Widener University Metropolitan Hall

Kevin Engel
Senior Thesis 2006
Construction Management Option

Agenda

Outline
- **Project Overview**
- **Constructability Review**
- **LEED™ Plumbing Analysis**
- **Schedule Acceleration**
  - •Structure Analysis
  - •SIPS Schedule

Background Information

Analysis 1: Constructability Review Research

Analysis 2: LEED™ Analysis of Plumbing Design

Analysis 3: Schedule Acceleration

Project Information

Outline
- **Project Overview**
- **Constructability Review**
- **LEED™ Plumbing Analysis**
- **Schedule Acceleration**
  - •Structure Analysis
  - •SIPS Schedule

Project Team

Owner:	Widener University
CM:	HSC Builders & Construction Managers
Architect:	Wallace, Roberts, & Todd LLC. and CuetoKearney, LLC
Civil Engineer:	Catania Engineering Associates
Struct. Engineer:	O'Donnell & Naccarato
MEP Engineer:	Alderson Engineering

Location

17'th and Melrose Ave.
Chester, PA 19013

General Information

Outline
- **Project Overview**
- **Constructability Review**
- **LEED™ Plumbing Analysis**
- **Schedule Acceleration**
  - •Structure Analysis
  - •SIPS Schedule

Construction Information

Use: Apartment Style Dormitory
Size: 92,000 s.f.
Cost: Total = 18 million, Building = 15 million
Schedule: July 2005 – August 2006

Structure

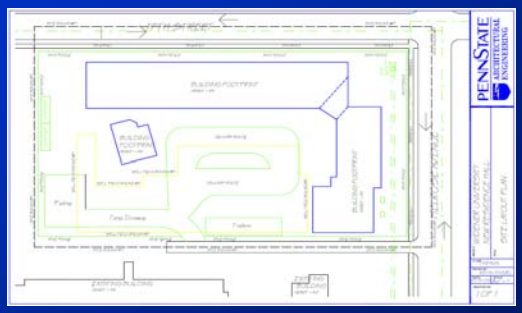
Floors and Roof: Precast Hollow Core Concrete Plank
Walls: 8" CMU

Other

LEED™ Certified
Geothermal Heat Pump System
R-2 Zoning

Site Layout

Outline
- **Project Overview**
- **Constructability Review**
- **LEED™ Plumbing Analysis**
- **Schedule Acceleration**
  - •Structure Analysis
  - •SIPS Schedule



Agenda

Outline
- **Project Overview**
- **Constructability Review**
- **LEED™ Plumbing Analysis**
- **Schedule Acceleration**
  - •Structure Analysis
  - •SIPS Schedule

Background Information

Analysis 1: Constructability Review Research

Analysis 2: LEED™ Analysis of Plumbing Design

Analysis 3: Schedule Acceleration

Constructability Review

Outline

Project Overview

Constructability Review

LEED™ Plumbing Analysis

Schedule Acceleration

- Structure Analysis
- SIPS Schedule

Reason for Research

- Increasing Pressure on Architects
- Shortening of Design Time
- Increasingly Complex Projects
- Errors and Omissions claims against Designers becoming more common
- Newer process that is catching on
  - (currently required by 12 state DOT's)

Data Acquired

- Supplied by The Foreman Group
- General Information from 13 Projects
- Detailed Reports from 5 projects
- General information compared against other projects in Foreman database
- All Projects Lump Sum, Multiple Prime Contractors

Method of Design Checks

Outline

Project Overview

Constructability Review

LEED™ Plumbing Analysis

Schedule Acceleration

- Structure Analysis
- SIPS Schedule

Create Team of 5-10 people

- Superintendent
- Architect
- Project Manager
- Structural Engineer
- Mechanical Engineer
- Electrical Engineer

Method of Design Checks

Outline

Project Overview

Constructability Review

LEED™ Plumbing Analysis

Schedule Acceleration

- Structure Analysis
- SIPS Schedule

Complete Checklist

- Approx. 500 Items
- Divided into General, Site, Architectural, Structural, HVAC, Electrical, and Interiors
- Look for any conflicts between drawings
- Check that specs. do not conflict with plans
- Locate confusing areas
- Add project specific items to checklist

