# Senior Thesis Project


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Construction Management


The New Jacksonville Arena

Jacksonville, Florida

Spring 2003

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# Executive Summary:

As a result of the widespread analysis of the New Jacksonville Arena, with regards to the building plan and the methods of construction, three areas of interest have been investigated to improve the value of the building while constructing it faster and cheaper, but with the same level of quality if not improved.

The first of these areas was chosen while the general constructions methods were being examined. It was noticed that the lower bowl raker beams were being made with pre-cast concrete instead of being poured on-site. This differed from the rest of the building as the rest of the building was being cast-in-place. It was thought that constructing these beams onsite would happen faster and cost less than ordering them from a pre-cast fabricator.

The second of the idea in changing the facility within the depth of my studies was chosen as a result of noticing that the entire outside of the building was to be made of placed nominal brick. Just looking at the shear size of the exterior of this building one can see that this is a lot of brick. It actually was around ninety-five thousand square feet of brick, or roughly fourteen-and-a-half thousand bricks. Alternatives for the exterior façade of the building were looked at, from a mortarless brick technology, to replacing the entire exterior wall with a composite product that was an all inclusive product.

The research and survey on this project came about when studying the plans for the ice system it was noticed that there were quite a few pipes being run under some of the slabs, as well as having multiple systems for creating the ice rink, melting the ice rink, as well as all of the other normal pipes for waste, plumbing, and the other MEP functions. The thought was to see how into the newer technologies such as 3-D and 4-D CAD some of the companies out in the field were, and if they felt that this was the way of the future, for handling such issues.

The final idea for improving the construction of the arena was just a feeling that steel might be more expensive to buy, but what if the savings in construction time proved to offset the difference or maybe even save money. The thoughts were that it would and completing the erection of the building earlier would also prove to be beneficial in finishing the arena sooner.



## Credits & Acknowledgements:

I would like to give a special thanks to the following persons and companies that aided my research and analysis regarding the changes that I proposed to the New Jacksonville Arena. Without their help I would not have had the guidance or the resources to accomplish what I wanted to with regards to this project. I give thanks to the following persons and companies in no particular order: Scott Radecic and Mark Bichel at HOK Sport+Venue+Event for helping me in selecting one of their fine athletic facilities to study; John Reich at Turner Construction Orlando who is the project manager on the arena, for helping me out with so many questions over the past two semesters; The Penn State AE staff who helped me with questions and guidance (Dr. Horman, Dr. Riley, Dr. Geschwinder, Dr. Hanagan, Paul Bowers, Jonathon Dougherty); Chris Shuster at EFCO Formwork in Pittsburgh who gave me insight into the uses of their technology; Ashley Smith from Smith-Midland who helped me out in attaining the Slenderwall information; James Coblin from Vulcraft who sent me more materials than I needed regarding joists and decking; Greg Krantz and Daniel Marcotte from Nova-brik who answered my questions on a number of occasions; John Cross at AISC in Chicago, who gave me the extra information I needed regarding the steel in my building; Darin Tranquillo my roommate, and IT guy who set up my online survey; my teammates and roommates for understanding what I was going through for my education; my family for continually telling me to keep it up and that all this work will be worth it at some point; and finally my sweetheart Melissa Wills who was always there for me throughout this past year, even when I had her do some of the structural takeoffs.



# Existing Conditions

*Introduction, Background, Project History, Site & General Architecture:*

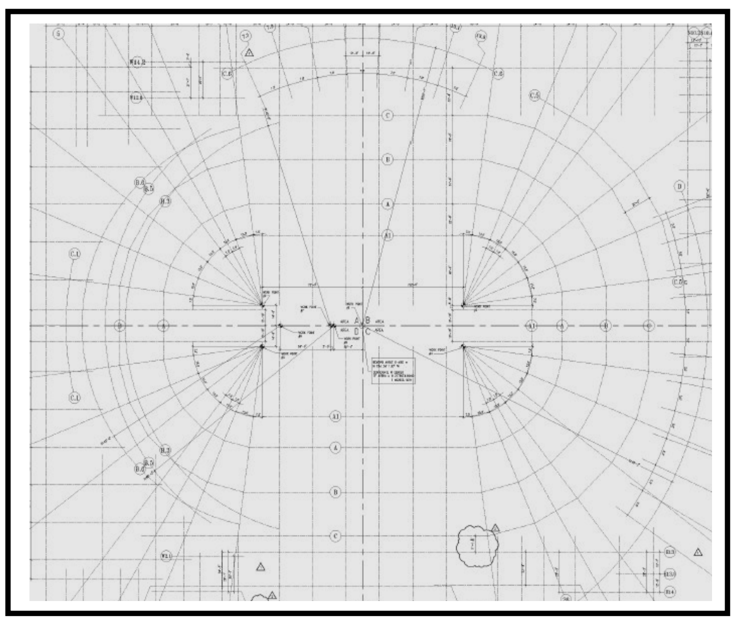
The construction for this project began in late May 2002, early June 2002, and the project is to be completed November 1, 2003. (Originally Oct. 1, 2003)

The initial cost analysis totaled the project at approximately $100,500,000.00. The arena is just part of a total plan to introduce a sports district into the metro area of Jacksonville. Along with the arena, there will be a new baseball park, as well as a new trolley lot to allow the movement of persons to and from the district.

The facility is going to be a general purpose arena (452,058 sq ft) which is expected to serve as a multi-purpose public assembly venue, capable of hosting events ranging from entertainment events, NCAA basketball and ECHL hockey to indoor football, indoor soccer, and other sports events. It is being built in conjunction with a new baseball stadium. Seating capacities will range from approximately 13,500 for hockey, to 14,850 for basketball, and up to 15,800 for a center stage concert. *A variety of premium seating types will be available, including private suites, and club seats.* Public restrooms, concessions, and concourse circulation space will be provided on a magnitude to promote spectator comfort and enjoyment. Locker rooms, press facilities, kitchens, storage, staging, and other support spaces will be provided to best serve the proposed events within the defined budget.

The new arena is being built in Jacksonville, Florida, within the city limits, two blocks from the existing Memorial Coliseum. The arena is being built in conjunction with a new baseball park located between the Memorial Coliseum and the arena, and a new Trolley Lot to provide parking and transportation to and from the area. The site that the arena is being built on is located between Palmetto Street, Adams Street and A. Phillip Randolph Ave. It also is surrounded by another street New Duval Street which needs to be rerouted as part of an initial phase. Located on the site is an existing building, the Perdue Building, which is to be left as is and worked around.

Figure 1: Building Geometry



The geometry of the building is oriented around the size and proportions of the basketball court and the hockey rink. The building is a combination of a rectangle and some partial ellipses taken from the face off circles on the hockey rink. The architecture of the building on the exterior is complementary of the landscaping surrounding the new building, as well as the adjacent ballpark, and Perdue Building. (See left)

The property is owned by the city of Jacksonville and has been deemed suitable for a sporting venue. Adjacent to the two sites for the arena and ballpark is the existing coliseum which the new arena is replacing.

