2006 AE Senior Thesis

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Charles Commons

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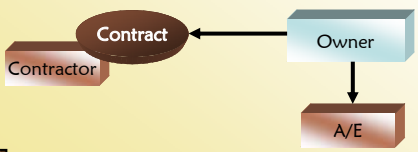
"Planning for Success
Builds Success"

Johns Hopkins University — Baltimore, MD

- Project Background
- DBOM/BOT Delivery Comparison
- Alternative Concrete Slab Systems
- Duct Rerouting/MEP Coordination

- Project Statistics
  - Size: 313,000 sf, 618 beds
  - Projected Cost: ~~$54,000,000~~ $67,000,000
  - Projected Schedule: ~~June '04 - July '06~~ June '04 -Oct '06
  - Project Delivery Method: Design-Bid-Build



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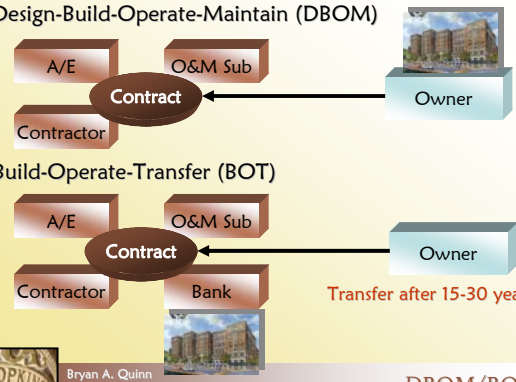
DBOM/BOT Delivery Comparison

- Goals
  - Introduce owners to integrated delivery methods
  - Apply research to reduce the overall Charles Commons schedule
  - Create a model for which owners can attain success with more effective delivery decisions

Design-Build-Operate-Maintain (DBOM)



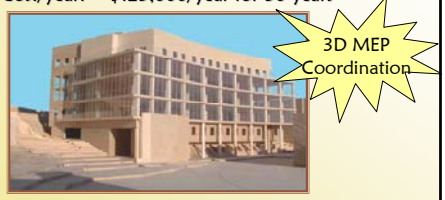
Build-Operate-Transfer (BOT)

Building Construction Market

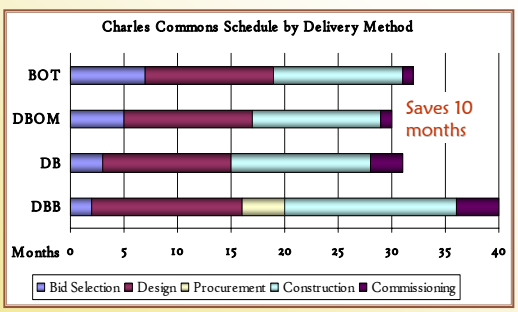
- Clackamas County Public Services Building
  - Schedule: July 2003 – July 2004
  - Initial Cost: $16.9 million
  - O&M Cost/year: $96,408/year for 30 years

Building Construction Market

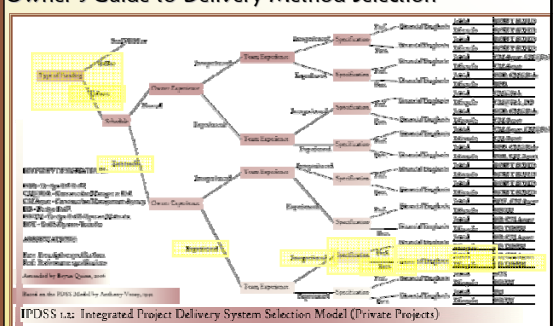
- UW Research & Technology Building
  - Schedule: July 2004 – March 2006
  - Initial Cost: $29,850,000
  - O&M Cost/year: $125,000/year for 30 years



Schedule Reduction



Owner's Guide to Delivery Method Selection


IPDSS 1.1: Integrated Project Delivery System Selection Model (Private Projects)

Delivery Method Comparison

Issue	DBB	DB	DBOM	BOT
Team Interfaces	×		✓	
Design Changes	×	✓	✓	✓
Best Value	×		✓	✓
Lifecycle/Green	×	×	✓	✓
Bonds/Guarantees	×	×	✓	✓
Owner's Risk	×		✓	✓
Schedule Reduction	×		✓	

