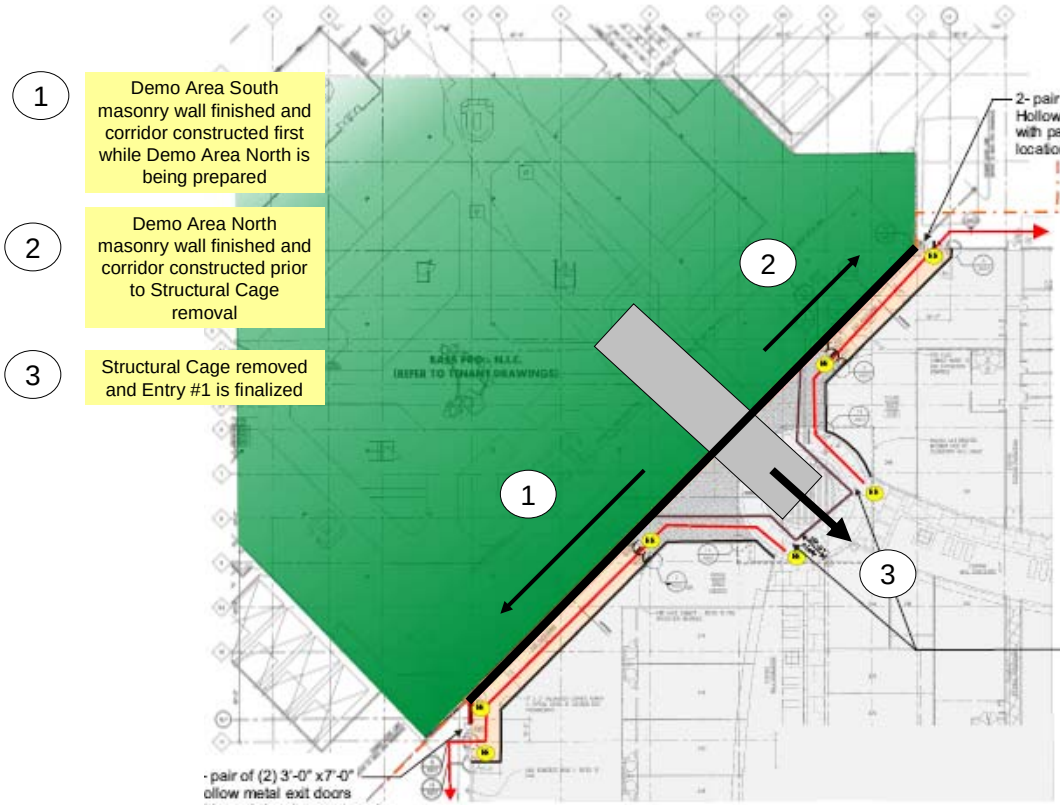
With demolition complete, masonry wall excavation, footings and block-laying will be accomplished starting in the South zone and proceeding into the North zone as seen on the next page.



F24. Column Line "A" Construction

Permanent Corridors

The permanent corridors will be placed upon masonry wall completion. The masonry wall will be completed at Entry #1, but the South zone will be completed before the North zone, and corridor construction will follow this lag before the Structural Cage is removed and a temporary wall is erected in front of Bass Pro Shop's soon-to-be entrance.



F25. Permanent Corridor Construction

Constructability Conclusion

The new sequence of construction based on the use of the Structural Cage in place of the two temporary egress corridors will allow for mall reconfiguration earlier then previously scheduled. The problematic Column Line "A" will no longer inhibit the demolition or construction plans.

The structural cage will be located partially in Entry #1 and proceed through the 30'x16' opening into what will ultimately become Bass Pro Shop. Once panels are removed, Entry #1 will be demolished over the Structural Cage, and the masonry wall construction from both zones can be joined and finished. The schedule and ease of construction is improved significantly. With demolition complete, masonry wall excavation, footings and block-laying will all be accomplished starting in the South zone and proceeding into the North zone. The permanent corridors will be placed upon masonry wall completion.

SCHEDULE REDUCTION

Original Detailed Project Schedule

The Dolphin Mall Expansion project is intended to be five months of intensive construction. Preconstruction commenced many months before mobilization to allow for Bass Pro Shop to begin work on October 2, 2006. Skanska U.S.A. Building Inc.'s work will conclude after Bass Pro has mobilized on-site. Both construction managers will be forced to coexist for approximately two months. The intended project schedule is broken down into subcategories.

Schedule Subcategories

- Permits-Permits
  - November 11, 2005 through September 14, 2006
- Site-Site Work
  - May 22, 2006 through October 30, 2006
- Bass Pro Shop-Boat Storage
  - June 5, 2006 through November 5, 2006
- Demo-Demolition
  - July 10, 2006 through September 7, 2006
- MC-Mall Reconfiguration
  - July 24, 2006 through December 1, 2006
- ID-Information Desk Relocation
  - November 11, 2005 through September 14, 2006

Permits

Permitting was a continuous process with the Miami-Dade Building Department. A site improvement and building permit was required. With each addendum, Miami-Dade Bldg. Dept. is required to review and approve all changes. The process includes resubmission of drawings, an expediting stage, and fee collection. Subcontractors are required to pull permits for each individual inspection area of the project they are responsible for. WASD approval is separate from the Miami-Dade Bldg. Dept. and was obtained after a three week evaluation period on September 7th, 2006.

Site Work

Mobilization took place on May 22nd, 2006 and proceeded throughout the demolition phase. Coordination was required to allow for utility tie-in while Pre-cast panels and the roof system were removed. A significant amount of storm water/ site drainage material was installed. The pad was supposed to be turned over on October 2nd, 2006 for use by Bass Pro Shop's construction team, but ultimately was completed later.

Boat Storage

Unlike the Bass Pro pad, boat storage had the ability for construction after the pad turnover date. Drainage, electrical, footings and a masonry wall were installed during the five-month duration.

Demolition

Demolition consists of system, selective and shell demolition. Removal of existing utilities had to be complete before the shell could be removed. Selective demolition was utilized to continue the demolition schedule when exterior Pre-cast panels could not be removed. An example of selective demolition can be seen in the roof top unit's removal. Dolphin Mall is located in a jurisdiction with hurricane restraints and requires a hurricane wall on its exterior at all times. Because of this code requirement, the interior of the demo areas were gutted and a temporary hurricane wall was constructed before panels and the roof system were touched. The last element removed was Entry #1. Entry #1 included an awning and glass door entrance. Egress restrictions forced this section of demolition to take place at the completion of the temporary egress corridors.

F26. RTU Removal for future re-installment

Mall Reconfiguration

Two former anchor stores were severed from Dolphin Mall. What remained of the two anchor stores was scheduled to be used as storage. The corner of the mall was removed in preparation for the addition of a new Bass Pro Shop. The mall was reconfigured to create an entrance 30'x16' into the new facility. Mechanical and structural systems were removed, altered, or installed to accommodate this construction.

Information Desk Relocation

An information desk located directly in the path of the new entrance was removed and reinstalled at Entry #2. The team was able to un-assemble the desk and reassemble it without need for a new design and construction. Existing concrete benches were trimmed and the desk's east side was cut 18-inches to allow for ten feet of egress between The Sports Authority tenant wall and the desk.

F27. Relocation area for Information Desk

Reduction Introduction

The Dolphin Mall Expansion project's temporary corridors control the schedule for the project. The temporary egress corridors, connecting entry #1 with the public, have proven troublesome for items such as demolition, foundations and block wall installation. The change of egress flow will require monitoring once exited from the building. By altering the design of the egress corridor 215 feet of egress construction gets cut to 45 feet. The time required to construct the Safety Cage will be minimal, and the overall temporary egress corridor construction will be cut by 75%. Because of the schedule decrease in the corridor construction, multiple other items can occur earlier then originally planned.

Permitting Schedule Reduction

Original 222 day duration starting on November 18, 2005 and ending on September 25, 2006 will be reduced to a 200 day duration starting on November 18, 2005 and ending on August 24, 2006.