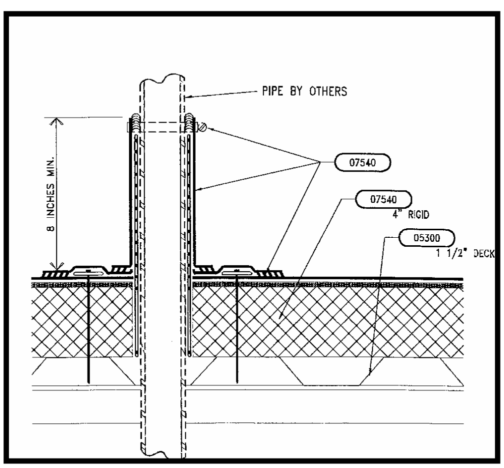
The Project was funded by The City of Jacksonville, who contracted HOK Sport+Venue+Event to design the building. Turner Construction bid for the job and is now subcontracting the work out to build it. The delivery method is design-bid-build.

The arena is being built just west of A. Philip Randolph Boulevard in the Sports Complex. The red brick exterior will complement both the new baseball park and the historic St. Andrews Church, which sit directly across A. Philip Randolph. With a capacity of 16,000, it will nearly double the seating of the 42-year-old Veterans Memorial Coliseum. The brick sits on the outside of a cavity wall with 8" CMU on the inside as a backup system.

The roofing system is thermoplastic membrane roofing sitting on top of a layer of insulation, 1-1/2" metal decking, and then the roof joists. (See left)

The electrical system includes a 15 kV primary service entrance, unit substations, switchboards, switchgear, secondary power wiring and distributing system, emergency standby engine generator system, motor control centers, power wiring for; HVAC; plumbing; and fire protection, motor starters, and surge protectors. The main power distributed throughout the building is a 277 V distributed load, stepped down to 120 in the finished areas.

Figure 2: Pipe Penetration Detail




The lighting in the arena consists of general lamps(3-F32T8) made by Columbia, wiring devices, the arena bowl lighting systems, the sports lighting for the court/rink, and the lighting protection systems. *On the exterior of the arena, also included in the work, are light cannons which send beams of light into the sky from an enclosed brick pilaster. They are located in the plaza between the arena and proposed ballpark.*

The more complicated mechanical systems of this building are those which are involved in the



venting of the air inside the building, as well as the piping for
the water involved in the ice systems.  Also included are dehumidifiers, and humidifiers which are responsible for maintaining a comfortable atmosphere within the arena.

The structural designer is utilizing all different kinds of structural elements in order to complete the arena, including cast-in-place concrete, plant-precast structurally pretensioned concrete, plant-precast architectural concrete, reinforced masonry, and structural steel, both A 36 and A 992.

The active fire control consists of fire-extinguishers, and the passive consists of one, two, and three hour rated walls and partitions, as well as sprayed-on fire proofing.  The fire proofing is being used on the structural steel.  Fire extinguishers are located within cabinets recessed into the walls of the building where required and the types of extinguishers are FE-1 through FE-6.

There are 8 electric traction elevators which handle 3500 lbs each located throughout the building.  There are also escalators which travel at 100 ft/min. located within the building for the transportation of persons up to different levels of the building quickly.  There are also waste chutes located within the building to transport waste from higher levels of the building quickly to the ground level, and into the dumpsters.

The telecommunications package includes general telephone lines, both internal and external, as well as a fiber-optic package which will be used for telecasts of events held in the arena.

Included in the special systems of the building are the ice making and thawing systems, the special construction required to maintain an ice sheet on the concrete slab, and the acoustical baffles located throughout the building to control the sound during events and concerts.

The design throughout the facility shall comply with the guidelines established by the Americans with Disabilities Act (ADA) and the Florida Accessibility Code.

Toilet rooms will be provided for men and women at each concourse level and appropriately distributed.  The ratio of spectators to fixtures is based on 50% male and 50% female attendance and will be in compliance with Florida 3:2 potty parity regulations.

A truck receiving area to accommodate four semi-trailer trucks will be provided at the entrance to the service facilities.  The receiving area is adjacent to the freight elevator, and has direct truck access to the arena staging and arena floor.  A minimum clear height of 15'-0" will be provided.  Dock levelers will be provided.  A separate dumpster dock will be provided in relation to the trash chute.  Adequate hose bibs and drains shall be provided within this area.

An area will be provided at the service level staging area to secure against illegal entry to or improper access within the arena.  The fire command area will be housed in this room.  The arena control will have views of the loading docks, staging area and control staff entry. Security for the entire facility will be monitored by closed circuit TV from this area. Adjacent to this area shall be a Police Room to include interview rooms and two toilets.

Mechanical equipment room for ice making will be provided, along with associated support rooms for one Zamboni. This shall include storage spaces, graphics and paint materials rooms, water purification, and ice equipment. An ice pit should be located directly adjacent to ice sheet approximately 32' x 6’ x 6'' will be provided.

An area adjacent to arena to be fenced or walled will be provided. This area to accommodate additional staging requirements as needed for shows and the circus and function as parking area.

A mechanical, self-loading trash compactor permanently located at the receiving area will be provided to process all refuse. Two recycling bins for aluminum and paper products will be provided.

Two of the three semi-trailer parking spaces at the service level staging area will be utilized for television vans. Adjacent electrical and telephone equipment rooms shall be provided. The television network will be consulted for input prior to final design.

Although no satellite communication facilities may be planned for initially, the advancement in satellite communication technology indicates a probable need for such facilities in the future. As part of the site planning, an area for satellite communication facilities, which has the proper orientation and site line characteristics, will be identified and reserved for future use.



# Depth Study:

## Raker Analysis:

### Initial Proposal:

The first proposed idea for the thesis research is to change the construction process of the lower bowl rakers. As they are designed now, all are to be precast and delivered to site to be installed. The analysis will look into the possibility of changing to a cast-in-place process. The initial thought is that the construction of these rakers will not interfere with the schedule of anything going up around it since the rakers are limited to within the bowl of the arena, but the cost to cast the rakers onsite is likely to be much lower than preordering them.

The idea of constructing the lower bowl rakers by cast-in-place, versus pre-cast, will be looked at. The schedule impacts, as well as the cost implications and constructability issues will all be looked at for each idea. They will all be looked at and the most sensible one will be chosen in the end of the analysis.

### Design Criteria:

The New Jacksonville Arena is a structure which is basically entirely cast-in-place reinforced concrete, except for the roof structure which due to the span needs to be a steel truss regardless of the material used to construct the rest of the structure. From the structure's columns to the grade beams to the elevated beams, they are all cast-in-place and are formed and poured on site. The lone exception is the lower bowl raker beams. There are sixty eight lower bowl raker beams which are all pre-cast. For reasons unknown the lower bowl rakers were to be constructed differently from the upper bowl raker beams, the owner may have had a relationship with a concrete contractor, or the structural designer may have thought that ordering some of them may have been cheaper. As the plans indicate the upper bowl raker beams (84 of them) are to be constructed in sequence with the rest of the structure including the intertwining of the reinforcing steel that passes between the rakers and the superstructure.

