RESIDENCE INN

BY MARRIOTT

ALEXANDRIA, VA

Julia Phillips | Construction Management

Presentation Outline

- Project Overview
- Analysis 1: Structural Breadth
- Analysis 2: Controls Breadth
- Analysis 3: Greywater Breadth
- Critical Industry Research: "Greening" of Hotels
- Conclusions

Project Overview

- Size: 15 Stories, 127,000 SF w/ 3 Levels Underground Parking
- Construction Cost: $33.5 Million
- Schedule: March 2007 – August 2008

Project Team

Owner: Miller Global

Tenant: Residence Inn by Marriott

Architect: dcs Design

Construction Manager: Balfour Beatty Construction

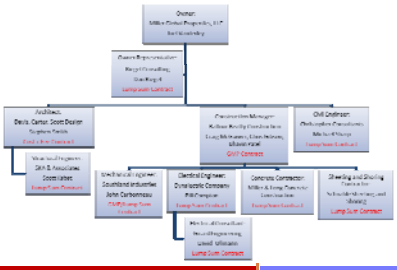
Structural Engineer: SK&A

Electrical Engineer: Dynalectric

Mechanical Engineer

Delivery Method

- CM @ Risk w/ GMP → Traditional Design – Bid – Build
- MEP → Design – Build



Building Systems

- Architecture
  - Off-set exterior edge
  - Punch-out windows
  - Brick and pre-cast façade with CMU back up
  - "Column of Light"
  - 20 LEED points

Building Systems

PROJECT OVERIVEW
ANALYSIS 1: STRUCTURAL RE-DESIGN
ANALYSIS 2: CONTROLS
ANALYSIS 3: GREYWATER
CRITICAL INDUSTRY RESEARCH: "GREENING" OF HOTELS
CONCLUSION

- *Structural*
  - *3' Mat slab - Foundation*
  - *8" CIP slab with drop panels - Garage*
  - *7.5" post-tensioned floor slabs - Tower*

Site Conditions

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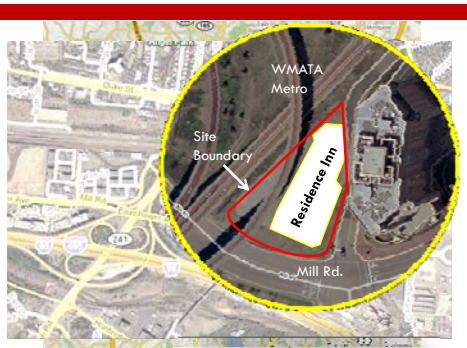

Analysis 1: Structural Re-Design of Underground Garage

Re-Design of Underground Garage

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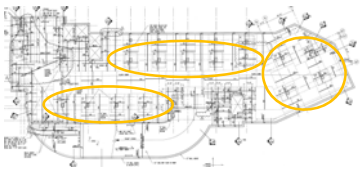
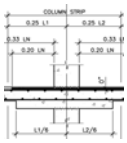
CONCLUSION

- *Background*
  - *8" slab with 5.5" drop panels = 13.5"*
  - *Cure to full 28 day strength*
  - *Unexpected Water Issues*





Re-Design of Underground Garage

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CONCLUSION

- *Goal*
  - *Decrease floor depth, minimize materials, accelerate schedule*
  - *Utilize Flat Plate OR Filigree Slab and Beam System*
  - *Compare Original, Flat Plate, Filigree*
    - *Lbs. / SF of Steel*
    - *Total steel tonnage*
    - *Steel Cost*
    - *CY of Concrete*
    - *Depth of slab, beam, and drop panel*
    - *Concrete Cost*
    - *Total formwork SF*
    - *Formwork Cost*
    - *Total Duration*

Flat Plate Design

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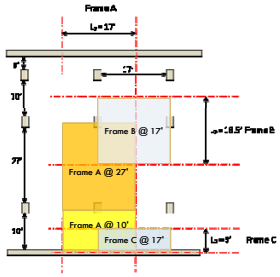
CONCLUSION

- *Eliminate Drop Panels by Direct Design Method*
- *h = 10 in. d = 8.50 in.*
- ** Assume Columns are In Line*
- ** Assume 10 Column Lines*
- ** Assume All Columns are 18" x 30"*
- ** Frame C is Doubled*