- Permit #2
  - Earlier start date
  - *Shorter duration*
  - Less review required
  - Shorter resubmission
    - Initial Bldg. Dept. meeting required
    - Experienced Expediter
- WASD Permit
  - Earlier start date
  - *Shorter duration*
  - Address WASD early in project
  - Do not assume engineer is capable of getting approvals

Site-Work Schedule Reduction

Original 139 day duration starting on May 22, 2006 and ending on November 30, 2006 will be reduced to a 116 day duration starting on May 22, 2006 and ending on October 30, 2006.

- Early Start Date
  - Earlier start date due to permitting process duration shrinkage
- Electrical Service
  - Earlier start date
  - Earlier start date due to permitting allowing electrical contractor to mobilize
- Transformer Pad
  - Earlier start date
  - Electrical Service will be prepared earlier
- Parking Fixtures
  - Earlier start date
  - Fixture installation follows the transformer pad work
- Relocation of Existing Water Service
  - Earlier start date
  - WASD permit will allow water line through center of site to be relocated
- Relocation of Hydrant
  - Earlier start date
  - WASD line will need to be connected at building earlier then previously done
- Repaving and Stripping
  - Earlier Start date
  - Repaving and stripping will no longer need to wait for WASD line to be relocated
- New Curbing
  - Earlier start date

- Curbing will commence after WASD line is relocated

Bass Pro Boat Storage Schedule Reduction

Original 113 day duration starting on June 5, 2006 and ending on November 8, 2006 will be reduced to a 99 day duration starting on June 5, 2006 and ending on October 19, 2006.

- Storage Water Permit
  - Earlier start date
  - WASD permit will allow earlier boat storage work commencement
- Water and Sewer Line
  - Earlier start date
  - Water and sewer line will be placed earlier in schedule to allow for footing placement
- Footing Construction
  - Earlier start date
  - Footing construction on southwest wall will no longer require a delay before construction
  - Footings and walls will be placed concurrently with no need for phased construction due to permit lag
- Road Cutting and Final Grading
  - Earlier start date
  - Early wall completion will allow grading commencement to accurate grade height
- Entry Gate
  - Earlier start date
  - Entry gate will be installed upon completion of Boat Storage walls
- Landscaping
  - Earlier start date
  - Irrigation and plant installation will commence with conclusion of wall construction

Demolition Schedule Reduction

Original 50 day duration starting on July 10, 2006 and ending on September 15, 2006 will be reduced to a 35 day duration starting on July 3, 2006 and ending on August 18, 2006.

- Structural Cage
  - Five day duration
  - Required cage for egress
  - Will require Entry #1 footing excavation and placement prior to erection
  - Will speed up numerous demolition activities
    - Shell demolition
    - Column Line “A” excavation
    - Storm water placement in site work
- Footing Placements
  - Earlier start date
  - *Shorter duration*

    - Start at Entry #1 and work both North and South
    - No potential destruction during demolition
        - Previous design ran footings through demolition zone to expedite the schedule misses
- Corridor Construction
    - Earlier start date
    - *Shorter duration*
    - Temporary egress corridor North no longer required
    - Temporary egress corridor South no longer required
        - Hurricane wall placed at exterior of tenant spaces
- Demolition Sequence
    - Earlier start date
    - *Shorter duration*
    - Not required to work across Column Line "A"
    - Drop exterior shell then proceed to Entry #1
- Masonry Wall
    - Earlier start date
    - *Shorter duration*
    - Placed in one sequence without stoppage for demolition
- Decreased Framing and Sheathing
    - *Shorter duration*
    - Framing and Sheathing for temporary egress corridor cut from 215 lineal feet to 45 lineal feet plus tenant walls
- Removal of Slabs
    - Earlier start date
    - *Shorter duration*
    - Slab removal no longer required to be phased with demolition.
    - Slab can be removed upon dropping of roof joists
        - Demolition contractor prefers slab act as smooth surface for material separation into dumpsters
- Temp Corridor Electrical/Fire Alarm/Fire Protection
    - Earlier start date
    - *Shorter duration*
    - Significantly less material required to complete task
- Demolition of Temporary Corridor
    - Earlier start date
    - *Shorter duration*
    - Substantially less temporary material required to be removed during construction of wall
- Temporary Entry #1 Wall
    - Earlier start date
    - Bass Pro Shop protective partition erected earlier

Mall Reconfiguration Schedule Reduction

Original 137 day duration starting on July 24, 2006 and ending on January 1, 2007 will be reduced to a 91 day duration starting on July 3, 2006 and ending on October 6, 2006.

- Easier Demolition Sequencing
  - Masonry wall will no longer inhibit demolition along roof cut line
- Footing Excavations
  - Earlier start date
  - Excavation at North and West walls will be excavated with all of Column Line "A"
- Wall Installation
  - Earlier start date
  - *Shorter duration*
  - Installation will not be phased
  - No break lines in mortar
- Steel Erection
  - Earlier start date
  - Steel erection from roof cut line to masonry wall will be accomplished sooner
  - Requires earlier submission of structural Shop Drawings to Miami-Dade Building Department
- Relocation of Drainage
  - Earlier start date
  - Drainage coincides with steel erection
- New Roof
  - Earlier start date
  - Roof placement follows competition of deck placement on steel joists
- Wall Finishes
  - Earlier start date
  - Finishes will take place upon completion of wall construction
- Drywall Placement
  - Earlier start date
  - Drywall will be hung, taped and coated upon completion of wall construction
- Lighting/Fire Alarms/Sprinkler Installation
  - Earlier start date
  - Systems will be installed upon completion of wall construction
- HVAC Tie-In
  - Earlier start date
  - HVAC duct and control placement coincides with roof and wall construction
- Doors
  - Earlier start date
  - Placement to follow Drywall and followed by C.O.

Info Desk Relocation Schedule Reduction

Original 72 day duration starting on October 9, 2006 and ending on January 16, 2007 will be reduced to a 20 day duration starting on September 11, 2006 and ending on October 6, 2006.

- Electrical Relocation
  - Earlier start date
  - Electrical work will commence prior to C.O. awarded to corridor
- Concrete Patching
  - Earlier start date
  - Patching to coincide with patching from mall configuration
- Desk Relocation
  - Earlier start date
  - Last mall construction
  - Follows completion of corridor
- Bass Pro Entrance Partition
  - Earlier start date
  - Temporary wall at entrance to Bass Pro Shop

Schedule Reduction Conclusion

The schedule can be significantly reduced in multiple categories. The use of the Structural cage and improved permit planning will allow for reductions in permitting, site-work, demolition and construction.

The permitting schedule reduction is 22 days starting with the original 222 day duration and decreasing it to a 200 day duration. The site-work schedule reduction is 23 days starting with the original 139 day duration and decreasing it to a 116 day duration. The Bass Pro Boat Storage schedule reduction is 14 days starting with the original 113 day duration and decreasing it to a 99 day duration. The demolition schedule reduction is 15 days starting with the original 50 day duration and decreasing it to a 35 day duration. The mall reconfiguration schedule reduction is 46 days starting with the original 137 day duration and decreasing it to a 91 day duration. Finally the info desk relocation schedule reduction is 52 days starting with the original 72 day duration and decreasing it to a 20 day duration.

The modified schedule is included to clearly illustrate the schedule reductions available through value engineering and the use of a Structural Cage through Entry #1

COMMISSIONING RESEARCH

Dolphin Mall Commissioning Introduction

The Dolphin Mall Expansion Project requires the relocation of one roof top unit and the addition of another. The owner and contractor have decided that because construction is limited to an entry and corridor, there is no commissioning on the job regardless of the $450,000 mechanical contract. The mechanical engineer, in compliance with a testing and balancing subcontractor, will monitor the installation and operation of the space. It is for this reason that the prospective addition of utilizing a Commissioning Agent was thought up. A survey was compiled asking a number of questions concerning experience with commissioning.