### Aspects of the Design:

The specification for the raker beams calls for the beams to made out of 4000 psi concrete, with ASTM A615 Grade 60 deformed reinforcing steel bars inside. The raker beams must be shored for 72 hours or until they reach a strength of 2800 psi, and then shored for 7 days after that. The lower bowl rakers are constructed in three different sizes as indicated in the table on the right.

Again all of the lower bowl raker beams are designed to be constructed off-site and pre-cast, so that they can just be set into place.

Table 1: Raker Beam Sizes

| Location | Width | Depth | Length |
|---|---|---|---|
| North | 24” | 24” | 32’ |
| South | 24” | 24” | 32’ |
| West | 24” | 42” | 44’ |
| East-Upper | 24” | 42” | 46’ |
| East-Lower | 24” | 24” | 32’ |

EFCO Systems:

When deciding to change the process of constructing the rakers to match that of the rest of the building and include it in the scope of work of cast-in-place concrete, I knew that formwork was going to be an issue in making this process cost less. I did my research and found that EFCO “Systems for concrete construction” produced a form system that had been used to construct these very same raker beams in other arenas and stadiums around the world.

The EFCO Plate Girder® Form System is shown in the image below. This system has been used on various projects including Redskins Stadium (Washington, D.C.), Air Canada Center (Toronto, Ontario), Eriksson Stadium (Charlotte, NC), and most recently on the University of Maryland Arena (College Park, MD). EFCO Formwork uses the strengths of steel and puts them to work in forming concrete. Using the tensile, compressive, and shear strengths of steel, the Plate Girder® Form System has the ability to be self-supporting, self-spanning, and work as an excellent high quality concrete form in the same application.

Figure 3: Lower Bowl Raker Beam Locations

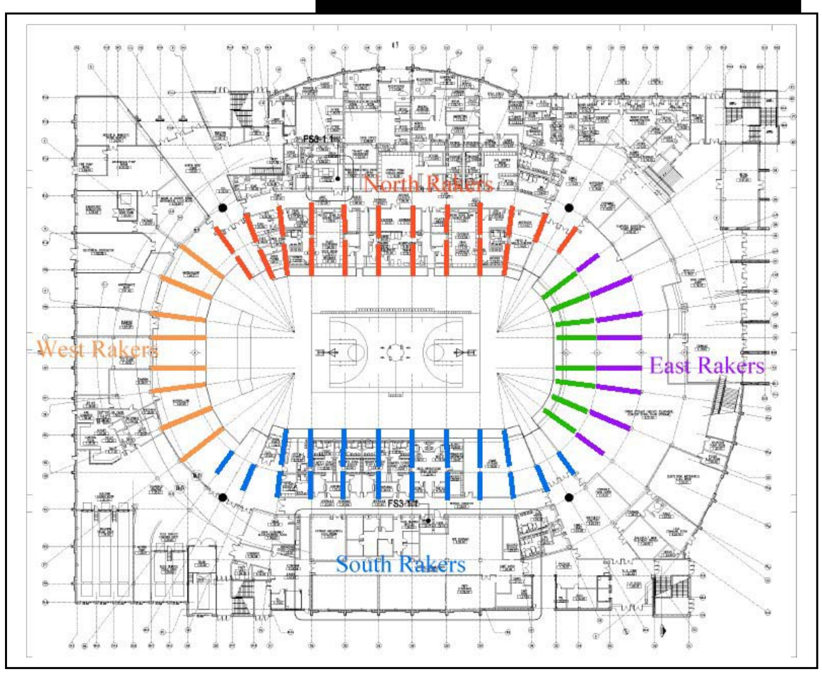
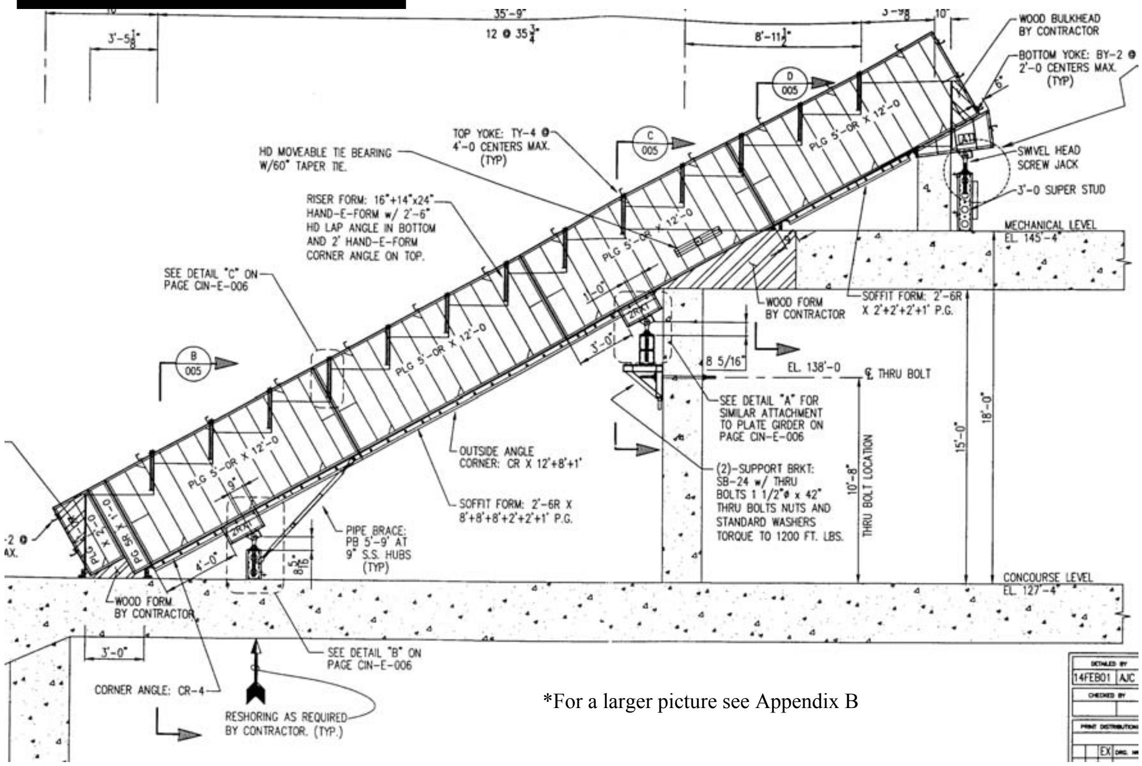


Figure 4: EFCO Formwork Example




*For a larger picture see Appendix B

In addition to the advantages already stated there are four additional features which make the EFCO Plate Girder® Form System stand out.