Flat Plate Design

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- *Results*

	Column Strip				Middle Strip			
Description	M_{EXT}^-	M_{EXT}^+	M_{INT}^-	M_{INT}^+	M_{EXT}^-	M_{EXT}^+	M_{INT}^-	M_{INT}^+
Frame A @ 10'			(6) #6	(10) #6			(10) #4	(10) #4
Frame A @ 27'	(6) #6	(6) #6	(6) #6		(6) #5	(10) #4	(10) #4	
Frame B @ 17'			(5) #6	(5) #6			(13) #4	(13) #4
Frame C @ 17'			(2) #4	(3) #4			(5) #4	(5) #4

Analysis Description	Re-Designed CIP Slab without Drop Panels
Steel (TONS)	42.10
Steel (lbs./SF)	1.91
Concrete (CY)	1361.11
Concrete Drop/Beam (in.)	0
Concrete Slab (in.)	10

Filigree Slab & Beam Design

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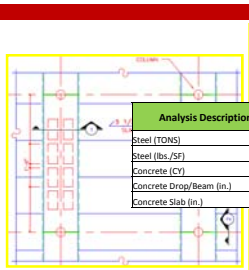
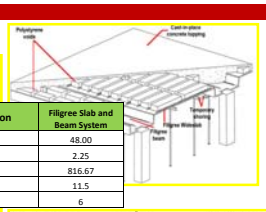
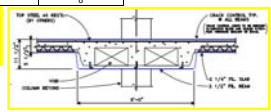




Analysis Description	Filigree Slab and Beam System
Steel (TONS)	48.00
Steel (lbs./SF)	2.25
Concrete (CY)	816.67
Concrete Drop/Beam (in.)	11.5
Concrete Slab (in.)	6



System Comparison

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Structural System Comparison			
Analysis Description	Existing CIP Slab with Drop Panels	Re-Designed CIP Slab without Drop Panels	Filigree Slab and Beam System
Savings Analysis			
Steel (TONS)	n/a	19.90	13.99
Steel (lbs./SF)	n/a	0.90	0.56
Steel Cost	n/a	$27,952.49	$19,656.81
Concrete (CY)	n/a	-14.53	529.92
Concrete Cost	n/a	-$6,367.53	$232,262.48
Formwork (SF)	n/a	1907.95	1907.95
Formwork Cost	n/a	$10,493.74	$110,468.44
Slab Duration (Days)	n/a	17	23
Total Cost Savings	**n/a**	$32,078.70	$362,387.72
Location Factor Adjustment	0.94	0.94	0.94
Adjusted Total Cost Savings	**n/a**	**$30,153.98**	**$340,644.45**

Schedule Reduction

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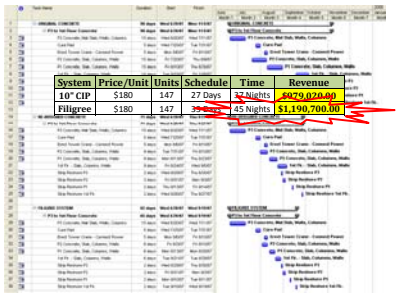

System	Price/Unit	Units	Schedule	Time	Revenue
10" CIP	$180	147	27 Days	32 Nights	$979,020.00
Filigree	$180	147	33 Days	45 Nights	$1,190,700.00

Conclusion & Recommendation

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CONCLUSION

- *Filigree slab and beam system is the recommended system.*
  - *Smaller overall depth which is key in designing clearance heights and piping and plumbing work.*
  - *Construction is 33 days faster which enables an early opening.*
  - *Saves the owner $340,644.45 in construction cost.*
  - *Add additional revenue of $1.2 million within the first 45 nights.*

Analysis 2: Mechanical Controls

Mechanical Controls

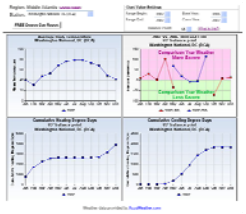
- *Background*
  - *WMATA metro tracks create 102 dB noise level.*
  - *Half of the noise is blocked by the façade. The FCU's create white noise to help guests sleep at night.*
    - *Original System*
      - *Fan Coil Units running 24 / 7 to block out noise.*
    - *INNCOM System*
      - *Highly intelligent utilizes door switches, temperature and occupancy sensors.*
      - *Activated when a guest checks in at the front desk, otherwise the systems in unoccupied rooms are off.*
      - *Runs at a low fan speed throughout the night to mask noise.*