Commissioning Background

Commissioning costs between .15 and 1 percent of total construction cost yet pays back 3 to 11 dollars for every one dollar spent in fees. The benefits include:

- Improved coordination of CD's
- Accurate specs
- Reduced RFI's
- Reduced costs
- Reduced callbacks
- Knowledge increase
- Smooth turnover of building
- Reduced energy costs
- Design air quality
- Enhanced documentation
- Risk mitigation
- Function from day one
- Third party reviews

Commissioning Survey Sent to Approximately 1000 Industry Members

My name is Travis A. Smith. I am an Architectural Engineering student at The Pennsylvania State University, researching the construction industry's building commissioning process. Attached is a short Word Doc. survey created to assess commissioning experience, success and failures. The survey is currently being released to all regions of the United States and will be answered by Owners, Architects, Engineers, Commissioners and Construction Managers and Contractors. Your responses will be kept confidential and all information obtained will be utilized solely for academic purposes. Please feel free to answer any questions that your experience permits.

Your assistance on this survey will be greatly valued. Responses can be emailed to tas317@psu.edu. You may also mail your responses to Travis A. Smith, 338 Reynolds Ave. Bellefonte, P.A. 16823. Handwritten or typed responses on the survey or separate sheet are perfectly acceptable. Results will be analyzed in late February. Your expedited reply to the survey is most appreciated.

Sincerely,
Travis A. Smith
Pennsylvania State University
Architectural Engineering Graduate Student
Construction Management
President of D.B.I.A. Penn State Chapter
Vice President S:P.A.C.E.
Architectural Engineering Undergraduate Teaching Intern

1. Your Name:

2. Current Company (optional):

3. Commissioner, Engineer, Designer, Construction Manager, General Contractor, or Owner:

4. Have you been involved with commissioning before on a project?

5. What is the approximate number of projects with respect to commissioning that you have been involved with?

6. Public or Private Project experience with commissioning:

7. Type of project(s) commissioning was implemented on (can be multiple):

8. What was the approximate total cost of each project?

9. Based on your experience, who should hire the commissioning agent and why?
    - o Owner contracted commissioning agent
    - o Contractor contracted commissioning agent
    - o Third party commissioning agent agreed upon by o/a/c
    - o Owner and Contractor each hire a commissioning agent

10. What is the best time to get a Commissioning Agent involved with the construction process?

11. What is the best method to utilize a Commissioning Agent during the construction process?

12. Based on your experience, should the Commissioning Agent be involved with the specification writing, and if not, which project types and why?

13. Do post occupancy reports convey any trends with respect to commissioning?

14. Based on your experience, do buildings perform at a higher level when commissioned at different times in the building process?

15. Are there trends in the number or type of callbacks in commissioned or non-commissioned building?

16. Who should decide the percentage of system checks for passage during the commissioning process (i.e. how many faucets/toilets/lights operate correctly?)

17. Does commissioning directly effect the as-built drawings turned over to the owner?

18. Are warranty costs lower with different commissioned buildings?

19. Should Operations & Maintenance be outsourced to the Commissioning Agent, and what is your experience with such occurrences?

20. Should a permanent member of the O&M team be on the commissioning team, and what is your experience with such occurrences?

21. Should General Contractor warranties begin at substantial completion or when a Commissioning Agent recommends they begin (to assure systems are at 100% before the start date?)

22. Is commissioning fiscally responsible for all buildings types and sizes, and if not why?

23. What are your positive experiences with commissioning?

24. What are your negative experiences with commissioning?

Survey Involvement

The following companies chose to acknowledge who they were when asked for identification on the survey. A special thank you is extended to all who participated. Clark Construction Group, Metropolitan Transit Authority-New York City Transit, Clark Construction Group-California L.P., The Pennsylvania State University, Burns & McDonnell Engineering Company, Inc., LCS Constructors, Inc., O&G Industries, Inc., Dorvin D. Leis Co., Inc., Purdue University, M.A. Mortenson Company, Gilbane Building Company, Ryan Companies, Parsons Corporation, Barton Malow Company, Olympic Associates Company, Fentress Bradburn Architects, Yost Grube Hall Architecture, City of Phoenix Water Services Department, Momentum Inc., Carroll County Government, Hensel Phelps Construction Co., CCI Mechanical, Inc., Freese & Nichols, Inc., Great Valley Consultants, Opus North Corporation, Con-Way Freight Inc., Pegasus Group, ECC International, LLC, Welsh Commissioning Group, Inc., GRD Energy, Bonestroo, Rosene, Anderlik & Associates, CH2M HILL, WCS/Ca, KJWW Engineering Consultants, Green Time LLC and GRG Inc., McKinstry Company, Carter & Burgess, Inc., Rosendin Electric, Inc., ACS Installations, Environment & Facility Management, Chinook Systems Inc., Bechtel Power Corporation, Centex Construction

Company, and Sustainable Engineering Group. Additional companies are included in the survey and choose to remain anonymous.

Surveyed Population

The survey consists of six commissioning companies (12%,) twelve owners (24%,) four architecture firms (8%,) twenty-two contractor or construction managers (44%,) and six engineering firms (12%.) Some participants fit into multiple categories and therefore were placed according to the position held by the surveyed individual. A total of fifty (50) surveys were utilized for research.

Commissioning Experience

The project experience for those involved in the survey is as diverse as the backgrounds the individuals come from. The number of commissioning projects one has been involved with varies from only one, up to quantities in the hundreds. Thirteen of the participants have experience on five or fewer commissioning projects (26%,) fourteen participants have experience with five to ten projects with respect to commissioning (28%,) nineteen members of the survey pool have worked on ten to fifty commissioned projects (38%,) and four surveyed have experience with over fifty projects (8%.)

Commissioning Resistance

Industry's resistance to the green building movement is related closely to the cost benefit analysis. If an owner can't be adequately convinced that a potential cost increase to make his building green can be outweighed by environmental advantages, or even the often overlooked long term life cycle of a facility, then green is typically pushed under the rug. Is commissioning any different? In theory those who operate a facility are interested in long term commitment while those looking to flip a development share little concern with respect to long term goals, as they will be making interest on their investment long before such dividends would be paid. The survey backs up this industry standard by resulting in an overwhelming public-to-private project involvement ratio for commissioning. The government is currently very much in favor of commissioning.

Public vs. Private

Twenty of the survey pool have only ever commissioned public projects (40%,) twenty-four of the surveyed have worked on both public and private projects that involved commissioning (48%,) and six of the surveyed have worked solely on private projects involving commissioning (12%.) Therefore a substantial eighty-eight percent of those in the survey have been involved, in some capacity, with a public project's commissioning process. An easily understood statistic when "public" by its very nature implies "the peoples," and the representative of the people, the government, is well aware of the necessity to commission a building to prevent life cycle damage and cost escalation.

Does the Dollar Control Commissioning

Public projects clearly utilize the commissioning process more often then private projects. Is this a direct reflection of cost? Is commissioning a "big boys" technique reserved for projects of mass scale and cost? Is commissioning done on smaller projects,

and just how small is small? Declaration of project experience in the construction industry is often taken with a grain of salt do to the influx of ones "bigger and better then you" ego. With ***honest*** results in this survey, returns make clear that commissioning is done more often on larger projects. What does this tell us? Do projects with new or substantial HVAC and electrical installations typically require more attention then smaller renovations or fit-outs? The fact is, the survey is inconclusive as to what projects are getting commissioned simply based on cost, but it does show that projects that do cost significant amounts are being commissioned. The results are synonymous with the purchase of a high-end vehicle. The more expensive the vehicle, typically, the more in-depth the maintenance will be.

Project Cost Data

Many believe that it is simply not fiscally intelligent to commission a smaller project because the value added is not great enough to offset the cost. This is an item that will be discussed later in the survey. Four percent of those polled have worked on a project valued under $100,000 where commissioning took place, while nine percent have experience with a project value of $100,000-$1,000,000. As the cost of the project grows, so does the respective percentage. Twenty-three percent of those surveyed were involved with a project in the range of $1,000,000-$10,000,000, forty-four percent in the $10,000,000-$100,000,000 and finally nineteen percent have experience with projects valued at over $100,000,000. While there are exponentially more projects in the United States, and abroad, in the $1,000,000 and less project range, a higher ratio valued at $100,000,000 are commissioned. Owner preference, industry knowledge lag, value analysis, or simply ignorance to what commissioning is can all be attributed to this.