1) The heavy gauge EFCO steel web does double duty, acting also as the form face.
2) The steel ribs of the Plate Girder system form panels serve not only as web stiffeners but also as beams to transfer the horizontal pressures of the liquid concrete from the form face to the form panel top and bottom flanges.
3) The Plate Girder Form System comes in modular lengths that can easily be bolted together giving flexibility for changing job conditions.
4) The EFCO bolting block ensures the transfer of the flange forces between the individual modular forms. This provides EFCO's Plate Girder Form System with its unique self-spanning characteristics which enable the contractor to pour aerial concrete without expensive and time consuming interspan shoring.

*For more EFCO Plate Girder® information refer to the Appendix B.

**Additional Background:**

**Existing:** The subcontractor who is installing the rest of concrete structure is also taking care of the upper bowl rakers that are built in conjunction with the structure, is using a wood formwork to form the upper bowl rakers. This process wastes a ton of wood, being that the formwork only has a limited number of uses usually less than three or four, as well as time pouring and stripping the rakers.

The subcontractor is furnishing the rakers to the site, and is also responsible for installing them. It was a package deal although the subcontractor usually will subcontract out the work of installing them to another subcontractor, since they usually do not do that type of work. The schedule for the installation of the pre-cast rakers was approximately four weeks, including column setting.

**Goals:** In my initial thoughts regarding this change I wanted to analyze the effect of the change on things such as lead time and total schedule implications, external effects (other trades crane feasibility, connections), construction time (onsite and off), cost (fabrication and construction). Below is a chart of a few of the other projects which used EFCO formwork and how many sets they were cycling:

Table 2: EFCO Projects & Uses

| Project | Number of EFCO Forms | Section of Stadia |
|---|---|---|
| Redskins Stadium | 2 | Lower |
| | 4 | Middle |
| | 2 | Upper |
| Air Canada Center | 2 | Sidelines |
| | 2 | Arena Ends |
| Eriksson Stadium (54 Rakers) | 5 | Lower |
| | 4 | Upper |
| Maryland Football Stadium | 10 | Very Top (see appendices) |

**Historical Production Rates:** The University of Maryland's football stadium project used a crew of three carpenters, one laborer, and one foreman. They could strip and form one EFCO Form in twelve hours. Maryland's rakers were one-hundred and ten feet long; the maximum on this job is less than fifty feet so I divided by two, and then used the same crew as the University of Maryland to move the forms. They took six hours to strip, move, and form an EFCO Plate Girder® Form

System that was fifty feet long. Thus on the Jacksonville Arena project I assumed that it took three hours to strip one form, three hours to set one form, one hour to pour (R.S. Means), and one hour to set the rebar cage in the formwork. I am working with an offset workday, and the formwork workers will be working from 7 a.m. to 4 p.m., the concrete workers will work from 8 a.m. to 5 p.m., and the finisher will work from 9 a.m. to 6 p.m.

* Note: the concrete needs to shore for seventy-two hours according to the drawings (reference structural notes on drawings)

**Adjusted Production Rates:** The production rates which I calculated were that one crew could set and strip two forms in one day, one crane crew could pour nine rakers in one day, and one finisher could finish eight rakers in one day. I used these numbers to balance a workforce and came up with, four crews setting and stripping eight rakers per day, and one crane crew pouring eight rakers per day with inefficiencies accounted for, and one finish guy finishing the eight rakers per day.

**Summary & Conclusions:**

**Issue at hand:**

Will the C.I.P. raker beams be cheaper or quicker? **Answer: YES**

Table 3: Raker Cost & Time

| Method | Cost | Time |
|---|---|---|
| Cast-in-Place | $260,916 | 30 Days* |
| Pre-Cast | $500,000 | 70 Days |

*See schedule of raker construction in Appendix B

**Solution:**

I suggest changing to cast-in-place raker beams, not only are they cheaper to construct, but the fact that the concrete contractor would be taking care of their construction would also lessen the cost, since the constructor would be packaging the lower bowl rakers with the rest of the superstructure. This package by itself costs $260,926.00 to construct it using the cast-in-place method. The original method of constructing the rakers using pre-cast beams made off site and delivered to be installed originally cost $500,000.00, almost twice as much as the proposed plan. The time to construct the cast-in-place beams is thirty days versus the seventy to construct the beams using the pre-cast, due to lead time.



**Potential Benefits:**

The benefits of changing the construction process produce a quicker cheaper, more effective way of constructing the lower bowl rakers. The GC in Jacksonville usually prefers to use the EFCO Plate Girder® Form System which I had chosen prior to this knowledge that that is the company which they use. This system was used for the Florida Gators Football Field. The fact that they can be assembled on the ground and just lifted into place cuts the amount of time to construct the form in half, as well as the fact that they can be used an innumerable amount of times, a great advantage to the wood forms traditionally used.

**Feasibility:**

Initially I was worried about the potential cost problem associated with the formwork that would have to be used; I wasn't sure how many uses I was going to get out of each of them. On top of that the rakers were different sizes on the different sides of the arena, so there was going to have to be different formworks at different places. Basically it was going to be a huge mess.

**Project impact:**

*Schedule:* C.I.P. is better as it only takes approximately half of the time.

*Cost Implications:* C.I.P. is better as it costs approximately half of the cost to construct them using the pre-cast beams. The difference does not take into consideration the cost benefits of being done early, due to the nature of the element involved, and its' small nature with respect to completion date of the project. Granted, the early finished involved will allow the GC to allow other trades to move in and commence their work earlier, but you can not associate a cost with this movement of time.

***Recommended:*** **C.I.P. is the best option to go with.**

**Comparative Analysis of Options:**

Table 4: Comparative Analysis

| Cost Implication | Units of Cost | Total Cost C.I.P. | Total Cost As Is Pre-Cast |
|---|---|---|---|
| Time to Construct | Days | 30 days | 70 days inc. lead time |
| Formwork | Square Feet | $10,704 | Inc. |
| Rebar | Tons | $232,835 | Inc. |
| Finishing | Square Feet | $2,611 | Inc. |
| Placing | Cubic Yards | $23,560 | Inc. |
| Concrete Material | Cubic Yards | $41,416 | Inc. |
| Total | $ | $311,126 | Inc. |
| Location Factor | - | 0.82 | Inc. |
| Sub-Total | $ | $255,123 | Inc. |
| Crane | $/Time | $5,803 | Inc. |
| Grand Total | $ | $260,926 | $500,000* |

* Ballpark Estimate from Turner Construction Orlando



## Analysis of change to Façade System:

### Initial Proposal:

The idea of using pre-formed light weight curtain wall panels for the exterior of the building instead of the actual masonry brick. While this material is only on about half of the exterior of the building the initial thought is that the construction would go quicker even though the cost may be a bit more for the materials. The constructability, schedule implications, cost, and tie-ins to other trades will be looked at to make a good value engineering decision on weather to change materials or to stay with the original design.