Effectiveness

Outline

Project Overview

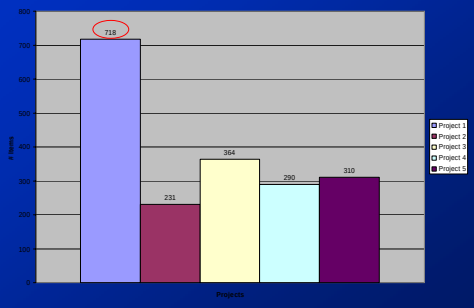
Constructability Review

LEED™ Plumbing Analysis

Schedule Acceleration

- Structure Analysis
- SIPS Schedule

Items Requiring Attention



Effectiveness

Outline

Project Overview

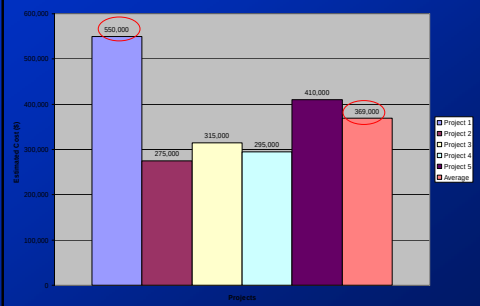
Constructability Review

LEED™ Plumbing Analysis

Schedule Acceleration

- Structure Analysis
- SIPS Schedule

Estimated Cost of Items Found



Effectiveness

Outline

Project Overview

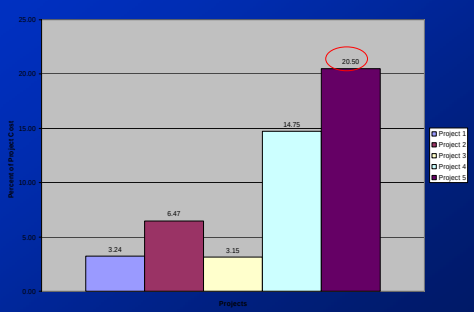
Constructability Review

LEED™ Plumbing Analysis

Schedule Acceleration

- Structure Analysis
- SIPS Schedule

Estimated Value as Percent of Project



8 Items Found on Every Project

Outline

Project Overview

Constructability Review

LEED™ Plumbing Analysis

Schedule Acceleration

- Structure Analysis
- SIPS Schedule

1. Reflected ceiling plans match architectural floor plans. All MEP fixture locations are coordinated with ceiling.
   - RCP's did not match lighting fixture requirements with the mechanical and plumbing needs, room numbers or walls shown incorrectly on RCP.
2. All material choices listed in the finish schedule are consistent with the materials identified on the plans and specs.
   - The finish schedule was either incomplete, missing, or in conflict with the specifications.
3. The size, location and type of foundations are clearly defined on the plans. Foundation plans include drains and tie-ins.
   - Foundation drains or depth not shown in the plans
4. Structural drawings are clear and do not confuse bidders with respect to scope issues.
   - There were items missing from any scope of work and items that were covered under more than one scope.

8 Items Found on Every Project

Outline

Project Overview

Constructability Review

LEED™ Plumbing Analysis

Schedule Acceleration

- Structure Analysis
- SIPS Schedule

5. HVAC routing of duct and pipe does not conflict with architectural plans.
   - All of the projects had conflicts between mechanical or electrical work and the ceiling.
6. Architectural and Electrical drawings appear to be coordinated.
   - Missing fixtures, equipment, and specialties, also inadequate clearances for electrical items.
7. Specifications- Contractors scopes are clearly defined.
   - The specifications were missing work scopes, contained improperly defined scopes, or missed items.
8. Roof Drains shown and correct.
   - The Roof Plans did not show gutters and downspouts. Some did not show any roof drains or had them in locations that conflicted with architectural or plumbing drawings. Also, several Roof Plans showed roof types that differed from the specifications or other plans.

Problems

Outline

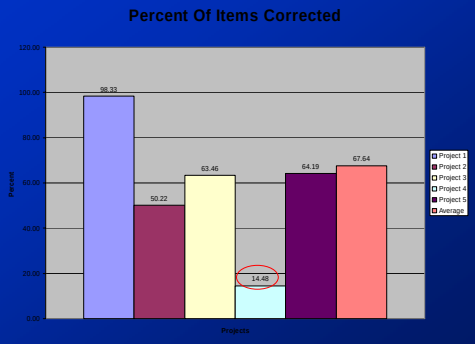
Project Overview

Constructability Review

LEED™ Plumbing Analysis

Schedule Acceleration

- Structure Analysis
- SIPS Schedule



Other Data

Outline

Project Overview

Constructability Review

LEED™ Plumbing Analysis

Schedule Acceleration

- Structure Analysis
- SIPS Schedule

For typical $15 million project:

- Plan Review costs $30,000
- $100,000 of Potential Change Orders Found
- Number of RFI's cut in half
- Out of 260 contracts, only 1 claim filed

Conclusions

Outline

Project Overview

Constructability Review

LEED™ Plumbing Analysis

Schedule Acceleration

- Structure Analysis
- SIPS Schedule

Everybody Makes Mistakes

- Having an independent company review design documents before bids are taken will help reduce change orders later in the project.
- Catching major errors can save a considerable amount of money
- Reviews are more effective if designers are open to revisions.

The Same Mistakes Are Being Repeated

- Report serves as feedback loop, designers should learn what to look for and check for it on their own
- Contractors know what to look for during bidding

Conclusions

Outline

Project Overview

Constructability Review

LEED™ Plumbing Analysis

Schedule Acceleration

- Structure Analysis
- SIPS Schedule

Constructability Reviews Benefit All Involved

- Owner- Reduced Change Orders Later in Project
- Architect- Less likely to have claim filed against them, half the RFI's of a normal project
- Contractors- Clearer construction documents are easier to understand

Reviews Most Effective If Designers Cooperate

- Need to know how the process can benefit them
- Owner needs to enforce the execution of the reviews

Agenda

Outline

Project Overview

Constructability Review

LEED™ Plumbing Analysis

Schedule Acceleration

- Structure Analysis
- SIPS Schedule

Background Information

Analysis 1: Constructability Review Research

Analysis 2: LEED™ Analysis of Plumbing Design

Analysis 3: Schedule Acceleration

LEED™ Basics

Outline

Project Overview

Constructability Review

LEED™ Plumbing Analysis

Schedule Acceleration

- Structure Analysis
- SIPS Schedule

LEED™ = Leadership in Energy and Environmental Design

- Rating system for environmental friendliness of buildings

2 Points Available for Water Reduction

- Savings compared against Energy Policy Act of 1992 Req.
- 1 point for 20% water savings
- 2'nd point for 30% water savings
- Fixtures compared limited to:
  - Water closets
  - Urinals
  - Lavatory faucets
  - Showers
  - Kitchen sinks

Requirements

Outline

Project Overview

Constructability Review

LEED™ Plumbing Analysis

Schedule Acceleration

- Structure Analysis
- SIPS Schedule

Fixture Flow Requirements per Energy Policy Act of 1992

- Water Closets = 1.6 gpf
- Urinals = 1.0 gpf
- Showerheads = 2.5 gpm
- Faucets = 2.5 gpm

Design Comparison

Outline

Project Overview

Constructability Review

LEED™ Plumbing Analysis

Schedule Acceleration

- Structure Analysis
- SIPS Schedule

This is the only noticeable design change

Figure 3: Pressure Assist Water Closet[1] vs. Wall Mounted Water Closet[2]

Design Comparison

Outline

Project Overview

Constructability Review

LEED™ Plumbing Analysis

Schedule Acceleration

- Structure Analysis
- SIPS Schedule

Screw-on Flow Controller-used to restrict flow to shower head to 1.5 gpm

Design Comparison

Outline

Project Overview

Constructability Review

LEED™ Plumbing Analysis

Schedule Acceleration

- Structure Analysis
- SIPS Schedule

Table 1. Current Fixture Water Use Calculations

Quantity	Use / Day	Item	Manufacturer	Model Number	Water Use	Daily Use (Gal/Day)	Cost (ea. $)	Cost Total
103	1500	Water Closet	American Standard	2257.103	1.6 gpf	2400	249.00	25647.00
103	2100	Lavatory	Delta	525	2.3 gpm	4830	115.15	11860.45
101	4500	Shower Head	Delta	1323WS	2.5 gpm	11250	130.55	13185.55
48	1500	Kitchen Sink	Delta	100	2.3 gpm	1500	89.25	4284.00
					Totals	19980		$54,977.00

Table 2. Redesigned Fixture Water Use Calculations

Quantity	Use / Day	Item	Manufacturer	Model Number	Water Use	Daily Use (Gal/Day)	Cost (ea. $)	Cost Total
103	1500	Water Closet	Mansfield Plumbing	147-153	1.0 gpf	1500	414.50	42693.50
103	2100	Lavatory	Kingston Brass	KB-541-B	2.0 gpm	4200	66.07	6805.21
101	4500	Shower Head	Existing w/ NRGSaver	NS377	1.5 gpm	6750	135.05	13640.05
48	1500	Kitchen Sink	Delta	100	2.3 gpm	1500	89.25	4284
					Totals	13950		$67,422.76