Commissioning Project Types

Knowing that lower total cost projects are commissioned less, what projects out there are being commissioned? The survey pool has a large variety of commissioned work experience inclusive of: *schools, offices, hospitals, condominiums, performing arts centers, clinical research centers, power plants, specific government facilities, commercial spaces, laboratories, healthcare facilities, museums, industrial projects, pharmaceutical facilities, retail space, universities, airports, biotechnical facilities, hotels, manufacturing plants, transportation hubs, bus depots, community centers, warehouses, data centers, libraries, central plants, various renovations, maintenance facilities, municipal buildings, postal centers, utility projects, athletic facilities, aviation facilities, food plants, waste water treatment facilities, baggage handling systems, senior centers, trade/financial centers, sewer construction, demonstration wetlands, lift stations, clean room construction, military centers, police stations, oil/gas facilities and stations, foreign resorts, emergency tunnel ventilation plants, subway tunnel infrastructure, nuclear facilities, chemical plants, and rail system command centers.*

Commissioning is not just for the heavy MEP projects. There is no right or wrong way to commission every project. The purpose of the survey is to find out what has worked, and what has not from the very people who utilize commissioning.

Who Hires The Commissioning Agent (CxA)

To best analyze some of the responses of those surveyed, the information has been broken down into five categories; commissioners, architects, engineers, contractors/construction managers and finally owners. Some opinions will coincide with each other, while others are distinctly different. Commissioning is like a popular recipe, it is never done the exact same way by everyone who uses it, and can have different end products. There is no expected right way to do commissioning coming from this research, but a documentation of what industry currently does will be revealed.

Commissioning is not always too expensive, too time consuming, adversarial relationship building prone or simply put, not necessary. Commissioning can be the perfect cure to the building performance dilemma, but usually is just overall a good idea to deliver a product like it was intended to be purchased.

The hiring of a CxA is often the cause of many disputes. Contractors get aggravated by an owner putting a watch-dog on them. Architects feel a contractor hired agent will solely serve their boss and not the building project.

In the event that a commissioning process is deemed desirable who should hire the commissioning agent.

Owner Opinions on Hiring of CxA

Ten owners want an owner contracted commissioning process. Only one owner saw benefit in having the contractor hire the agent and one owner felt both an owner and a contractor should have their own agent.

Those believing in the owner hired agent had the following comments:
"Having an owner and third-party is a waste of money and creates problems,"
"Contractors should never hire the agent,"
"CxA must work in the best interest of the owner, loyalty to the owner and no one else,"
"Typically done through the designer unless distrust becomes evident between contractor and designer,"
"Depends on the project set up, but owner should hold the checks and balances,"

The owner in favor of contractor control of the CxA had the following opinion:
"Owner should have representative knowledge about the process but the contractor should provide greater coordination inclusive of scheduling."

Contractor/Construction Manager Opinions on Hiring of CxA

Five contractors want an owner contracted commissioning process. Eleven contractors saw benefit in having the contractor hire the agent, three contractors wanted to form an agreement with the owner and select a CxA, and two contractors felt each party should hire their own Agent.

Those who support the owner hiring the agent are quoted with the following:
"Keep it in the owner's hands so contractors don't cut corners,"

"Owner can do it but the architect should really be in charge since you can't hide the design deficiencies on a project, so why not resolve them out in the open,"
"Owner, but contract documents must be explicit about responsibilities,"

Believers of the contractor hired agent process are quoted with the following:
"If in contractors scope utilize a cm contracted agent to avoid complicated interfaces between the owner and contractor especially in design build where the contractor is responsible to turn over to the owner a contract compliant plant or facility,"
"95% of the time the owner lets us handle commissioning in-house based on our expertise, the owner typically has no idea what to do or the time to deal with this issue,"
"Owners are too busy, A/E like to think it's a conflict of interest if we do it but CM's can better manage a CxA and for each of us to hire one is just too costly,"
"Contractor should hire the CxA to minimize cost,"
"As long as there are updated drawings, the contractor should handle the CxA,"
"Design builder has the intimate knowledge that an owner doesn't, owner can help select but the process needs to go smoothly with no ground standing consultants hired by the owner who are worried about how they look,"

Support for a third party CxA agreed upon by both owner and contractor believe the following to be true:
"A third party commissioning agent that has the knowledge of the process and project that is agreeable to both the owner and contractor is ideal,"
"Pay them from a predetermined allowance but let the contractor and owner agree on who the CxA is,"

The hiring need for two agents is explained with the following:
"The contractor is required to do the testing, balancing and oversee systems operate to spec but an owner contracted agent could also spot check the contractor hired agent,"
"Delivery method, level of contractor involvement, competency criticality and complexity decide that one for us, but comfort level is a big one and so owner and contractor should each have one,"

Engineer Opinions on Hiring of CxA

Engineers believed that the owner should hold the commissioning agent. Engineers are most likely contracted by the owner and see little benefit in letting the contractor oversee the checking of installation and operation. Support comments of the owner doing the hiring are as follows:
"Owner should hire, but spot check his agent,"
"If owner hires, then no conflict of interest,"
"Make sure you throw in a year of O&M on that owner contract,"
"You don't want the contractor to intimidate the agent,"
"I have worked on projects where owner or contractors have both had success with hiring but I lean toward the owner being in charge of his building."

Commissioner's Opinions on Hiring of CxA

Commissioners stated that they most prefer to be contracted by the owner. A feeling of restriction exists when a contractor hires an agent to check his work. One commissioners saw benefit in the owner and the contractor hiring an Agent.

Owner hired commissioners are quoted as follows:
"No conflict of interest when reporting deficiencies,"
"Ideally if the owner does it, but contractor and owner need control,"
"By and far, the owner contract is the best commissioning provider,

Architect's Opinion on Hiring of CxA

All architects polled strongly support the owner contracted Commissioning Agent. Architects are quoted with the following:
"Owner is paying for it and deserves to know systems are installed as expected,"
"LEED requires both owner and contractor hired agents otherwise leave it to the owner,"
"Owners building he deserves the value."

When the CxA Should be brought on According to Owners

Owners with desire to use the CxA early on:
"During design at the latest,"
"At the conclusion of schematic design,"
"Early in the construction phase of the project,"
"During design document creation,"
"Prior to design development,"
"Planning and design is ideal to sign on a commissioner to assist in determining what a potential building could need to operate completely,"
"Construction kick-off meeting with contractors,"
"During the conceptual phase"

Some owners differed in opinion as to when they like to get commissioners on-board:
"As part of construction administration and inspections,"
"After the project is 25% complete,"

When the CxA Should be brought on According to Contractor/Construction Managers

General contractors are in general agreement and have comments with respect to the best time to get a commissioning agent involved. Responses include answers such as:
"Design phase,"
"During development, then again after design is complete, and finally during the acceptance of turnover packages and balancing,"
"Early enough to create a schedule that coincides with construction,"
"Peer review is a good idea before drawings are created,"
"Throughout design and construction,"
"During the submittal phase,"
"During the kick-off meeting with the architects and engineers,"

"Early but focus on the transition from civil into the MEP work during construction,"
"Preconstruction is the time to play with design before it is complete,"
"Get the commissioner involved in the program phase conversations,"
"During the final stages of rough-in, prior to the close of interiors,"
"No later then programming,"
"Commissioners know manufacturers and products and that can be a huge ally down the road."

When the CxA Should be brought on According to Architects

Architects are known to have a level of resistance toward commissioners stealing some of their thunder. Architects reported their intent to better the building but not relinquish responsibility.

Architect responses to the best time to get a commissioning agent involved on a project are:
"Early design phase is ideal,"
"Commissioners need to have input on systems and controls during design,"
"If the mechanical engineers have anticipated commissioning in their system design it may not be necessary to bring your CxA into the project until systems are nearing completion perhaps in phases long before completion of the whole building,

When the CxA Should be brought on According to Engineers

Engineers were reportedly less resistant then architects to having system design assistance.