### Design Criteria:

The exterior brick façade makes up the most of the exterior skin of the building along with the glass work, and the pre-cast architectural concrete. The square footage per side of the building is given in the table on the right. The exterior wall system is a brick façade, combined with a cavity, blanket insulation, and an 8" brick CMU wall. (See pictures in Appendix D) Along with the brick exterior are architectural precast concrete panels, and the exterior glass. The amount of architectural precast is not negligible with respect to the amount of the exterior brick, but is definitely far less with respect to square footage. It is approximately 5% (5,042 square feet) of the total brick/concrete area of the façade. Blast design issues were not accounted for in this analysis.

Table 5: Square Footage of Brick / Precast

| | *Area of brick/precast* |
|---|---|
| South | 29,761 sq .ft. |
| East | 21,392 sq. ft. |
| North | 25,126 sq. ft. |
| West | 24,552 sq. ft. |
| **Total** | **100,831 sq .ft.** |

### Aspects of the Design:

- **Original Brick Façade Design:** The current design for the façade calls for a brick cavity wall on the whole of the exterior where there is not glass. In most places the wall is backed up by a layer of 8" CMU blocks, but there is a large portion mostly towards the top of the building where the wall is backed by metal studs and drywall. (See Appendix D for differing wall sections) As well as having a brick exterior to the façade there is a somewhat small proportion of the façade that is architectural precast concrete panels.
- **Proposed Novabrik Façade Design:** As an initial alternative to the brick façade I proposed a mortarless technology in brick façade work called Novabrik. These bricks lay on top of one another and are intermediately screwed to the structure via furring strips. I felt that the lower cost of the bricks combined with the increase in construction time without the mortar would

benefit the whole construction process from both a cost and a time standpoint. The details of this system follow.

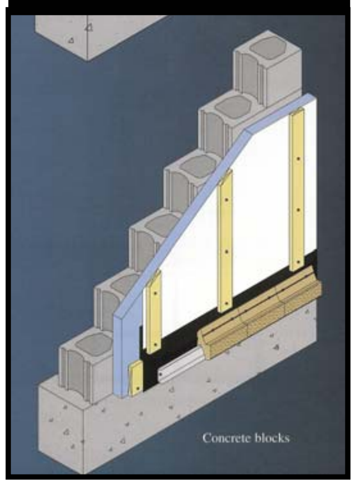
- Proposed Slenderwall Design: While researching the different brick panel manufacturers I ran across a company called Smith-Midland. They offer a product called Slenderwall, which is a combination precast panel with the option of including metal panels and even drywall to the inside of the façade wall. The exteriors come designed as requested, so they can manufacture the panels to match the existing architectural design, with both the brickwork and the architectural pre-cast concrete already on the same panel. This presents a bit of a dilemma due to the increased cost of the materials, but these panels can be erected at a much faster pace than either the brickwork, or the pre-cast concrete panels. The details of this system follow.

Novabrik System for Mortarless Brickwork:

Novabrik is a patented mortarless brick siding system. The high strength concrete bricks overlap and interlock to create a strong, water resistant brick veneer. Novabrik can be installed on wood studs, steel studs and concrete structures. Application on innovative Building systems like Insulating Concrete Form (ICF) systems and steel buildings is very easy and cost effective. Because the bricks hang on the wall, no brick ledge or steel support is necessary for support. All of the inconveniences of mortar have been eliminated. There is no variation in the mortar joint color or thickness and no height limitation for installation in a single day. There also is no mortar joint to maintain over the life of the building. Because Novabrik can be installed by workers without masonry skills, the installation cost of the mortarless brick system is less than that of conventional brick walls. In addition, a 50-year limited transferable warranty is provided.

Advantages to this system are that it resists seasonal freeze/thaw cycles. It is made of very durable, fire resistant stone. It is manufactured to stone quality and it will not dent, chip or fade. It increases the strength of the structural framework of traditional homes by 35%. It resists water penetration. It has high soundproofing for improved comfort. (See picture on right for an example)

Figure 4: Nova-brik Example




*Additional information in appendix

**Smith-Midland Slenderwall Product:**

Slenderwall is the only wall system that combines these proven components: architectural precast concrete, *Thermaguard Æ and light-gauge steel studs engineered into a single, efficient wall system. The ductility of the steel components in Slenderwall is engineered to allow the building frame to move independently of the exterior skin, preserving the structural integrity and the water tightness of the wall system.

Slenderwall eliminates staggering recladding costs and responsibility battles by using permanent components; corrosion from water and vapor infiltration by using corrosion and rust-proof materials

It also is designed to endure structural challenges such as building frame lateral displacement, beam and floor deflection, column shortening and long-term creep.

Smith-Midland's product reduces structural steel and foundation requirements when compared to conventional architectural precast concrete. It also reduces shipping costs because more lightweight panels can be shipped in each load, and reduces heating and cooling costs with Thermaguard connecting anchor and the added air space which reduces heat transfer by 25%. It reduces installation time and costs due to ease of erection, as the insulation and interior drywall is applied directly to the light-gauge steel stud. At 28 pounds per square foot, Slenderwall panels are 40 to 60% lighter than conventional precast concrete panels.

*Thermaguard Æ is an exclusive epoxy-coated stainless steel Nelson® anchor that prevents corrosion and reduces thermal transfer from the precast element to the steel studs, etc.

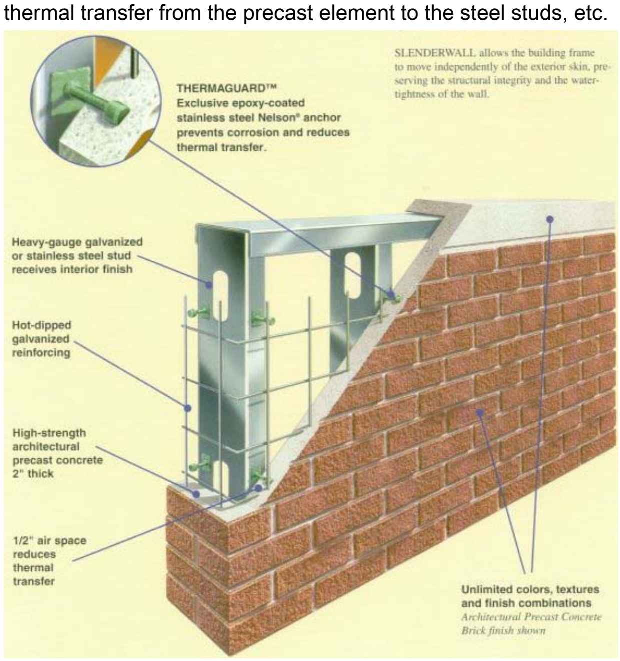



Figure 5: Slenderwall Example

*For more information on the Slenderwall Product see Appendix D

## Summary & Conclusions:

### Issue at Hand:

Will the construction time be quicker using another material/method other than normal brick? **Answer: YES**