Favorable	*Fair*	*Unfavorable*
✓		×

✓ DBOM

- Project Background
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- Alternative Concrete Slab Systems
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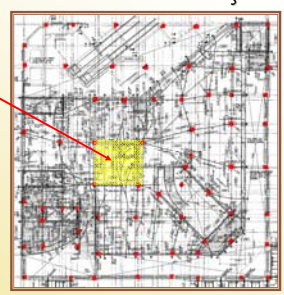
Alternative Concrete Slab Systems

- Goals
  - Eliminate factors that upset the success of the overall project
  - Recapture the cost and schedule losses
  - Improve the constructability of the St. Paul building

Existing Structure

- Post-tensioned slabs with drop caps
  - 8" structural slab
  - 29' largest span
  - 6'x6' drop caps
- Slab loads
  - LL: 125 psf
  - $DL_{Superimposed}$: 28 psf
  - $DL_{Selfweight}$: 100 psf



Existing Structure

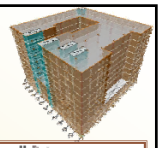
- Concrete Strengths
  - Columns
    - 1st-2nd floors: 8000 psi
    - 3rd-4th floors: 6000 psi
    - 5th-10th floors: 4000 psi
  - Slabs/Edge Beams
    - 1st-2nd floors: 6000 psi
    - 3rd-10th floors: 4500 psi
  - Shearwalls: 4000 psi

Alternative Concrete Slab Systems

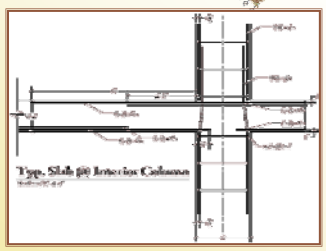
- Flat plate slab
- One-way beams with drop caps
- Precast plank on CIP beams & columns

- Not considered:
  - Flat plate slab with drop caps
  - Precast plank on precast beams & columns

Flat plate slab

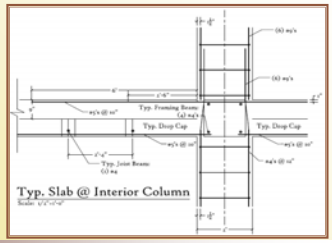


- ACI 318, Table 9.5b: Live & Long-term Deflections
- Modeled Gravity, Wind & Earthquake Loads
- 14" thick, 4000 psi
- $DL_{Selfweight}$: 175 psf



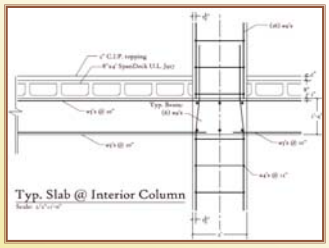
One-way beams with drop caps

- ACI 318, (9.5.2.1): clear span/28
- Modeled Gravity Loads
- 9" slab, 14" beam-joists @ 28"
- $DL_{Selfweight}$: 160 psf

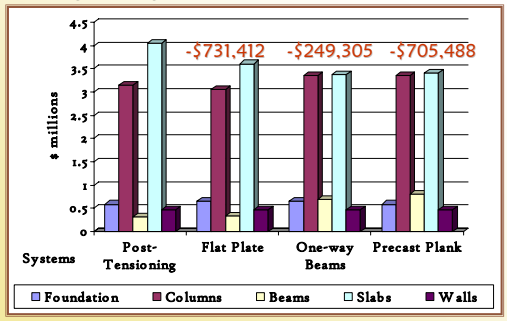


Precast plank on CIP beams & columns

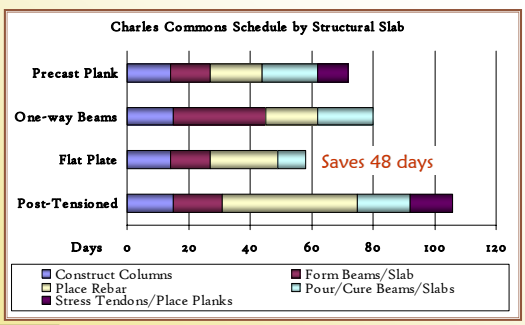
- Modeled Gravity Loads
- 8"x4' SpanDeck by Nitterhouse
- 24"x16" CIP beams
- $DL_{Selfweight}$: 83 psf



