Kennedy Krieger Institute
Outpatient Medical Center
Baltimore, Maryland

Katie Sennett
Construction Management
Dr. Messner

Spring 2008

Kennedy Krieger Institute Outpatient Medical Center Baltimore, Maryland

Katie Sennett
Construction Management

Improving Cost, Constructability, & Quality

Kennedy Krieger Institute Outpatient Medical Center Baltimore, Maryland

Katie Sennett
Construction Management

Project Overview

Location: Baltimore Maryland

Occupancy and Function: Outpatient Medical Center for the Developmental Disabilities of Children

Size: 115,000 Square Feet

Schedule: 24 Months – Starting Jan. 2007 & Ending Jan. 2009

Total Project Cost: $3.5 Million

Project Delivery Method: CM @ Risk

11/28/07 – North elevation from ground

11/28/07 – Precast finished at southwest corner

Kennedy Krieger Institute Outpatient Medical Center Baltimore, Maryland

Katie Sennett
Construction Management

Project Overview

Location: Baltimore Maryland

Occupancy and Function: Outpatient Medical Center for the Developmental Disabilities of Children

Size: 115,000 Square Feet

Schedule: 24 Months – Starting Jan. 2007 & Ending Jan. 2009

Total Project Cost: $3.5 Million

Project Delivery Method: CM @ Risk

Project Team

Owner: Kennedy Krieger Institute

CM: Whiting- Turner Contracting Company

Architect: Stanley, Beaman, and Sears

Structural & MEP Engineer: RFM Engineering

Civil Engineer: RK +K

Kennedy Krieger Institute
Outpatient Medical Center
Baltimore, Maryland

Katie Sennett
Construction Management

Project Overview

Existing Site Condition: A parking lot

Foundation : Mat Slab Foundation System

Kennedy Krieger Institute Outpatient Medical Center Baltimore, Maryland

Katie Sennett
Construction Management

Project Overview

Existing Site Condition: A parking lot

Foundation : Mat Slab Foundation System

Structure: Cast In Place Concrete

Building Envelope: Precast Architectural Panels

Kennedy Krieger Institute
Outpatient Medical Center
Baltimore, Maryland

Katie Sennett
Construction Management

Analysis 1

Changing Structural System

Problem: Structural System was timely and required employees to work weekends for 2 months. It was also had a high price.

Objective: To change structural system from Cast –In-Place Concrete to Structural Steel to reduce construction schedule and project cost.

Kennedy Krieger Institute
Outpatient Medical Center
Baltimore, Maryland

Katie Sennett
Construction Management

Analysis 1

Changing Structural System

Problem: Structural System was timely and required employees to work weekends for 2 months. It was also had a high price.

Objective: To change structural system from Cast –In-Place Concrete to Structural Steel to reduce construction schedule and project cost.

Procedure

- Redesign structural system
- Determine NEW construction schedule
- Create Sequence schedule
- Cost comparison to original system

Kennedy Krieger Institute
Outpatient Medical Center
Baltimore, Maryland

Katie Sennett
Construction Management

Analysis 1

Changing Structural System

Problem: Structural System was timely and required employees to work weekends for 2 months. It was also had a high price.

Objective: To change structural system from Cast –In-Place Concrete to Structural Steel to reduce construction schedule and project cost.

Procedure

•Redesign structural system
•Determine NEW construction schedule
•Create Sequence schedule
•Cost comparison to original system

Initial Building: Typical Bay Size 29’ x 29’
Pan and Joist Flooring System
(Orientation North-South)
Columns Size: 30” diameter

Kennedy Krieger Institute
Outpatient Medical Center
Baltimore, Maryland

Katie Sennett
Construction Management

Analysis 1

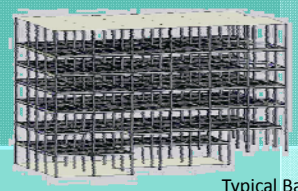
Changing Structural System

Problem: Structural System was timely and required employees to work weekends for 2 months. It was also had a high price.

Objective: To change structural system from Cast –In-Place Concrete to Structural Steel to reduce construction schedule and project cost.