Responses to the best time to get a commissioning agent involved on a project are:
"As early as possible in the design process,"
"CxA need to know project requirements and design intent early on so they can do their job they way they are needed to, right from the beginning!,"
"Peer reviews can be a huge asset to verify if design can meet an owner's expectations,"
"During design to ensure it is constructible."

When the CxA Should be brought on According to Commissioners

Commissioners actually prefer to meet with the owner before the architect is hired. Commissioners feel they are often silenced by architects with reputations.

Commissioner responses to the best time to get a commissioning agent involved on a project are:
"During planning before hiring the architect and engineers,"
"It is best to get involved in the design process before construction ever begins,"
"The earlier the better, but the start of construction has to be the absolute latest,"
"Owners project requirements and basis of design should be followed by a commissioner's review,"
"Depends on philosophy and budget, because the book tells you prior to schematics, but a review before final documents are drawn up typically will get the job done."

Proper use of a Commissioning Agent Once On-Board

When asked how you should utilize a commissioning agent once he/she is on board, responses varied. Some look for the CxA to be a major team player while others simply want to utilize them as a spot checker. The following are the responses of the surveyed:

"CxA's need to be on site once construction commences,"
"Accepted design needs to be monitored during the construction phase,"
"CxA is in charge of developing and managing plans for commissioning, they need to be part of the team, the more time they give you during design the less they will be required to give during the later stages of the project,"
"Agents should coordinate all the equipment installations, testing and integration, oversee installing contractors and coordinate pre-start and start-up checklists then following through with acceptance testing and resolving issues during construction,"
"Pre-functional inspections, witness testing and validation of scenario based performance testing,"
"Quality assurance and plan development are essential,"
"Working at the behest of the owner, coordinated by the contractor as a part of the team,"
"Field inspections to catch problems early,"
"Cost effective to utilize the CxA early and not during construction,"
"Create and use a Cx schedule,"
"Architects review work so it is a waste of money to have a commissioner do it as well, but pre-testing checklists should be signed by the contractor to save a commissioner from constantly having to be on-site,"
"LEED guidelines should be used for use of a commissioner,"
"Set up a schedule and plan with the contractor, because at the end of the day the project manager owns the job,"
"CxA runs bi-weekly meetings with constructability reviews,"
"Commissioning should be phased,"
"Should visit suppliers before shipping, report any deviations and create a completed commissioning manual at project close-out,"
"Quality control and value engineer it all,"
"Constantly review submittals, be preventative not reactive,"
"Preparation of the Cx plan, master equipment list, develop construction checklist, functional performance tests, O&M manual review, training facilitation and Cx process and meeting facilitation,"
"Use ASHRAE Guideline 0 for methods and approach,"
"Paper collector or in the trenches depends on what works for the owner,"
"Becomes more involved as equipment and systems are delivered, installed and started-up, absolutely require one year of O&M in the contract,"
"Commissioning agent defines the process for everyone; develop a commissioning plan that is bought into by the subcontractors."

CxA and Specification Writing

It is obvious that there is an overwhelming desire to get the commissioning process going as early in the project as possible, most of those surveyed claim the design phase is ideal. Intending this to be the case, the survey requested input on whether or not

the commissioning agent should be involved in the specification writing. There is no specific trend in any of the five subgroups.

62% of those surveyed feel the CxA must be involved in the specification writing. Comments for those who support this are as follows:
"Especially performance based specifications so any element that is important to the CxA should be included in the specs,"
"Yes but only on design-build projects where construction can commence prior to final design,"
"Commissioning is the capstone event of the building and bridges the construction phase to the lifetime occupation and use of the structure,"
"Section 01810 is all theirs,"
"A project of typically more then 10,000,000 will typically have a budget to get the CxA involved with specs,"
"A CxA can adapt to specs written by others but this is not optimum,"

38% find no need for a CxA to be involved in specification writing and instead feel they should be limited to system review and construction. Comments for those who support this are as follows:
"The CxA should be checking specs not writing them, the liability of their design is on their professional registration,"
"Review and comment,"
"CxA are not the design professional of record but they can provide recommendations, it is the designer's responsibility to write specs,"
"CxA need to write the specs for any commissioning related activity,"
"No because the input can be onerous and self serving,"
"CxA is responsible only for commissioning scope of work not design,"
"CxA have no risk in the game,"
"Rarely is it the case that a public-sector client has gotten their agent hired before design and documentation wrap-up,"
"The commissioning team implements the end product and must assume that the design is 'fit for purpose,'"
"Writing specifications can blur the distinction,"

Post Occupancy Reporting

To best understand the benefits of commissioning one can look at the post occupancy report of a building. When asked if commissioning plays a role in the post occupancy reports on projects 68% said yes while 32% said commissioning plays little role in post occupancy reports.

Of those who felt that post occupancy reports were effected by commissioning the following comments were made:
"Less services calls as a result of systems operating as designed,"
"POR absolutely convey trends in commissioned facilities by stating the performance of commissioned systems and whether or not they are maintained properly,"

"Significantly less call backs, warranty issues and comfort or performance issues become almost non existent,"
"POR prove the value added by commissioning,"
"Makes transition from construction to operation more thorough and less troublesome, this should eliminate downtime,"
"Absolutely- the trending uncovers serious design & installation issues that can impact occupant comfort heath and energy costs when commissioning is not brought on board,"
"POR tells a story about not only how well the commissioning process went but in some cases reveals flaws in equipment,"
"A desire for healthier post-occupancy reports is driving the industry towards sustainability and LEED which in return results in a need for commissioning, especially if re-commissioning is in the 5-10 year plan,"
"POR portray a much lower level of complaints, can show a success or a very real example of lessons learned,"
"POR are our educational tool to fine toothed comb the bugs in commissioning,"
"Fewer issues are the result of correcting/managing the problems during the commissioning process,"
"POR are the only way to know whether or not commissioning is useful, in my experience its clear cut that lack of commissioning on a project results in system difficulty post occupancy,"
"The owner is always more satisfied knowing he got what he paid for,"
"Trends are the simplest method to map performance."

For the members of the surveyed population who saw little impact of commissioning on post occupancy reports the comments are as follows:
"PORs typically represent design and construction issues not commissioning,"
"POR are user group concerns with the project,"
"Commissioning leaves short of preparing occupants for facility operation,"
"O&M staff must be armed with everything it takes to run the facility correctly otherwise POR can be a moot point,"

Commissioned Building Performance

Post occupancy reports may invite criticism as self serving but they are a very solid tool in the hunt for commissioning success. Owners are the best source, but are not the only ones out there with evidence on the level of performance of buildings that have been commissioned.

When surveyed, the pool's positive responses on whether or not commissioned buildings perform at different levels were as follows:
"Commissioned buildings are the least expensive and are impacted greatest by early commissioning,"
"Commissioning must be implemented over the life cycle of the facility, the earlier the CxA got involved the better the building performed,"
"Definitely the purpose of a CxA is to validate that the owner gets exactly what he signed his name for,"

"Sadly we have found that if not commissioned, owners will take an incomplete or flawed as-installed building system because of the great cost of corrective action,"
"Commissioning is the easiest way to get balanced,"
"If we tune our cars on a consistent basis why wouldn't we want to tune-up our buildings and commissioning allows the opportunity to fine tune the machine,"
"Bottom line is absolutely yes, buildings and their systems wear out over time and preventative maintenance is the only way to keep up,"
"Building performance is directly correlated to critical system commissioning, a higher level of attention will be paid by everyone if the CxA is around and that means a better building down the road,"
"Buildings will perform from the day of turn over not after a nice period of shake-out,"
"CxA will make a buildings development more relaxed and less rushed because of system complications and the owner will not have to sacrifice desire for affordability,"
"We may never know because commissioning should never end so get back to me in about 40 years,"

When surveyed, the pool's negative responses on whether or not commissioned buildings perform at different levels were as follows:
"I have had success with early and late CxA involvement but that is highly reliant on the knowledge for the design team concerning systems,"
"The CxA was brought on too late and the performance of the building systems left the owner significantly disappointed with project requirements not as they were intended,"
"Not necessarily, sometimes commissioning is time driven,"
"Phased commissioning projects don't perform at the level that single phase commissioned projects do, simply because there can not be seamless system integration,"
"Commissioning has to be utilized during design or the building will perform the same as one that is tested and balanced,"
"Major errors will not magically be corrected by hiring a CxA, the designer still needs to be a master of his trade,"
"No! and if done right can be a huge money maker for some at the owners expense,"

Call Back Trends

Call-backs are typically the reason that commissioning is discussed. Owners want to work out system flaws early so they don't have to deal with complications later in the building life cycle. The question was asked: Are the any trends in the types of call backs in commissioned and non-commissioned buildings?