Will the other method be cheaper than using normal brick? **Answer: YES**

### Solution:

It is suggested that the New Jacksonville Arena be enclosed using the Slenderwall system manufactured by Smith-Midland. The initial shock of the increase of cost would turn some people away, but once the extra costs are looked at, along with the speed of erection, it becomes the most logical choice. The cost of the brick cavity wall system in place now is between $1,593,942 and $1,614,110.1. The cost of changing the brick type to a mortarless technology called Novabrik is $1,300,827.7-$1,320,995.7; a small decrease in cost. And the last option is the cost of the Slenderwall system which is between $2,117,451 and $2,520,775. Although this process is the most expensive it cuts the enclosure time by more than four weeks. Since enclosing the building is a critical path process saving a month off of the completion of this process would push up the completion date by approximately this time period. This change would reap benefits that the city could look at directly as extra profit opportunities of events that they could hold. If every event, on average, brings in $150,000 in profit, the city would only need to hold 7 events during this extra month of time and it would already be making profit. Any extra event that they choose to hold during that month is just extra profit.

### Potential Benefits:

The benefits of the mortarless brickwork are that it is mortarless, making installation time much quicker. The cost of the bricks is $1,300,827.7-$1,320,995.7, but you also save money by not having to purchase any mortar, much less install it. The benefits of the Slenderwall product are why it is the best choice. Since it is a composite product the installation of the whole wall system in one lift cuts total construction time by more than half. Inefficiencies were not accounted for; it was assumed that the crews were working at their maximum capabilities.

### Project Impact:

The conclusions of the analysis regarding the change of the skin on the façade of the building are listed below:



*Schedule:* Slenderwall is by far the best option as it completes the process more than four weeks early.

*Cost Implications:* From the chart below it is evident that the original brick design was the most cost effective, with the Novabrik being almost equal. The Slenderwall product was approximately one million dollars more, from a materials cost. But when looked at from a cost aspect of the total dollars saved or spent, the Slenderwall product's benefits, and time saving issues make it the most cost effective choice.

*Answer:* **Slenderwall is the best option to go with considering all of the implications of changing the façade to this composite product.**

Table 6: Skin Calculations

| | Slenderwall | Novabrik* | Precast | Brick Façade* |
|---|---|---|---|---|
| Base Price/ S.F. | $16-20/ S.F. | $3 | $16-20 | $4.19 |
| Freight | $1.00 / S.F. | $0.50 | $1.50 | $0.50 |
| Installation | $4.00 / S.F. | $5.00 | $5 | $7.40 |
| Light-gauge framing | Included | $0.88 | $1.5 | $0.88 |
| Foundation Extra Cost | None | None | $0.50 | None |
| Struct. Steel Extra Cost | None | $1.80 | $1.80 | $1.80 |
| Drywall | Included | $0.63 | $0.63 | $0.63 |
| Wall Ties | Included | $0.30 | $1.00 | $0.30 |
| Total | $21-25 / S.F. | $12.11 / S.F. | $27.93-31.93 / S.F. | $15.17 / S.F. |
| Brick Square Footage | --------------- | 95,789 | ---------------------- | 95,789 |
| Precast Square Footage | --------------- | ------------ | 5,042 | ------------- |
| Total Square Footage | 100,831 | ------------ | ---------------------- | ------------- |
| **Total Price** | **$2,117,451-<br>$2,520,775** | **$1,300,827.7-<br>$1,320,995.7** | | **$1,593,942.1 -<br>$1,614,110.1** |
| Total R Value | 23.63 | 21.92 | | 21.98 |
| Corresponding U-Value | 0.042 | 0.0456 | | 0.0455 |
| Production Rates | 7,500 -10,000<br>S.F./Day | 5000 - brick<br>7356 – studs<br>7000 – gyp bd | 320 S.F. / Day<br><br>(16 days) | 3080 – brick<br>7356 – studs<br>7000 – gyp bd |
| **Total Time** | **10-14 Days** | **25 Days** | | **36 Days** |
| Time Saved | 4+ Weeks | 11 Days | | 0 Days |

*Note: Just brick is not an option as there is a required precast element as well, as is the same with Novabrik



# Survey Investigation & Research

Survey Results: Results of survey regarding the implementation of 3-D/ 4-D modeling into the construction companies and into the coordination with subcontractors, and clients

Initial Hypothesis/Thoughts: The time where the business of construction, to a certain extent, is utilizing computers more and more has come. A survey has been conducted amongst people out in the industry form PM's, to architects, to see how they think 3-D Cad as well as other visualization products are going to be used and implemented into the work environment. Hopefully people will feel that the technology is going to be needed as well as helpful out in the field and in the office of the future. Below is a copy of the Online Survey introduction. The full survey is located in Appendix E. This type of system would benefit the construction on the Jacksonville Arena in that it would have allowed the contractor and the subcontractors to coordinate the extensive MEP work in the building, especially underneath the concrete slab for the ice rink where there is a vast number and sizes of pipe of both water and power to run. It was thought that this also would have allowed the GC (Turner) to better present and visualize the construction process, mainly the order of trades through the space. They did not run into any major problems during the construction thus far, but had they had a better more visually adaptive plan they might have saved some time, and possibly made up the month delay that they are enduring right now. The delay was not their fault, instead it had to do directly with the city, but as the GC they might have been able to make it up to them, and possibly made some more profit.

Introduction:

The Purpose of this survey is to see how prevalent companies and persons out in the construction industry find the use of upcoming technologies the equivalent of 3-D/4-D AutoCAD. I hope to get a representation as to where we are as an industry with regards to the usage of newer technologies, as well as how willing they would be able to try to implement these systems.

Proposed Idea:

The idea I am proposing is to implement a 3-D/4-D model of a project at an early stage in the design process. In this drawing you can sequence the installation of the foundation, structure, MEP coordination. This will allow you the GC/CM to better coordinate with the subs or design engineers. I am proposing to possibly being able to download this time dependant drawing onto a palm pilot or tablet PC so that if needed you could take it out into the field an show the contractor what he/she needs to see, you could. Also you could take this and show the owner or client for presentation purposes.

Relevant Background:

Recently, the construction industry has begun to accept 3-D models as a design tool, not just a three-dimensional representation that augments traditional 2-D systems. This initiates the argument that these models can and probably should be used for coordination and planning uses. This can be much more detailed and easier than the two-dimensional way of coordinating trades throughout the spaces, as these 3-D drawings allow contractors to see where their work and materials can go or run, and if allowed access they can update the drawings themselves. It is also been started that these 3-D models are allowing contractors as well as designers to cover the entire spectrum of the engineering process, from pre-construction planning all the way through start-up, and the commissioning of the project.