Procedure

•Redesign structural system
•Determine NEW construction schedule
•Create Sequence schedule
•Cost comparison to original system



Typical Bay size: 29’ x 29’

Total Building Live Load: 246.5 kips
Total Building Dead Load: 378.1 kips

Beam Size: 16 x 26
Girder Size: 21 x 68
Column Size: 14 x 90
(Orientation of beams East-West)

Kennedy Krieger Institute
Outpatient Medical Center
Baltimore, Maryland

Katie Sennett
Construction Management

Analysis 1

Changing Structural System

Problem: Structural System was timely and required employees to work weekends for 2 months. It was also had a high price.

Objective: To change structural system from Cast –In-Place Concrete to Structural Steel to reduce construction schedule and project cost.

Procedure

- Redesign structural system
- **Determine NEW construction schedule**
- Create Sequence schedule
- Cost comparison to original system

NEW Schedule

Original Schedule = 86 days
New Schedule = 43 days

Reducing Schedule by = 43 Days

Kennedy Krieger Institute Outpatient Medical Center Baltimore, Maryland

Katie Sennett
Construction Management

Analysis 1

Changing Structural System

Problem: Structural System was timely and required employees to work weekends for 2 months. It was also had a high price.

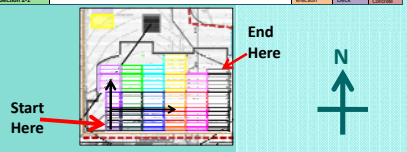
Objective: To change structural system from Cast –In-Place Concrete to Structural Steel to reduce construction schedule and project cost.

Procedure

- Redesign structural system
- Determine NEW construction schedule
- **Create Sequence schedule**
- Cost comparison to original system

Construction Sequence Schedule: Showing only the 1st floor up to the 2nd floor.

Section Schedule	25-Jun	26-Jun	27-Jun	28-Jun	29-Jun	2-Jul	3-Jul	4-Jul	5-Jul
Section 1-1	Steel erection	Metal Deck	Concrete						
Section 1-2		Steel erection	Metal Deck	Concrete					
Section 1-3			Steel erection	Metal Deck	Concrete				
Section 1-4				Steel erection	Metal Deck	Concrete			
Section 1-5					Steel erection	Metal Deck	Concrete		
Section 1-6						Steel erection	Metal Deck	Concrete	
Section 2-1							Steel erection	Metal Deck	Concrete



Kennedy Krieger Institute
Outpatient Medical Center
Baltimore, Maryland

Katie Sennett
Construction Management

Analysis 1

Changing Structural System

Problem: Structural System was timely and required employees to work weekends for 2 months. It was also had a high price.

Objective: To change structural system from Cast –In-Place Concrete to Structural Steel to reduce construction schedule and project cost.

Procedure

- Redesign structural system
- Determine NEW construction schedule
- Create Sequence schedule
- **Cost comparison to original system**

Description	Cost
Foundation system	580,800
Structural Steel	1,899,951
Concrete Shear Walls	388,292
Concrete Flooring	406,350
Fire Proofing	173,179
Tower Crane	69,400
Total	$3,517,972

Kennedy Krieger Institute
Outpatient Medical Center
Baltimore, Maryland

Katie Sennett
Construction Management

Analysis 1

Changing Structural System

Problem: Structural System was timely and required employees to work weekends for 2 months. It was also had a high price.

Objective: To change structural system from Cast –In-Place Concrete to Structural Steel to reduce construction schedule and project cost.

Procedure

- Redesign structural system
- Determine NEW construction schedule
- Create Sequence schedule
- **Cost comparison to original system**

Description	Cost
Foundation system	580,800
Structural Steel	1,899,951
Concrete Shear Walls	388,292
Concrete Flooring	406,350
Fire Proofing	173,179
Tower Crane	69,400
Total	$3,517,972

Cost Comparison

Cast in Place Concrete = $4,181,700
Redesigned Structural System = $3,517, 972

A TOTAL SAVINGS OF = $663,738

Kennedy Krieger Institute Outpatient Medical Center Baltimore, Maryland

Katie Sennett
Construction Management

Analysis 1

Changing Structural System

Problem: Structural System was timely and required employees to work weekends for 2 months. It was also had a high price.

Objective: To change structural system from Cast –In-Place Concrete to Structural Steel to reduce construction schedule and project cost.