Mechanical Controls

- *Goal*
  - *Reduce energy consumption*
  - *Provide an intermediate system*
  - *Compare original system, INNCOM system, and Networked system*
    - *Total kWh's used per year*
    - *Total Cost per year*
    - *Unit Cost*

Energy Analysis

- *Annual weather for Washington D.C. in 2007.*
- *68% heating and 32% cooling annually.*



System	Conditioning	Duration (hrs.)
Original	Heating	16.32
	Cooling	7.68
Networked	Heating*	9.96
	Cooling*	4.69

81% Occupancy rate
7:30am commute
5:00pm dinner

Energy Analysis

Total kWh =	1,765,059.67
Total Cost =	$5,764.27

Original

Total kWh =	1,068,828.11
Total Cost =	$3,451.33

Networked DNT-T103

- *Networked Thermostat Delta DNT-T103*
  - *Controls all FCU's from a central computer.*
  - *Provide user control during the day.*
  - *"Over-ride" from 10:00pm to 7:00am*

Comparison & Conclusion

Controls System Comparison

System Type	Original	Networked	INNCOM
Price / Unit	$30.00	$98.00	$200.00
Total T-stat Cost	$5,670.00	$18,522.00	$37,800.00
Installation	$32,230.00	$50,000.00	$50,000.00
Sensors, etc.	n/a	$19,350.00	$96,550.00
Total System Cost	**$37,900.00**	**$87,872.00**	**$184,350.00**
Unit Cost	$200.53	$464.93	$975.40

- *Delta DNT-T103 is Recommended*
  - *$49,972.00 More than Original*
  - *$96,478.00 Less than INNCOM*
    - *Saves:*
      - *696,231.56 kWh = 40% Energy annually*
      - *$2,312.94 Energy Cost Annually*

Analysis 3: Constructed Wetlands Greywater Treatment System

Constructed Wetlands Greywater

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CONCLUSION

- *Background*
  - *Hotels generate greywater: 30 Gallons/day/person*
  - *No water recycling system in place.*
- *Goal*
  - *Institute Constructed Wetlands Greywater System*
    - *Use shower water to flush toilets*
    - *Reduce water consumption*



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Constructed Wetlands Analysis

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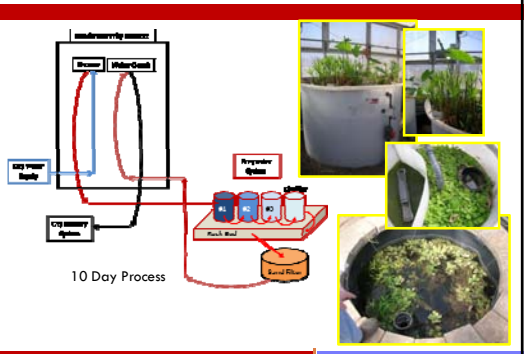

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Constructed Wetlands Analysis

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CONCLUSION

- *Occupancy rate of 81% → 203 people.*
- *5,075 gal supply > 974.4 gal demand*
  - *Surplus of 4,100 gallons a day.*

- *Use 1/3 of supply, 83 people → Toilets and Fountain*
  - *2,075 gal supply = 974.4 gal demand + 1100 gal fountain*

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Constructed Wetlands Analysis

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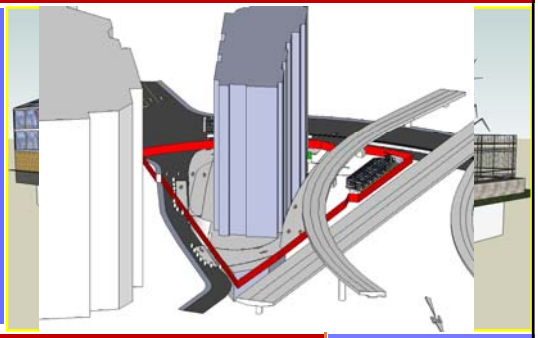

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System Review

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Sanitary Riser Length =	46 LF	for 4" pipe	
Total Sanitary Riser Length =	506 LF	for 4" pipe	24LF/man-day
Total Sanitary Riser Cost =	$3,363.13		
Redircted Horizontal Piping =	130.00 LF	for 4" pipe	18LF/man-day
Horizontal Piping Cost =	$864.05		