Aspects of proposed system:

The proposed system would allow the designers or even the CM/GC's to upload the drawings onto a network that could be accessed by outside companies and contractors, who provided with the password could edit and save their work right there on one drawing file, that can be accessed by all involved in the project. The 3-D capabilities of the proposed system can be utilized to allow for coordination and planning, far and above the normal layout of the building. These technologies can be used for such uses as; visualization, marketing, design coordination, estimating, drawing production, field planning, and other superintendent issues. The 16 companies who use CAD said that they used it for:

| *Uses* | Number of the 16 Companies Who Use CAD for This |
|---|---|
| *Visualization* | 4 |
| *Design Coordination* | 11 |
| *Estimating* | 6 |
| *Marketing* | 8 |
| *Drawing Production* | 14 |
| *Field Planning* | 3 |
| *Other Issues* | 8 |

Of the 17 GC's who responded they generally coordinated their field work with the subs by using floor plans and scheduling on a weekly basis. They all said that they have problems with their current system of coordinating with their subs, and 15 of the 17 thought that using this 3-D system to help coordinate with the subs would prevent some of those problems. In response to what issues with the coordination process needed to be improved, most answers were that planning for the other trades that would interfere with the major trades was a problem. They also said that a huge problem, and most of the companies felt this way, was material storage and handling around the site. These two problems could come to an end if the respective trades had coordinated their work on one drawing that they both could see three-dimensionally to prevent any interference. The material storage and handling is easily solved by plotting the materials and equipment on a site plan in CAD, although most companies have their own method for doing this, putting it into CAD allows the processes to be changed more easily and different phases can all be put into a time dependant drawing (4-D) to allow the contractor to see the whole project in a rendering of the construction time period.

Summary of Results:

There were 25 responses to the online survey. Some companies have already begun using the network accessibility technology, mostly the architectural firms to update drawings onto one network from all involved in the design process. These firms allow the companies access to the specific files and every morning the files are uploaded so that on any day a company can go in and see the most up-to-date version of the drawings. Others are using this aspect to upload visible .PDF files instead of actually using the CAD files, every couple of weeks or when a new set of drawings are released. As far as the 3-D technology use is concerned; six of the sixteen companies who are using CAD are taking advantage of the 3-D or 4-D technologies in that software. Almost all, or 23 of the 25, felt that their employees would be receptive to learning and using the software. The surprising fact is that all of the companies have employees who are AutoCAD proficient but only 16 of them are actually taking advantage of their employees' knowledge. Most of the companies if they were to implement this technology would need an outside IT person to set-up and teach this software to their employees. With respect to the proposed idea, 4 companies said that they would be willing to try and implement this idea of using the computers to their full capabilities, while basically the rest of them said they would have to see good results of another company using the technology before they would be willing to put any money into it. The majority of the companies said that they would give the technology between two and four projects to prove its worth in the field. All of the companies replied and said that the system would have to save a month or more on a project in order for them to adopt the technology.

### Conclusions to Results:

In conclusion to the replies of the survey, the proposed system is going to have to prove its worth in the field with some of the industry's leading corporations in order for the rest of the companies to follow and begin implementing the technology as well. Most of the companies felt that this technology could be used for a variety of uses which in turn could allow a project to be better coordinated and flow better, thus finishing on time, or earlier. It also can save money in the coordination of trades, as; the software in three dimensions allows the different trades to place their materials where they need to be with respect to other trades' work. Almost every company has someone or some people who know how to use the CAD software, but may not have the training to start using the 3-D or 4-D aspects of the program. Training and possible installation of the programs is going to be a necessity with implementing this idea into companies as most do not have an IT department. Hopefully some of the leading companies out in the field will begin to take full advantage of these programs, and in turn prove to the other companies that this is where they are going to have to go to be competitive in the business of the future. Once clients see how organized the companies who are using this technology are, they will expect it from any company they do business with in the future, or only go to those using it, and put the others at a disadvantage. This software which was not used by the GC on the New Jacksonville Arena would have allowed better coordination of the trades and possibly allowed the GC to make up lost time by the owner at the beginning of the project. It was used to an extent in the design process, as the architect published the drawings in PDF format online as the drawings went to print.

# Breadth Study:

## Structural Redesign:

Analysis of change in structure from C.I.P. concrete structure to a structural steel frame with shear studs, metal decking and poured slabs, or more often referred to as a composite floor system.

### Initial Proposal:

The final proposed idea for change in the arena project would be for the entire structure to be completed using steel. This would mean changing all of the beams and columns, as well as the intermediate beams and joists which are made from reinforced concrete right now. As the building stands (or is being built) now the entirety of the building is cast-in-place concrete until you get to the roof level where the long spans begin to come into play, (ie. the roof trusses). The truss system will be left as is. The research will look into the value engineering of the proposed change in the changed structural system involved in supporting the upper levels of the building as well as the equipment of the higher levels. The change in the structure type will be looked at from a constructability point of view, can the site handle the change, and can the building be constructed as planned. The schedule and costs will be reevaluated to see how much time this change will save as well as can the change occur without affecting the budget drastically. In researching the ability for this change to occur certain design alternatives will have to be addressed regarding the change in the structure to accommodate the new loads and sizes of beams and columns. This also will have a small affect on the architectural design of the building, so that will have to be looked at as well. The cost and schedule will be reevaluated to incorporate the proposed changes regarding the change from concrete to steel, including material, labor, contractual incentives, etc. The initial thought is that the construction of the building will be accelerated, minus the lead time for the steel.

### Design Criteria:

The New Jacksonville Arena is a structure which is almost entirely made out of cast-in-place concrete except for the roof trusses. The arena needs to be able to endure a love load of one hundred pounds per square foot, and a wind load specified by ASCE 7-98 of one hundred and fifteen miles per hour. The current beams are cast to have the strength of four thousand pounds per square inch, and the slabs are cast to be three thousand five hundred pounds per square inch.

Aspects of Design:

Current: The current design consists of beams which are forty eight inches deep, and columns which are on average forty three inches wide. The decks are made from poured concrete which is required to be shored for up to seventy two hours after the pour or until the concrete reaches two thousand eight hundred pounds per square inch. They then need to be reshored for an additional 7 days. The beams need to be shored for 7 days and then reshored for an additional 14 days. The current slab is on average eight to nine inches thick.

Proposed: The proposed design will consist of beams which are on average thirty five inches deep, and columns which are on average thirty inches wide. The proposed idea for the structure involves using a three inch deep LOK decking from United Steel Decking Company, along with shear studs and a four inch concrete slab on top of the decking.