Procedure

- Redesign structural system
- Determine NEW construction schedule
- Create Sequence schedule
- Cost comparison to original system

Recommendations

Benefit s the Owner by using a steel structural system by:

- Reduces the project schedule and gets the owner into the building two months sooner which allows them to start making a revenue sooner.
- Reduces overall project cost which allows owner to purchase more specialized equipment for the children.

Kennedy Krieger Institute
Outpatient Medical Center
Baltimore, Maryland

Katie Sennett
Construction Management

Analysis 2

Heat Recovery System

Problem: Since the building is a medical center, it requires 100% exhaust air. This increases energy costs to heat/cool supply air.

Objective: To decrease energy costs by installing enthalpy wheels into the 3 AHU and maintain indoor air quality.

Initial Mechanical System

•Includes 3 Air Handling Units with a 40,000cfm Capacity
•Cooling Capacity : 246.9 Tons
: 2,962.2 Mbh

•Heating Capacity : -2,270.4 Mbh

Energy Consumption

Kennedy Krieger Institute
Outpatient Medical Center
Baltimore, Maryland

Katie Sennett
Construction Management

Analysis 2

Heat Recovery System

Problem: Since the building is a medical center, it requires 100% exhaust air. This increases energy costs to heat/cool supply air.

Objective: To decrease energy costs by installing enthalpy wheels into the 3 AHU and maintain indoor air quality.

Procedure

- Evaluate Mechanical system with a heat recovery system
- Re-design air handling unit
- Cost of system
- Cost comparison to original system

Kennedy Krieger Institute
Outpatient Medical Center
Baltimore, Maryland

Katie Sennett
Construction Management

Analysis 2

Heat Recovery System

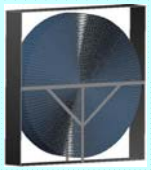
Problem: Since the building is a medical center, it requires 100% exhaust air. This increases energy costs to heat/cool supply air.

Objective: To decrease energy costs by installing enthalpy wheels into the 3 AHU and maintain indoor air quality.

Procedure

- **Evaluate Mechanical system with a heat recovery system**
- Re-design air handling unit
- Cost of system
- Cost comparison to original system

The best heat recovery system for this building is the enthalpy wheel. It preconditions the air before final heating/cooling the supply air.



Enthalpy Wheel:

- Captures the hot/cold element from the exhaust air to pre condition the supply air.
- It prevent contaminates by expelling contaminates out through exhaust air duct.

Kennedy Krieger Institute
Outpatient Medical Center
Baltimore, Maryland

Katie Sennett
Construction Management

Analysis 2

Heat Recovery System

Problem: Since the building is a medical center, it requires 100% exhaust air. This increases energy costs to heat/cool supply air.

Objective: To decrease energy costs by installing enthalpy wheels into the 3 AHU and maintain indoor air quality.

Procedure

•Evaluate Mechanical system with a heat recovery system
•Re-design air handling unit
•Cost of system
•Cost comparison to original system

Mechanical System with Enthalpy Wheels

•Includes 3 Air Handling Units with a 40,000cfm Capacity
•Cooling Capacity :216.6Tons
: 2,559.9 Mbh

•Heating Capacity : -1,974.7 Mbh

Energy Consumption

Kennedy Krieger Institute
Outpatient Medical Center
Baltimore, Maryland

Katie Sennett
Construction Management

Analysis 2

Heat Recovery System

Problem: Since the building is a medical center, it requires 100% exhaust air. This increases energy costs to heat/cool supply air.

Objective: To decrease energy costs by installing enthalpy wheels into the 3 AHU and maintain indoor air quality.

Procedure

•Evaluate Mechanical system with a heat recovery system
•Re-design air handling unit
•Cost of system
•Cost comparison to original system

Mechanical System with Enthalpy Wheels

•Cooling Capacity Difference = 30 Tons
• =400 Mbh

•Heating Capacity Difference = 300 Mbh

Energy Consumption

Building Energy Consumption = 1,955 Btu/ft^2-year

Kennedy Krieger Institute
Outpatient Medical Center
Baltimore, Maryland

Katie Sennett
Construction Management

Analysis 2

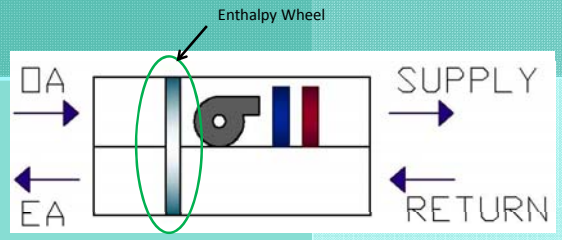
Heat Recovery System

Problem: Since the building is a medical center, it requires 100% exhaust air. This increases energy costs to heat/cool supply air.