Value Engineering



Schedule Reduction



Constructability Review

Issue	PT	Flat Plate	One-way	Precast
Safety	×	✓	✓	
Building Height	✓		×	
MEP Coordination	×	✓		×
On-site Mistakes	×	✓	✓	×
Delivery/Laydown		✓	✓	×
Complexity	×	✓	✓	
Value Engineering	×	✓		✓
Schedule Reduction	×	✓		

✓ Flat Plate

- Project Background
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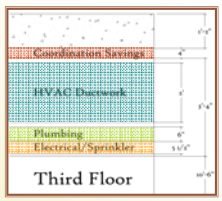
- Duct Rerouting/MEP Coordination
  - Goals
    - Recover losses from increased building height due to flat plate slab
    - Insure MEP Coordination success by using a multi-dimensional modeling method

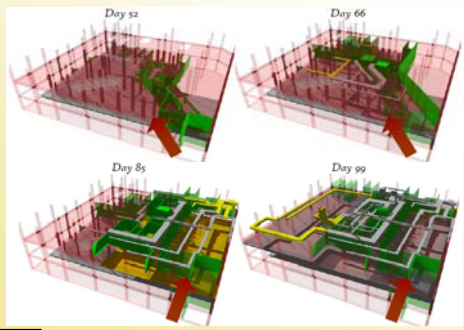
- Duct Rerouting & Sizing
  - Coordinate plenum space
  - Six rerouted ductwork branches
    - Air flowrate
    - Air velocity
    - Friction losses
    - Equivalent length of straight duct
    - Pressure drop



- Value Engineering
  - Savings of 18" on total building height
    - Saved Building Cost: $396,000
  - Six adjusted branches of ductwork
    - Added Material Cost: $1,177

- 2D & 3D MEP Coordination
  - Interior Walls, HVAC, Plumbing, Electrical, Sprinkler
  - Difficulty dividing zones into equal work quantities among trades

- 4D MEP Coordination



Duct Rerouting/MEP Coordination

Issue	2D	3D	4D
Barriers to Entry	✓	✓	×
Software Deficiencies	✓	✓	×
Lack of Technicians	✓	✓	×
Ability to Eliminate Interferences	×	✓	×
Team Communication	×	✓	
Ability to Eliminate Sequence Problems	×	×	✓

+ Duct Rerouting Saves $394,823

✓ 3D

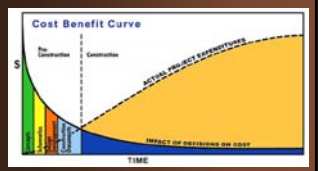
Conclusion

- Hire an O&M contractor and use DBOM delivery
  - Saves on long-term costs & 10 months
- Use flat-plate structural slabs
  - Saves $731,412 & 48 days
- Use 3D for MEP coordination & rerouting ductwork
  - Saves $394,823

Planning for Success Builds Success

Planning for Success Builds Success

1. Show owners how to use the Integrated Project Delivery System Selection Model.
2. Think simple. Design structures that have little impact on other systems.
3. Use the right MEP Coordination technology for your project.
4. But most of all, planning for success now pays off later!



Acknowledgements

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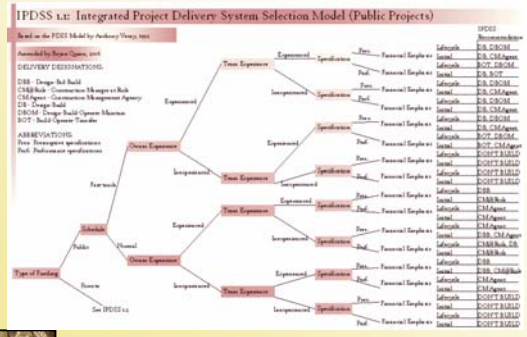
- John Whitlow & Jon Szczeniak, CollinsWoerman
- My Mom & Dad

Questions?