Total Greywater System Cost = $68,298.09

Add 30% for Shipping and Customization of Tanks

Total Greywater System Cost = $88,787.52

500 Gallon Storage Tank =	$700.00	
Total Open Top Tank Cost =	$27,900.00	
6,800 Gallon Basin =	$5,500.00	2 Basins needed, customized for filters and fountain.
Total Basin Cost =	$16,500.00	
Pumps and Fountain Head Cost =	$470.00	
3" to 5" VA 1,2,3,4 Stone =	$25.00 per TON	79 Tons needed
Pea Gravel, Stone #78 =	$30.00 per TON	35.84 Tons needed
Total Rock Bed Cost =	$3,050.20	

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Conclusion & Recommendation

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CONCLUSION


- *Costs $88,787.52*
- *Adds to schedule*
- *Saves:*
  - *757,375 gallons = 60% Water annually*
  - *$518.80 Water costs annually*

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Critical Industry Research: "Greening" of Hotels

"Greening" of Hotels

- *Background*
  - *There is an unfortunate misconception in this industry that adding green value or achieving LEED points simply costs too much.*
  - *Alexandria, VA requires new construction to have at least 20 LEED points.*
  - *Marriott firmly believes in adding green or LEED credits to many of their new hotels and resorts.*

"Greening" of Hotels

- *Goal*
  - *Investigate the sustainability or "Greening" of hotels by incorporating green design and analyzing the corresponding cost.*
  - *Compare typical building materials and systems to their green alternative by:*
    - *Upfront Cost*
    - *Installation Cost*
    - *Life Cost*

Materials & Systems

- *Painted Gypsum Board*
- *Colored Clay Plaster*
- *Fiberglass Batting Insulation*
- *Blown Cellulose Insulation*
- *Ceramic Tile Flooring*
- *Polished Concrete*
- *Continuously powered A/C units*
- *Programmed Networked A/C units*
- *Typical Sanitary System*
- *Constructed Wetlands Greywater System*

Initial Survey

- *Purpose*
  - *Gain an initial opinion regarding green technologies.*
- *Results*
  - *Greater understanding the LEED system than GREEN technologies.*
  - *No consistency between the participants as to which is better.*
  - *Green is most cost effective.*

Final Survey

- *Purpose*
  - *Research overview*
  - *Determine effectiveness*
- *Results of Material & System Comparison*
  - *Painted Gypsum Board*
  - *Either Insulation*
  - *Polished Concrete*
  - *Programmed A/C Units*
  - *Greywater System*

Research Conclusion

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CONCLUSION

- *Most participants did not have a clear understanding of what costs are associated with each product.*
- *Green technologies are favored among industry members, and are regarded as cost effective.*
- *Overall, it shows that when presented with hard numbers in terms of cost and savings, the decision makers chose the environmentally friendly alternative.*

Conclusions

Thesis Conclusions

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CONCLUSION

System	Cost Savings	Additional Savings
Slab and Beam Filigree Structure	$340,644.45	$1,190,700.00 Added Revenue in 45 Nights
Delta Controls DNT-T103	$98,790.94	696,231.56 kWh of Energy Annually (40%)
Constructed Wetlands Greywater	-$88,268.72	757,375.00 Gallons of Water Annually (60%)
Grand Total Cost Savings	**$351,166.67**	

- *The Filigree slab and beam system is the recommended system based on structural design, cost, schedule, and constructability. Brings in approximately $1,190,700.00 in revenue.*
- *The Delta Controls system using the DNT – T103 is the recommended system to reduce energy consumption.*
- *The constructed wetlands greywater system is recommended because Marriott is extremely focused on helping the environment and increasing aesthetic appeal of the building.*

Questions or Comments??

Building Systems

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- *Lighting/Electrical*
  - *3000 amp @ 480/277 volt 3ø. 4W. Switchboard*
  - *400 kw, 480 v back-up generator*


- *Mechanical*
  - *(1) 155 ton Chiller*
  - *(2) 1.53 mil BTU Boilers, for AHU's*
  - *(2) 1.43 mil BTU Shell and Tube Heat Exchangers*
  - *Chilled Water / Electric Heat FCU's in guestrooms*

Stud Rail Design

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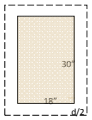
CONCLUSION