Initially costs $12,445 extra

Saves 6,030 gallons per day

Payback Period

Outline

- Project Overview
- Constructability Review
- LEED™ Plumbing Analysis
- Schedule Acceleration
  - Structure Analysis
  - SIPS Schedule

Table 3. Utility Cost Saved

Original	Re-design	Saved	Units
19980	13950	6030	gal/day
599400	418500	180900	gal/month
5394600	3766500	1628100	gal/yr (9 mo. Occ.)
721.2032	503.5428	217.6604	Mcf
21856.72	15312.36	6544.36	Utility bill ($/yr)

Payback Period = $12,445 / $6,544 = **1.90 Years**

Conclusions

Outline

- Project Overview
- Constructability Review
- LEED™ Plumbing Analysis
- Schedule Acceleration
  - Structure Analysis
  - SIPS Schedule

2 points toward LEEDTM Certification

Extra initial cost of $12,445

Saves $6,544 per year in Utility bills

Pays for itself in less than 2 years

Agenda

Outline

- Project Overview
- Constructability Review
- LEED™ Plumbing Analysis
- Schedule Acceleration
  - Structure Analysis
  - SIPS Schedule

Background Information

Analysis 1: Constructability Review Research

Analysis 2: LEED™ Analysis of Plumbing Design

Analysis 3: Schedule Acceleration

Schedule Acceleration

Outline

- Project Overview
- Constructability Review
- LEED™ Plumbing Analysis
- Schedule Acceleration
  - Structure Analysis
  - SIPS Schedule

Strict schedule due to need to occupy building in Fall 2006

2 Schedule Reduction Ideas Analyzed

- Change in Structural System
  - Design-Build Contract allows Construction Manager to make design decisions
- SIPS Scheduling of Finish Trades
  - More detailed planning in order to reduce time needed to complete finishes

Structural Options

Outline

- Project Overview
- Constructability Review
- LEED™ Plumbing Analysis
- Schedule Acceleration
  - Structure Analysis
  - SIPS Schedule

Tilt-Up Wall Panels found to be least expensive structural option while also saving money

Table 1 Structural Wall Comparison

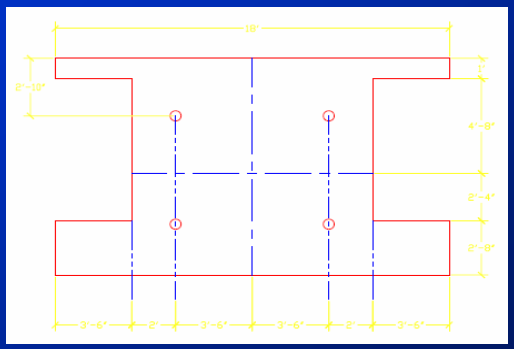
Wall Type	Daily output	Unit Cost	Unit	Duration (days)	Total Cost ($)
CMU	365	5.95	s.f.	252	320033
Steel Column	600	21.50	l.f.(column)	4	4300
CMU Wall	375	5.70	s.f.	245	524400
Steel Girders	912	42.50	l.f.	1.1	43818
Steel Total				250.9	572518
Precast Concrete	768	13.45	s.f.	120	723435
Tilt-Up	1600	5.42	s.f.	58	291526

* Tilt up cost includes: preparation of pouring surface, erect and strip forms, concrete in place, steel trowel finish and curing, reinforcing, inserts and misc. items, panel erection and alignment

Panel Design

Outline

- Project Overview
- Constructability Review
- LEED™ Plumbing Analysis
- Schedule Acceleration
  - Structure Analysis
  - SIPS Schedule



Panel Final Notes

Outline

- Project Overview
- Constructability Review
- LEED™ Plumbing Analysis
- Schedule Acceleration
  - Structure Analysis
  - SIPS Schedule

Panel description:

6" thick, with #3 rebar spaced 12" o.c. in both directions located 1-1/2 inches from the top of the panel as poured and two #3 rebar 1-1/2 inches from the top of the cantilevered sections around the window

Panel checked and meets the following failure possibilities:

- Shear at lifting points
- Moment at lifting points
- Load in place
- Failure at window openings

SIPS

Outline

- Project Overview
- Constructability Review
- LEED™ Plumbing Analysis
- Schedule Acceleration
  - Structure Analysis
  - SIPS Schedule

SIPS = Short Interval Production Scheduling

- A method of planning to increased detail in order to improve efficiency
- First documented by Alvin Burkhart in 1989 article titled "The use of SIPS as a productivity improvement tool."