Examples of Site Congestion

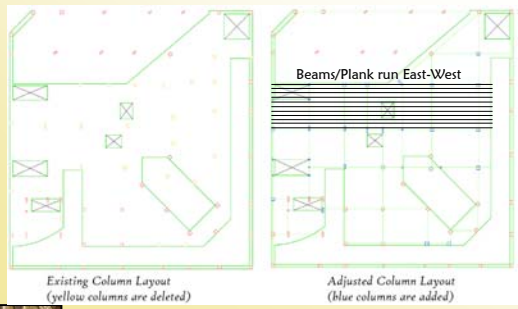
Public IPDSS



Direct Design Method, ACI 318-05 Section 13.6.1

- In each condition, there are at least four spans in all directions
- The most drastic rectangular bay is 17' x 29', which has a $l_2/l_1 = 1.71 < 2.0$
- The most drastic shift in span length between two adjacent spans is 9', or 31%, less than one-third of the largest span
- Columns are offset 6"-3' from the building grid
- There are only a few instances of cantilevers and irregular column grids, which would be assessed individually

Column Layout for One-way Beams and Precast Plank



Existing Mechanical System

- CAV, All-air system
  - Localized gas furnaces for apartments

Air-Handlers

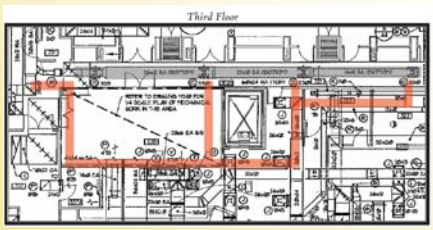
AHU #	York Model #	Service (floor)	Capacity (cfm)	Min OA (cfm)	AHU Size (wxh) in.	Room Size (lxwxh) ft
AHU-4	500	Bookstore (2nd)	25055	11200	125 x 95	48x36x10
AHU-5	305	Dining (2nd)	12900	9000	103 x 64	48x36x10
AHU-6	215	Kitchen (3rd)	10450	10450	91 x 55	32x15x10
AHU-7	305	Meeting (3rd)	14800	14800	103 x 64	36x21x10

Fan-Coil Units

FCU #	Magic Aire #	Service (floor)	Capacity (cfm)	Min OA (cfm)	FCU Size (wxh) in.	Room Size (lxwxh) ft
FCU-1	60-HBAW-6	Lobby (1st)	2500	250	72 x 48	48x36x10
FCU-3	24BVW	Bkstr. (2nd)	400	0	48 x 48	16x14x10

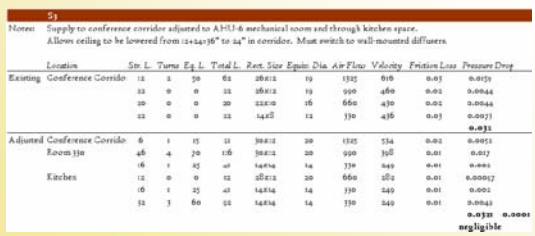
Duct Rerouting Example

- 26"x12" supply duct rerouted through mechanical room to not impede massive 60"x24" return duct



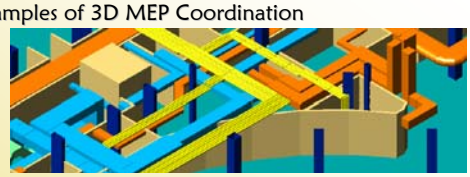
Duct Rerouting Example Continued

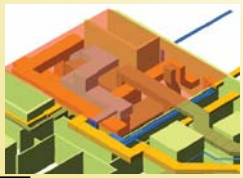
- Branch pressure drops were maintained in rerouted case



	Location	Str. L.	Turns	Eq. L.	Total L.	Rect. Size	Equiv. Dia.	Air Flow	Velocity	Friction Loss	Pressure Drop
Existing	Conference Corrido	12	2	50	62	26x12	19	1325	616	0.03	0.0531
		22	0	0	22	26x12	19	990	460	0.02	0.0044
		20	0	0	20	22x10	16	660	430	0.02	0.0044
		22	0	0	22	14x8	12	330	436	0.03	0.0071
											0.031
Adjusted	Conference Corrido	6	1	15	21	30x12	20	1325	534	0.02	0.0052
	Room 330	46	4	70	116	30x12	20	990	398	0.01	0.017
		16	1	25	41	14x14	14	330	249	0.01	0.001
	Kitchen	12	0	0	12	26x12	20	660	262	0.01	0.00017
		16	1	25	41	14x14	14	330	249	0.01	0.001
		32	3	60	92	14x14	14	330	249	0.01	0.0041
											0.031 0.0001 negligible

- Examples of 3D MEP Coordination





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