- *No Existing Edge Beams*
- *Exterior Panels → ln/30*
- *Interior Panels → ln/33*
- *h = 10 in. d = 8.50 in.*
- *P = 1.2D + 1.6L = 214 psf*
- *Distributed Load = 3.745 kips*
- *Tributary Load at Column*
  - $V_u = P * w * (1/2d + 1/2l) =$ *68.35 kips*
- *Effective Width*
  - $b_o =$ *130.00 in.*



- *Shear Strength*
- *Φ = 0.75*
- *ΦVc = Φ4 * Vf'c * bo * d =* ***234.41 kips > 68.35 kips***
- ***No Shear Stud Rails Required***

Constructed Wetlands Analysis

- *20,750 gallons per 10 days*
  - *Half held in rock bed, Half in "biofilter" tanks*
  - *(8) 6,800 gallon tanks required*
    - *2 sets of each: 3 "biofilter" tanks, 1 clarifier tank*
- *With 25% Safety Factor = 3,468 CF*
  = 1,206 SF rock bed, 25' x 50'
- *6,800 gallon Sand Filter or Fountain Storage tank*

Final Survey

Technology	Material Up Front Cost	Installed Cost (labor)	Total Cost	Life Cost	Product Life (Yrs.)	Choose One
Colored Clay Plaster	0.21 $/SF	7.8 $/SF	8.01 $/SF	0.11 $/SF/Yr	75	
Painted Gypsum Board	0.35 $/SF	3 $/SF	3.35 $/SF	0.13 $/SF/Yr	25	
Blown Cellulose Insulation	1.45 $/CF	1.52 $/CF	2.97 $/CF	0.10 $/CF/Yr	30	
Fiberglass Batting Insulation	0.7 $/SF	0.27 $/SF	0.97 $/SF	0.06 $/SF/Yr	15	
Polished Concrete Floor	1.75 $/SF	7.25 $/SF	9 $/SF	0.09 $/SF/Yr	Building Life	
Ceramic Tile Floor	8.44 $/SF	3.26 $/SF	11.7 $/SF	0.23 $/SF/Yr	50	
Pre-Prgrammed A/C Units*	98 $/Unit	$50,000.00	$68,522.00	362.55 $/Unit	n/a	
Continuously Powered A/C Units	30 $/Unit	$32,230.00	$37,900.00	200.53 $/Unit	n/a	
Greywater System*	n/a	n/a	Add $150,000	n/a	Building Life	
Normal Sanitary System	n/a	n/a	n/a	n/a	Building Life	

Building Life is assumed to be 100 years.

Pre-Prgrammed A/C Units*	Saves 696,241.5 kWh/Year = $2,312.94 /Year
Greywater System*	Saves 355,656 Gallons of Water/Year = $487.25 /Year

Materials & Systems

Painted Gypsum Board

- *Used for wall covering and acoustics*
- *Double layers between guestrooms and on North, West, and South façades.*

Colored Clay Plaster

- *Flexible and workable*
- *Stained instead of paint*
- *Equivalent acoustics*
- *Derived from a Renewable Resource*

Survey Results: Painted Gypsum Board

- *Ease Installation and Repair*
- *Lower upfront cost*
- *Easier to renovate*
- *Excellent Material BUT Difficult to Install and Repair Properly*
- *Higher upfront cost BUT longer product life*
- *Difficult to renovate*

Materials & Systems

Fiberglass Batting Insulation

- *Specified widths = 6"*
- *In all walls for acoustics*
- *Noncombustible*

Blown Cellulose Insulation

- *Any volume*
- *Inhibits air infiltration and good for acoustics*
- *Class A Fire Rating*

Survey Results: Both

- *Easy Installation for Stud Cavities*
- *Equivalent Life Cost*
- *Better Thermal Performance*

Materials & Systems

Ceramic Tile Flooring

- *Add Grout and Tile*
- *Higher Installation Cost*
- *Multiple Colors and Patterns*

Polished Concrete

- *Sand and Polish Existing Concrete Floor*
- *Can be Stained and Patterned*

Survey Results: Polished Concrete

- *Long Life Cost*
- *Difficult to Repair need Skilled Labor*
- *Architectural Appeal*
- *Lower Upfront Cost*
- *Longer Product Life*
- *"Good Savings and a Durable Solution"*

Materials & Systems

Survey Results: Programmed Networked A/C units

- *Higher Upfront Cost justified by Energy Savings*

Survey Results: Constructed Wetlands Greywater

- *Water savings outweighed Upfront Cost*
- *Need Proper Design, Installation, and Maintenance*