Objective: To decrease energy costs by installing enthalpy wheels into the 3 AHU and maintain indoor air quality.

Procedure

- Evaluate Mechanical system with a heat recovery system
- **Re-design air handling unit**
- Cost of system
- Cost comparison to original system



Kennedy Krieger Institute
Outpatient Medical Center
Baltimore, Maryland

Katie Sennett
Construction Management

Analysis 2

Heat Recovery System

Problem: Since the building is a medical center, it requires 100% exhaust air. This increases energy costs to heat/cool supply air.

Objective: To decrease energy costs by installing enthalpy wheels into the 3 AHU and maintain indoor air quality.

Procedure

- Evaluate Mechanical system with a heat recovery system
- Re-design air handling unit
- **Cost of system**
- Cost comparison to original system

Cost of System

Each Enthalpy wheel costs = $39,550

The new system needs 3 (one for each AHU)
Total = $118,650

Kennedy Krieger Institute
Outpatient Medical Center
Baltimore, Maryland

Katie Sennett
Construction Management

Analysis 2

Heat Recovery System

Problem: Since the building is a medical center, it requires 100% exhaust air. This increases energy costs to heat/cool supply air.

Objective: To decrease energy costs by installing enthalpy wheels into the 3 AHU and maintain indoor air quality.

Procedure

- Evaluate Mechanical system with a heat recovery system
- Re-design air handling unit
- Cost of system
- **Cost comparison to original system**

Cost Comparison to Original System

	Electric	Gas	Total Cost
	$/yr	$/yr	yr
Existing System	$122,824	$3,774	$126,598
Redesign	$120,098	$3,602	$123,700
		Total Savings =	$2,898

Kennedy Krieger Institute
Outpatient Medical Center
Baltimore, Maryland

Katie Sennett
Construction Management

Analysis 2

Heat Recovery System

Problem: Since the building is a medical center, it requires 100% exhaust air. This increases energy costs to heat/cool supply air.

Objective: To decrease energy costs by installing enthalpy wheels into the 3 AHU and maintain indoor air quality.

Procedure

- Evaluate Mechanical system with a heat recovery system
- Re-design air handling unit
- Cost of system
- **Cost comparison to original system**

Recommendations

- The Enthalpy wheel was found to save about $3,000 per year on energy costs. However, the total cost of the wheels is $118,650 and it would take 41 years to pay off the wheels before saving money on energy consumption.
- The wheels are also very large and need a long lead time prior to installation.
- The buildings roof is also not designed to be remove to maintain and replace the systems which are located in the penthouse.
- Saving energy is good but in this case it is just to costly for the owner.

Kennedy Krieger Institute
Outpatient Medical Center
Baltimore, Maryland

Katie Sennett
Construction Management

Analysis 3 - Critical Industry Research

3D Design Coordination

Problem: This project did not use 3D design coordination for the MEP system. This created many unproductive meetings and many changes orders.

Objective: To research the use of 3D design coordination for MEP systems with clash detection and to figure out companies think about it.

Kennedy Krieger Institute
Outpatient Medical Center
Baltimore, Maryland

Katie Sennett
Construction Management

Analysis 3 - Critical Industry Research

3D Design Coordination

Problem: This project did not use 3D design coordination for the MEP system. This created many unproductive meetings and many changes orders.

Objective: To research the use of 3D design coordination for MEP systems with clash detection and to figure out companies think about it.

Procedure

Figure out the cost of the program

Survey results

Conclusion

Kennedy Krieger Institute
Outpatient Medical Center
Baltimore, Maryland

Katie Sennett
Construction Management

Analysis 3 - Critical Industry Research

3D Design Coordination

Problem: Many unproductive MEP coordination meetings which resulted in many changes orders.

Objective: To research the use of 3D design coordination for MEP systems with clash detection and to survey the contractors and designs on the project about their thoughts on the program

Procedure

Figure out the cost of the system

Survey results

Conclusion

The cost of the system

3D design coordination requires computer software and training.