Finishing Trades Defined As:

- wall painting
- ceiling
- electrical trim and lights
- casework
- plumbing fixtures
- doors and hardware
- flooring

Productivity Rates

Outline

- Project Overview
- Constructability Review
- LEED™ Plumbing Analysis
- Schedule Acceleration
  - Structure Analysis
  - SIPS Schedule

Productivity rates of finish activities

Hours/Unit	Unit	Activity
0.006	s.f.	Paint Walls
0.011	s.f.	Paint Ceiling
0.50	ea.	Elec. Trim & Light Fixt.
0.40	l.f.	Casework
1.6	ea.	Plumbing Fixt.
1.14	ea.	Doors / Hardware
0.016	s.f.	Flooring

Balancing Durations

Outline

- Project Overview
- Constructability Review
- LEED™ Plumbing Analysis
- Schedule Acceleration
  - Structure Analysis
  - SIPS Schedule

Vary crew size in order to give each activity the same duration

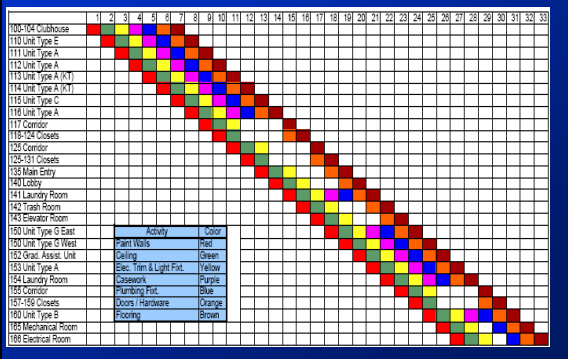
crew size	Preffered Order	Durations	# Crews Needed	Resulting Duration (days)
1	Paint Walls	2 days	2	1
1	Paint Ceiling	2.25 days	2*	1.125
1	Elec. Trim & Light Fixt.	2 days	2	1
2	Casework	1 day	1	1
1	Plumbing Fixt.	2 days	2	1
1	Doors / Hardware	1 day	1	1
1	Flooring	2.5 days	2*	1.25

* It is cheaper to pay overtime for these two activities than to add another person

SIPS Table Graphic

Outline

- Project Overview
- Constructability Review
- LEED™ Plumbing Analysis
- Schedule Acceleration
  - Structure Analysis
  - SIPS Schedule



Schedule Comparison

Outline

- Project Overview
- Constructability Review
- LEED™ Plumbing Analysis
- Schedule Acceleration
  - Structure Analysis
  - SIPS Schedule

- The SIPS Schedule reduced the time required for finish trades from 34 to 33 days per floor
- The work flowed in a more orderly fashion and would be easier to speed up by joining adjacent areas

4D Model

Outline

Project Overview

Constructability Review

LEED™ Plumbing Analysis

Schedule Acceleration

- Structure Analysis
- SIPS Schedule

In order to better represent the flow of work through the spaces, a 4D Model (3D + Time) was created

The colors in the video match the colors of the SIPS Table Graphic

Play Video

Thesis Conclusion

Outline

Project Overview

Constructability Review

LEED™ Plumbing Analysis

Schedule Acceleration

- Structure Analysis
- SIPS Schedule

Constructability Reviews

- Save money by reducing change orders
- Reduce RFI's, making project flow more smoothly
- Result in clearer construction documents

Plumbing Analysis

- 2 Possible LEED™ Points
- Payback Period of 2 years

Schedule Acceleration

- Tilt-up concrete panels can be faster, less expensive structural system
- SIPS scheduling will not necessarily reduce time, but will introduce more orderly flow to work

Acknowledgements:

Outline

Project Overview

Constructability Review

LEED™ Plumbing Analysis

Schedule Acceleration

- Structure Analysis
- SIPS Schedule

Thank You To:

HSC Builders and Construction Managers

The Foreman Group

Nitterhouse Concrete Products

Penn State Faculty

5'th Year AE's

Friends, Family, and Pets

Questions???