Additional Background:

Summary & Conclusions:

Issue at hand:

Will the structure be constructed quicker? Answer: YES

Will the structural change cost more or less money? Answer: LESS

Will the architecture be changed enough to look at a redesign of the exterior of the building? Answer: NO

Solution:

I suggest that the New Jacksonville Arena be erected using steel. The initial thoughts were that the steel material was going to be much more expensive, which it was, but that the difference would be more than made up by completing the work quicker. The cast-in-place method took eight months to complete, and cost eight million five hundred thousand dollars. The steel method for constructing the structure is only going to take two months instead of eight, and is going to cost seven-point-one million dollars. The total time saved by switching to the steel method is between five and six months when you account for inefficiencies as well as the other trades other than steel finishing their work. If you stagger the trades in behind the steel the work can keep up almost like a domino effect, one after another in a row. The proposed change kept the column heights the same in order to not change the exterior effect of the structure. The preliminary analysis in this area used hand calculations and plastic analysis methods for calculating the beam sizes and come up with on average smaller beams. One analysis came up with W21 x 48 beams where RAM Steel, a computer analysis program came up with W24 x 55 beams. After this it was realized that in the calculations by hand wind was not taken into consideration, so RAM Steel was used for the remainder of the calculations of beam sizes. The hand calculations also did not take moment connections into consideration.

### Potential Benefits:

The potential benefits of using concrete are that it is plentiful in Florida and the costs implications with this would offset the time issue. This is not the case here. Hirshfeld steel in Dallas, Texas who provided the steel for Heinz Field in Pittsburgh, Pennsylvania, said that their costs for delivering and producing the steel, when combined with the installations costs from the erectors, are usually right around the data provided in R. S. Means. This gave a total cost of $2,150 per ton of steel. The cost of steel is usually greater than that of concrete for the material, as well as the installation, but the advantages are that it goes up much quicker. This allows the structure to be topped off and this is always a major milestone in the construction process. The decrease in the beam depth and slab depth increases the plenum or open space by fourteen inches. This allows for more room for the MEP work to be coordinated without extending down further towards the people below in the concourses, offices, locker rooms, etc.

### Project Impact:

The conclusions of the analysis regarding the change from a cast-in-place concrete structure, to an all steel building.

*Schedule:* Steel is quicker and takes less than half the original time of the cast-in-place.

*Cost Implications:* The C.I.P. costs $8,500,000, while the Steel costs $7,080,628.

***Answer:*** **Steel is the best option to go with, 30% of the time, and $1.4 Million saved.**

*see next page for a comparative analysis of the two options

Comparative Analysis of the Two Options:

| | Cast-in-place | Units | Steel |
|---|---|---|---|
| | Unit Costs & Totals | | Unit Costs & Totals |
| *Floor-to-floor height* | 56” | Inches | 42” |
| *Extra Space* | | Inches | 14” |
| *# of pieces* | N/A | pieces | 1,776 pieces |
| *Welding* | N/A | $/ton | $134.00 |
| *Fireproofing* | Built In | $/l.f. | $40.60 |
| *Shear Studs* | N/A | # | 2,160 studs |
| *Shear Stud Cost* | N/A | $ | $2.00/ stud |
| *Slab* | 8-9 inches Shored | inches | 4” + 3” in the decking |
| *Slab Cost* | Inc. | $/s.f. | $5.00 / sq. ft. |
| *Area of Slab* | 326,350 sq. ft. | S. F. | 326,350 sq. ft. |
| *Finishing* | Same for Both N/A | $/s.f. | Same for Both N/A |
| *Tons of Steel* | N/A | Tons | 1,326 tons |
| *Cost of Steel* | N/A | $/ton | $2,150 / ton |
| *Linear Ft of Steel* | N/A | ft | 7258.6 feet |
| *Decking* | N/A | $/s.f. | $6.50 / sq. ft. |
| *Decking Sq. Ft.* | N/A | S. F. | 326,350 sq. ft. |
| *Production Rate* | ------------- | ------- | 30 picks / day |
| *Total Time* | 200 Days / 8 Months | Days | 60 days |
| *Time Saved* | 0 Days | Days | 140 Days |
| *% of Original Time* | 100 % | % | 30% |
| *Total Cost* | $8,500,000 | $ | $7,080,628 |
| *Savings* | $0.00 | $ | $1,419,372 |

# Summary & Conclusions:

For the construction improvements on the New Jacksonville Arena I suggest changing to cast-in-place raker beams, not only are they cheaper to construct, but the fact that the concrete contractor would be taking care of their construction would also lessen the cost, since the constructor would be packaging the lower bowl rakers with the rest of the superstructure. This package by itself costs $260,926.00 to construct it using the cast-in-place method versus the original method of constructing the rakers using pre-cast which cost $500,000.00, almost twice as much as the proposed plan. The time to construct the cast-in-place beams is thirty days versus the seventy to construct the beams using the pre-cast, due to lead time. This is a savings of more than half the time.

It is suggested that the New Jacksonville Arena also be enclosed using the Slenderwall system manufactured by Smith-Midland instead of being enclosed by nominal brick. The cost of the brick cavity wall system in place now is between $1,593,942 and $1,614,110.1. The cost of changing the brick type to a mortarless technology called Novabrik is $1,300,827.7-$1,320,995.7; a small decrease in cost. And the last option is the cost of the Slenderwall system which is between $2,117,451 and $2,520,775. Although this process is the most expensive it cuts the enclosure time by more than four weeks. Since enclosing the building is a critical path process saving a month off of the completion of this process would push up the completion date by approximately this time period allowing the city to hold events which would more than pay for the increase in cost.

In conclusion to the replies of the survey, the proposed system is going to have to prove its worth in the field with some of the industry's leading corporations in order for the rest of the companies to follow and begin implementing the technology as well. Most of the companies felt that this technology could be used for a variety of uses which in turn could allow a project to be better coordinated and flow better, thus finishing on time, or earlier. It also can save money in the coordination of trades, as; the software in three dimensions allows the different trades to place their materials where they need to be with respect to other trades' work. Almost every company has someone or some people who know how to use the CAD software, but may not have the training to start using the 3-D or 4-D aspects of the program. Training and possible installation of the programs is going to be a necessity with implementing this idea into companies as most do not have an IT department. Hopefully some of the leading companies out in the field will begin to



take full advantage of these programs, and in turn prove to the other companies that this is where they are going to have to go to be competitive in the business of the future.

Finally I suggest that the New Jacksonville Arena be erected using steel. The initial thoughts were that the steel material was going to be much more expensive, which it was, but that the difference would be more than made up by completing the work quicker. The cast-in-place method took eight months to complete, and cost eight million five hundred thousand dollars. The steel method for constructing the structure is only going to take two months instead of eight, and is going to cost seven-point-one million dollars. The total time saved by switching to the steel method is between five and six months when you account for inefficiencies as well as the other trades other than steel finishing their work.

Overall the cost savings for all of these changes, minus the technology because dollar amounts could not be associated for this project, were a little over three million dollars. The total time saved pushing up other activities in the construction process, was over 200 days. Granted this time can not just be taken off of the final completion date but these times will allow the project to push forward in other areas sooner, which in turn will complete the project earlier. It would be impossible to put a finish time on the project, especially since when a schedule is done in the beginning it is always tentative anyway, unless the owner puts a finalized move-in date on the project. This would not affect the arena seeing as these changes would initiate an earlier finish date with a savings to go along with it too.