Responses of those who saw trending in commissioned and non-commissioned facilities were as follows:
"Occupancy comfort has got to be at the top of that list,"
"Backward dampers caught during commissioning could have been costly for a contractor down the road,"
"Knowing how to work your systems cuts the call backs in half,"
"The word warranty is used much less,"
"Fewer callbacks on commissioned facilities,"

"Experience would show that a dramatic drop in call backs is a direct result of commissioning,"
"Every glitch that is fixed or tweaked is one less call back at an increased cost and that is how commissioning saves the owner money,"
"Lessons learned are still taking place but commissioning will refine itself over time,"
"Because we mandate commissioning on all projects our warranty/post project costs are significantly lower then our competitors,"
"A December 15, 2004 report prepared by the U.S. Department of Energy will show everyone just how great the benefits of commissioning are on callbacks,"
"HVAC controls never seem to work perfectly in non-commissioned facilities,"

Responses of those who saw no trending in commissioned and non-commissioned facilities were as follows:
"Just because a facility is commissioned does not imply that it was commissioned correctly and call backs can happen if someone is not at risk to the job the right way the first time,"
"An accurate answer to this question may take a few years to arrive at; Cx is just too new for feedback,"
"Cleaning and HVAC adjustments can happen on both especially if not maintained,"
"In some cases the cost of call backs does not equate to the cost of commissioning,"

System Percentage Checks for Passage

The callbacks on a project may be related to system checks for passage. The owner, contractor and architect often differ on the percentage of checks that should take place for systems prior to substantial completion.

When asked who should decide the percentage of checks that must pass during commissioning the responses in favor of the owner were as follows:
"Equipment and systems are sensitive but the owner has to make the percentage decisions,"
"Owner-designer-CxA needs to establish these guidelines,"
"Owner needs to check the contractor,"
"Checks correlate to cost so the owner needs to select the balance that he is most comfortable with,"
"Consensus decision by CxA-owner-a/e rep,"
"Owner because is less than 100% ever acceptable and if so would you buy a car that only has 25% of its systems checked to see if they perform as they should?,"
"I am not cutting a check for something that doesn't work and if I have to pay a commissioner to make sure that is the case then that is what is required,"
"Commissioning costs can be high for high percentage of checks so the owner must decide,"
"Anyone but the owner will determine a number that is self serving and the only self-serving party on a project should be the owner,"

When asked who should decide the percentage of checks that must pass during commissioning the responses in favor of the designer were as follows:
"Engineers should have say on their systems,"
"ASHRAE Guideline 0-2005-The Commissioning Process has that one done for all of us,"
"Rarely does the owner have the CxA on board early enough so the MEP engineers specify these numbers in many public-sector jobs,"
"Designers should have say in percentage checks,"
"Architects,"
"Depends on the type of facility, whoever the engineer of record is, needs to decide how much time and effort is put into determining the performance of the system."

When asked who should decide the percentage of checks that must pass during commissioning the responses in favor of the commissioner were as follows:
"Commissioner should decide these statistics,"
"CxA has the experience so trust the people on your team to their job,"
"Some systems can be sampled but others should be 100% and that is the job the CxA to know the difference,"
"CxA because he is the owner's eyes,"
"An experienced CxA,"

When asked who should decide the percentage of checks that must pass during commissioning the responses in favor of the contractor/construction manager were as follows:
"Contractors understand budget concerns while CxA agents are not as concerned,"
"Contractor checks everything and the CxA should spot check 25% of that,"
"Anything not working needs to be replaced or contractors would take chances all over the place,"
"Contractor wants to check whatever is asked of him so he does not have to come back,"

As-Builts of Operations and Facility Management

Operations and management of a facility is as crucial, if not more important then construction. The operating costs will far surpass the construction costs over the lifecycle of a building. To best address concerns about a facility or potential renovations, accurate as-builts become essential. Does the commissioning process help deliver a more accurate set of mechanical-electrical-plumbing drawings to the facilities management personnel?

Those in support of the commissioning process's impact on as-buits expressed the following:
"Yes it does, because it gives control points and settings for all tests on equipment and systems,"
"Yes the completeness and quality of the drawings will be much greater,"
"By design commissioning should provide better documentation but can be outside of their scope to save money,"
"As-builts are part of the commissioning report and therefore are definitely better,"
"Commissioners deliver as-builts with greater detail,"

"System interfacing needs to be detailed and commissioners can do that,"

Those who recognize little improvement in the as-built set on a project with commissioning expressed the following:
"CxA must review and update drawings throughout the process to ensure this or the answer is no,"
"In my experience as-builts are unaffected by commissioning,"
"Not usually, but could be an added responsibility of the CxA,"
"Not usually but I'm sure it is a possibility,"
"All too often the CxA does not get their hands on the as-built drawings,"
"It should not, because those drawings should be accurate either way,"
"CxA comments can be ignored sometimes and therefore never included in the as-builts by the contractors,"
"Because of time constraints, and tight budget, the owner accepts flawed as-builts of systems when commissioners are not brought on early enough,"
"As-built drawings are turned over to the architect not the owner, by the contractor,"
"Accurate documentation is essential, vendors and installers must do their part to assist the commissioner or the as-builts will not truly represent the construction,"
"As-builts will only be altered if changes need to be made,"
"Control system as-builts, yes, but duct/piping or conduit no, in reference to temperature controls there is a big difference when commissioned,"

Warrantee Analysis

Warrantee's can cost up to 10% of the cost of a system and are therefore a major concern. Do warranty costs vary in commissioned and non-commissioned buildings?

Some maintain that warrantee cost is unaffected by the commissioning process and their assertions are as follows:
"More complex buildings entail greater warranties by nature and similarly a more complex facility will require commissioning, so to say that commissioning can cut the cost of a warranty would be inaccurate,"
"Too many variables to say lack of commissioning is the cost escalated for warranties,"
"Warranty management and system performance are two very different things,"
"No, there are no current premium deductions for utilizing commissioning on our projects,"
"Breakdowns are primarily due to lack of maintenance and that is on the O&M's shoulders regardless of how the system was installed, but manufacturers warranties will remain the same it's the contractors that can save trips,"
"Actually commissioners can find a number of items for the owner to make a claim on concerning manufacturers warranties,"
"I find warranties are related to equipment usage and type not installation method,"
"In 10 years lower warranty costs will be a trend but first commissioning needs to catch on like wild fire,"
"I would love to hear the answer because it sounds like it should be the case and I haven't had it happen yet."

Those who support the need for commissioning to decrease warrantee costs are quoted as having added the following:
"Commissioning does lower warranty costs, lower call backs mean lower premiums on a warranty,"
"Warranty costs are lower then competitors and that is a direct correlation to our use of commissioning,"
"Eventually it will be the same as a non-smoker paying less of an insurance premium then a smoker,"
"Yes as clearly identified in the U.S. Department of Energy December 15, 2004 release,"
"Contractors will be responsible to fix less in a commissioned project so the cost to the contractor absolutely drops during the warrantee period,"
"Equipment function is related to warranty cost and commissioning can lower that,"
"Training and maintenance can cut warranty costs,"
"In general formal commissioning controls can reduce warranty costs,"

Outsourcing of O&M to your Commissioner

The interface between construction and facilities management is a big issue. Should operations and maintenance be outsourced to the Commissioning Agent so that they have a vested interest in upholding their contract during construction? Each miss will result as a hit for them later in the project.