Software	Price
AutoCAD	$3,970
Revit MEP	$2,536
Revit Structural	$3,103
NavisWorks	$8,000

Autodesk
Corporate Classroom Training
3-Day (27hrs) = $2,350
5-Day (45hrs) = $3,950
Corporate On-Site Training
3-Day (27hrs) = $1,950
5-Day (45hrs) = $3,250

Kennedy Krieger Institute
Outpatient Medical Center
Baltimore, Maryland

Katie Sennett
Construction Management

Analysis 3 - Critical Industry Research

3D Design Coordination

Problem: Many unproductive MEP coordination meetings which resulted in many changes orders.

Objective: To research the use of 3D design coordination for MEP systems with clash detection and to survey the contractors and designs on the project about their thoughts on the program

Procedure

Figure out the cost of the system

Survey results

Conclusion

Survey Results

- Companies lack the resources and the funds
- Coordinating project team is very difficult
- Most larger companies are subcontracting the 3D design work out to specialists

Kennedy Krieger Institute
Outpatient Medical Center
Baltimore, Maryland

Katie Sennett
Construction Management

Analysis 3 - Critical Industry Research

3D Design Coordination

Problem: Many unproductive MEP coordination meetings which resulted in many changes orders.

Objective: To research the use of 3D design coordination for MEP systems with clash detection and to survey the contractors and designs on the project about their thoughts on the program

Procedure

Figure out the cost of the system
Survey results

Conclusion

Conclusion

- Companies are aware the price to implement the program
- Companies know the process to utilize
- Companies feel that once technology increases more and the demand to use 3D design coordination increases, companies will then start implementing and utilizing 3D design coordination on construction projects.

Kennedy Krieger Institute
Outpatient Medical Center
Baltimore, Maryland

Katie Sennett
Construction Management

Acknowledgements

I would like to thank:

Kennedy Krieger Institute

Project Team @ Whiting-Turner Contracting

AE Faculty and Staff

Family and Friends

Thank You

Kennedy Krieger Institute
Outpatient Medical Center
Baltimore, Maryland

Katie Sennett
Construction Management

Questions / Comments

Kennedy Krieger Institute
Outpatient Medical Center
Baltimore, Maryland

Katie Sennett
Construction Management

Improving Cost, Constructability, & Quality

Project Overview

Analysis 1: Structural System

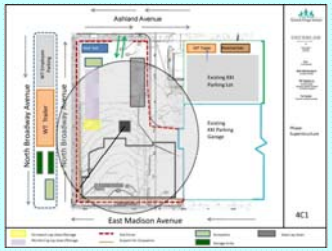
Analysis 2: Mechanical System

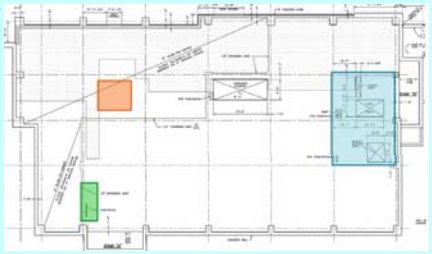
Analysis 3: 3D Design Coordination

Acknowledgements

Questions/Comments

Site Plan & Penetration

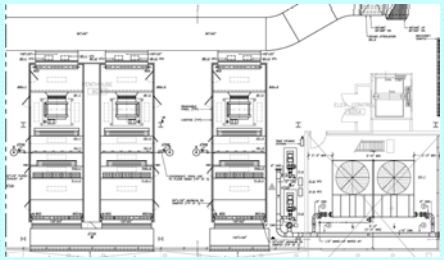




Kennedy Krieger Institute
Outpatient Medical Center
Baltimore, Maryland

Katie Sennett
Construction Management

Mechanical



Kennedy Krieger Institute
Outpatient Medical Center
Baltimore, Maryland

Katie Sennett
Construction Management

Interview Sources

Interview Sources		
Name	**Company**	**Role**
Fred Nash	Enterprise Electric	CAD Operator
Louis Westermeyer	Windsor Electinc Co.	Project Manager
Thomas Fidler	Brown & Heim Electric Contractors	Vice President
Graham Erbe	Southern Mechanical	Estimator/Project Manager
N/A	Mechanical Engineering & Construction Corporation	Project Manager