The supporters of combining O&M and commissioners had this to add:
"Yes, CxA is the perfect man for the job for the first year of operation to allow for a smooth transition to the O&M staff,"
"Owner's preference but why not, it would put pressure on the CxA to assure the building is operating at full potential,"
"Those with intimate knowledge of the systems should remain with the O&M staff for some predetermined time period."
"Many owners will hire a member of the construction staff to become their head of facilities because of their knowledge of the systems so why not let the team that installed, tested and balanced the system remain as the maintainer,"
"Owners may have a business model, the capability and the capacity for this to be a good idea, perhaps not O&M but spot checking would be a good idea,"

Those who oppose the combination of O&M and commissioning had the following reasons:
"O&M should be hired by the owner but get involved with the commissioning process,"
"CxA should work with the O&M until turnover but then step aside,"
"Not experienced with O&M outsourcing, if the O&M has a positive track record and good people there is no reason why this wouldn't work but the only case where it was utilized was a disaster in my experience because of inexperience,"
"Keep CxA and O&M separate,"
"It all comes down to money and who will pay for the service, liability and warranty issues could prevent the outsourcing to the CxA,"
"Can be combined but better for the building if kept separate contracts with different companies,"

"Outsourcing is not recommended,"
"Who takes control of the warranties if outsourcing occurs?,"
"No why allow the CxA to control his own scope of work, CxA needs to have no responsibilities after the turnover date or decisions will be made to benefit the CxA,"
"Commissioning works best when it is viewed as a specialized task,"
"CxA could be a good consultant on the hiring of an O&M team,"
"CxA would be far to expensive to handle O&M for public sector work, O&M should remain in house,"
"Avoid profit motive and keep the CxA in the design and construction phases, separate the functions and you will have a better system of checks and balances, "

Formulating your Commissioning Team

When providing a smooth transition from construction to facilitation of the building is it ever not appropriate to get a building engineer or facilities superintendent on staff?

When asked should a member of O&M be on the Cx team positive supported had this to say:
"Yes, always someone should remain on the O&M team,"
"Our commissioning spec require this for at least a period of time,"
"We have always had an owner representative on the Cx team but no requirements for a member of the Cx team to be on the O&M staff at the end of the project,"
"It is a necessity to have O&M on the Cx team; the contract will determine how involved the O&M guys need to get,"
"The O&M representative brings practical knowledge and provides continuity from one phase to the next, absolutely a huge part of the Cx process involves O&M,"
"Yes it is a very good approach, systems need to be learned intimately and O&M must be there from the start, this is the method of training,"
"O&M will want to work out bugs before they take full control, the more the owner is involved the better off the project is,"
"Not necessarily practical, O&M can be unrealistic when involving time and money,"
"O&M will be able to trust the systems if they have seen them from their inception and this is important in avoiding manual overrides which can ultimately damage system equipment and run inefficiently,"
"Faulty maintenance and user modification is a project on all systems, knowledge flow is essential,"
"Always in the power field of construction, I insist on it, helps considerably with the transition process."

When asked should a member of O&M be on the Cx team opposers had this to say:
"Many facilities have unique operating characteristics and the commissioning team may not consider facility maintenance,"
"Depends on whether or not the structure will have full time O&M,"
"Success is going to be gauged on how active the personnel is in the process,"
"Rarely do they seem to show up when invited,"

"If the facility engineer is on staff it will be of great use to everyone, but often a staff is not hired at this point on a new construction project,"
"Because of hectic schedules and responsibility the O&M member is usually not available as frequently as necessary and acts more of a shadow then a participant,"
"No, skill level is typically different between CxA and O&M,"
"If not in on design then stay out of construction and budget ultimately controls this decision,"

Warrantee Start Date

Should a Commissioning Agent decide the beginning of a general contractor's warrantee period? Does the point at which an owner declares a project substantially complete automatically begin the warranty period, or should that start date be decided by the Commissioning Agent when all systems are operational to design specifications. A general contractor can theoretically dissipate a significant portion of his warranty period while the testing and balancing period is still underway, ultimately making the true warranty period less then an owner should receive. Additionally, some projects substantial competition date is much earlier then turnover, and a warranty period can completely disappear before the building is ever even turned over. Phased projects are yet another issue with dates.

When Should Warrantee Periods Begin

Survey responses from owners displayed the following positive sentiment toward a non-substantial competition date:
"Warranties should start at an owner/contractor negotiated date typically at system start-up,"
"Once the owner can occupy, the warranty will commence, phased projects will have start dates at start-up not commissioning,"
"Building and contract type will dictate the warranty,"
"Warranties should be effective as of final completion, not substantial competition since a general contractor shouldn't warranty work he has not completed,"
"Contract documents can dictate warranty commencement at equipment acceptance, equipment warranties follow the equipment installation but general contractor warranties follow substantial competition,"
"Substantial completion should be the point where only minor non-safety related items remain but training should take place before a warranty begins,"
"Commissioners should dictate the warranty period because a contractor will always put it's priorities first,"
"Very difficult for a GC to delay a subcontractor or supplier warranty until after a CxA decides its time,"
"An owner should never eat the failures of an inadequate builder."

Survey responses from designers displayed the following sentiment toward a competition date:
"Political pressure will typically trump the lingering Cx issues,"
"Beneficial occupancy is the start date or the GC would be required to assume an unquantifiable risk as the building is being utilized,"

"Owners want it as late as possible and contractors want it to start as soon as possible find a happy medium and all parties will buy into it,"
"As a commissioner who represents the owner that date should be pushed back as late as possible,"
"Warranties are unrelated to systems being 100% they respond to the term fully operational,"
"System problems should push back any declaration of substantial completion and then the warranties can commence upon substantial competition,"
"Good CxA will have the systems at 100% by substantial completion,"
"State law may determine this already as in California where substantial completion is dictated as a user getting beneficial use of a facility."

Survey responses from contractors/construction managers displayed the following sentiment toward a competition date:
"Most systems can be commissioned long before substantial completion, warranties should start upon delivery but continue for a year or two after a commissioner has declared the facility operational,"
"Contractors will not take on undue risk, so good luck changing industry,"
"When an owner moves the date the GC passes on risk,"
"Start dates aren't the concern, it is duration, and retention should not be released until commissioning is complete,"
"An owner should not take control until systems are in compliance with specification otherwise you buy a Volkswagen when you ordered a Mercedes,"
"To be fair to the GC it has to be the substantial completion date but if the CxA is in charge he can mange both sides,"
"Depending on the owner sometimes it is unreasonable to wait to start warranties until all systems are at 100%,"
"Absolutely after commissioning otherwise why would an owner be spending all that money, a warranty may run out before commissioning is complete,"
"Contracts are difficult to sign and open ended dates make them nearly impossible,"
"Life safety systems warranties may be complete before the building is completely operational simply for safety sake,"
"Depending on the system, the warranties should coincide,"
"Subjective decisions will alter warranty commencement 99% of the time,"
"A hot issue contested for a long time and will continue on like this, in my estimation for an even longer time since no one ever wants to take on risk,

Commissioning's Economic Feasibility

For many, the bottom line is "can commissioning be economically feasible." Why do something that just does not add up.

Those who feel that there is economic feasibility for commissioning had the following comments:
"A little money can go a long way,"
"Absolutely, every project scope of work is budgeted and scheduled and if commissioning is included then its an expected cost,"

"A provider of a baseline for both the owner and the contractor on installation and performance is worth it, absolutely fiscally responsible,"
"Yes, yes, yes but scaling is important, limited commissioning saves 80 percent of the cost with many of the benefits such as performance testing,"
"Absolutely, commissioning can be done on many different levels of complexity, depending on system sophistication,"
"Yes, unless you don't have HVAC or a wall unit,"
"Generally yes, regardless of size, some level of commissioning should be required,"
"If nothing else the owner should get satisfaction,"
"All buildings benefit from functionally verifying systems, it's the soft items not hard costs that are exponentially added up when looking at value,"
"Fiscal responsibility spans beyond total cost positively effecting operations and management for building lifecycle,"
"Above 5 million dollars, yes, and anything with the name LEED on it for sure, can be overkill for multi-family homes but for commercial projects yes,"
"LEED requires fundamental commissioning, so where there's a LEED there's a yes to this question,"
"Buy it out in bid packages and fiscal responsibility gets passed on,"
"Should be a yes, but probably opposition, large complex facilities overwhelmingly yes,"
"Private sector, non residential is a yes, depends on the use, but definitely yes for healthcare and laboratories,"
"Long term construction costs are lower for a commissioned building period!,"
"Every Cx plan is customized to the specific project so yes,"

Those who oppose commissioning because of the lack of economic feasibility had the following comments:
"No only on complex facilities,"
"No, but as a facility becomes more complicated, the commissioning process becomes more viable,"
"Size and complexity dictate fiscal responsibility,"
"On smaller projects no, it can be handled by engineers and contractors,"
"An inflection point exists where commissioning cannot be cost effective, but depends on comfort level required and condition stability,"
"Architects should be able to double as a CxA on a small project,"
"*All* results in a negative answer, *most* is the accurate response,"
"Should be commissioned, but not necessarily need to be commissioned,"
"Low capital projects aren't often candidates because of low return on investment,"
"Experience has taught us that under $750,000 in scope commissioning is not cost efficient,"
"Technical complexity is a bigger driver then size or type of project,"
"Mechanical engineers can take the small projects,"
"Impact on public health projects gets a yes, but office buildings it is extra cost,"
"Depends on owners requirements of the commissioner,"
"Commissioning is really just a rigorous application of construction processes which should have been followed in the past,"
"In some cases it just does not make sense,"

"Storage warehouse no, hospital yes, it is not a money driven item its system complexity driven."

Negative Commissioning Lessons Learned

The most important thing learned about history is what not to repeat. Commissioning is not always a perfect process. The negative experiences that have taken place during commissioning projects are as follows:
"Can drag out tenant move in dates,"
"CxA get power happy and demand more then contracted,"
"Poor planning, late participation, independent and inexperienced,"
"Third party CxA brought on to interrogate are inflexible and sometimes not familiar with project requirements,"
"Not available for testing, delayed response to reports, high cost, sometimes more time is spent training the agent then utilizing them,"
"More concerned with justifying their existence then system performance,"
"Cost and limited agents that can do the job adequately,"
"Misunderstandings as to who does the documentation,"
"Third party CxA are to busy,"
"Turnover among CxA is high,"
"Just want to show up, perform tests and go home,"
"Lack of dedication, so lack of manpower can drag commissioning out,"
"Owners do not pay construction manages for additional time required for commissioning agents commands,"
"CxA needs to be aware of the schedule,"
"Rigid commissioning specs need to be project specific so they are tailored to the needs of the job,"
"Hired to late and the owner was resistant to the needed changes,"
"Can become punitive instead of objective,"
"Some CxA just lack common sense,"
"Owners and contractors place claims on each other,"
"Dishonesty-incompetence-ignorance-stubborness-laziness-avoidance,"
"CxA vs. Mechanical engineer can get nasty if not defined,"
"CxA can't be profitable if the contractor and engineer hammer him,"
"Commissioners need qualified engineers and contractors who buy in, not productive if the owner doesn't support it,"
"Public sector needs to get the commissioner on board during designs,"
"Cost can be rough, but schedule is everything,"
"Late submittals,"
"Contractor will claim just about everything using the CxA as his scapegoat,"
"Value is difficult to sell to some owners,"
"Can be a very difficult process,"
"If the CxA isn't in design he will constantly confront the designer,"
"Without proper planning, commissioning can equal building construction time,"
"Costs are increasing due to the training requirements,"
"Make sure that scope is well defined,"

"Tons of paperwork to act as a quality control device to force the GC to fix things they screwed up,"
"Beware of those who falsely represent CxA just to get contracts,"
"May be financially limited by owner,"
"CxA may underestimate an owner's knowledge and underbid a job therefore cutting corners during the process,"
"CxA can have their hands tied by subcontractors,"
"Shifting owner requirements, no clear test plans, no integrated system testing, no validations, no scenario-based testing such as a blackout, needs to understand total building commissioning not just mechanical and electrical, no O&M systems manuals for facilities people,"
"Keep your designer separate from your commissioner,"
"Owner can utilize commissioner to get free work out of subcontractor."

Positive Commissioning Lessons Learned

To recommend commissioning, there needs to be some success stories to back up one's case. One thing is for sure, the positives will continue to outweigh the negatives as the process is refined. The surveyed population had this to say about why commissioning is the wave of the future and needs to be on every owner's mind during project planning:
"Many good things to say,"
"Allows issues to be worked out proactively vs. reactively while helping to make clear design and operation intent,"
"Knowledge sharing can take place,"
"Clear test plans for verification and validation are great for everyone,"
"If started early, all parties are satisfied in the end,"
"Systematic approach helps organize a project during its most erratic stage,"
"Win-win if it is a good CxA,"
"Owner knows what is working and what is not,"
"Another set of eyes is always useful when they are there to help not hurt,"
"As an owner we are certain that the designer has provided us a working facility and the contractors constructed the building as designed and the operations and maintenance personnel are trained,"
"Buildings are more prepared for use,"
"Owners are happy and the facility performs as expected, operating with least amount of problems possible,"
"Difficult process but worth the effort for sure,"
"Systems are stable, contractors have direction, test reports are utilized by the O&M staff, major cost/schedule/operability issues are caught before they become a problem,"
"Re-commissioning took one of our buildings from gold to platinum,"
"Energy savings and occupant comfort compliment peak system performance,"
"All of our experiences with commissioning have been good,"
"Team members are proud to be a part of the project upon conclusion,"
"Better buildings and saves on energy,"
"Close out is easier and smooth transitions exist,"
"Commissioning records provide a baseline for efficient, cost effective operation of the system long-term,"

"It always has a good payback,"
"Projects finished earlier,"
"Far, far too many to list, every possible selling point for commissioning is usually pretty evident on most projects,"
"Lower warranty costs are always nice,"
"Peace of mind and confidence in a project,"
"Rewarding for everyone, enhanced team building as well as a higher quality of work,"
"For a power plant, paying for commissioning up front is like buying Google or Microsoft when it was first offered,"
"Design builders can't live without commissioning,"
"Cx is a broad term, but every building benefits from it,"
"Repeat business, a team together committed to honestly working to provide an end product that did what it was supposed to do,"
"Headaches are reduced significantly,"
"Reduced punch list items and overall accountability,"

Commissioning Relation to Dolphin Mall Expansion Project

The Dolphin Mall Expansion did not utilize commissioning. The Mall contracted Skanska U.S.A. Building Inc. to prepare the mall for the addition of a Bass Pro Shop. The system integration between mall and expansion was limited. The Mall should however have a member of their Operations and Management team familiar with all the systems installation and upgrades. While it may not be cost effective to commission limited systems, that is a decision best made after an estimate has been given by the CxA. The Mechanical Engineer on the project was constantly flying down to Miami during construction to verify only the parts of the system that were supposed to be demolished were demolished. System performance for the Mall, as a whole, should be monitored by the Commissioning Agent. It would have been best if the Anchor store tenant was given direction to utilize their Commissioning Agent on the corridor MEP to guarantee the tenant space matches the Mall's system. Fit-outs/renovations are often over looked with respect to commissioning agents, and the mall would have benefited from a commissioning consultation, even if it was a limited, low cost system design review. The value added by getting a CxA's opinion during the preliminary stages can no longer be overlooked in mechanical design. Taubman Centers delivers billions of dollars in malls throughout the United States, there are few corporations around that could benefit more from a commissioning division and or a Cx team utilization during construction every year.

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