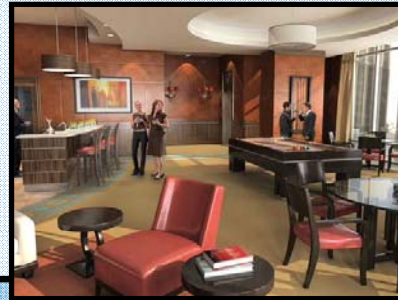


# Turnberry Tower Arlington

Luxury Condominium



Lawrence P. Warner Jr. Construction Management

Arlington, Virginia Location

1881 Rosslyn Associates c/o Turnberry Associates Owner

Facchina Construction General Contractor

BBG-BBGM Architects & Interiors Architect



Monday, April 13<sup>th</sup>, 2009



## Presentation Outline

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**Turnberry Tower Arlington**  
Luxury Condominiums

Lawrence P. Warner Jr.  
Construction Management

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**Location:**

Rosslyn, Arlington County, VA

**Project Size:**

6 Stories Below Grade  
26 Stories Above Grade  
750,000 SF

**Project Cost:**

\$250 Million

**Construction Schedule:**

September 2006– September 2009

**Owner:**

1881 Rosslyn Associates  
c/o Turnberry Associates

**Architect:**

BBG-BBGM Architecture & Interiors

**General Contractor:**

Facchina Construction  
(Formerly Facchina-McGaughan, LLC.)

**Function:**

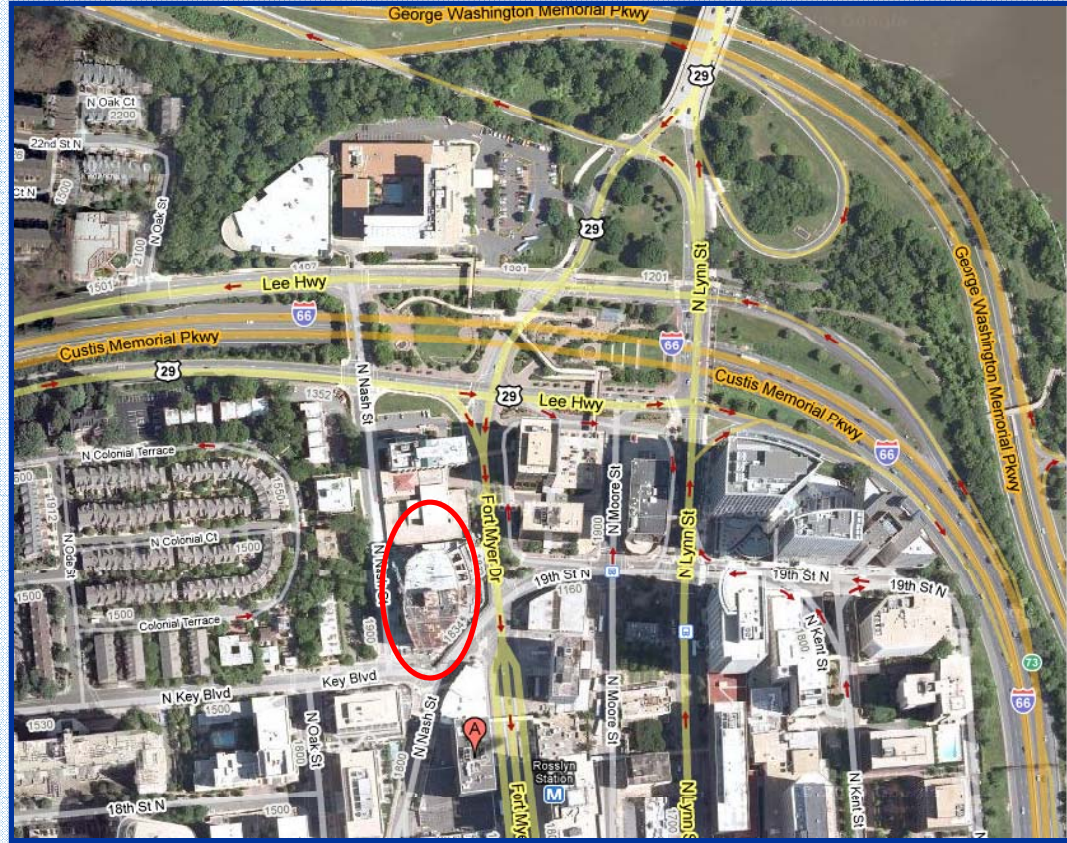
Luxury Condominiums

**Delivery Method:**

Design-Bid-Build

**LEED Desired:**

LEED Certified



Aerial View of Arlington, VA





## Quick Facts

- Building is being constructed in two parts:
  - Underground Paring Garage (6 Levels)
  - Tower Levels (25 Levels) – No 13 Floor
- Tower structure made up of post-tension concrete
- Each unit will have floor to ceiling glass and varying ceiling heights between 9' and 12'
- Glass in each unit will be either:
  - Window Wall (located behind the balconies)
  - Curtain Wall (corners of the building)
- Building has 11 elevators with 2 miles of rail
  - Private Elevators for some units



Exterior View of Turnberry Tower Arlington

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## Window Wall Attachment with Reinforced Concrete

### Problem:

- When the General Contractor was hired there was **NO** subcontractor for the exterior skin of the building
  - No design on how to connect the curtain wall and window wall to the post tension slabs
  - Submittals were submitted late and were rejected numerous times for the window wall
  - The window wall needed to be installed into the cured post tension decks
- As a result of hitting post tension tendons:



### Goal:

- Find out why post tension concrete was used
- Act as the GC during preconstruction and suggest using reinforced concrete slabs
- Accelerate the schedule
- Reduce the costs (no remediation needed)

# 20 Post Tension Tendons Failed





## Why Use Post Tension Concrete?

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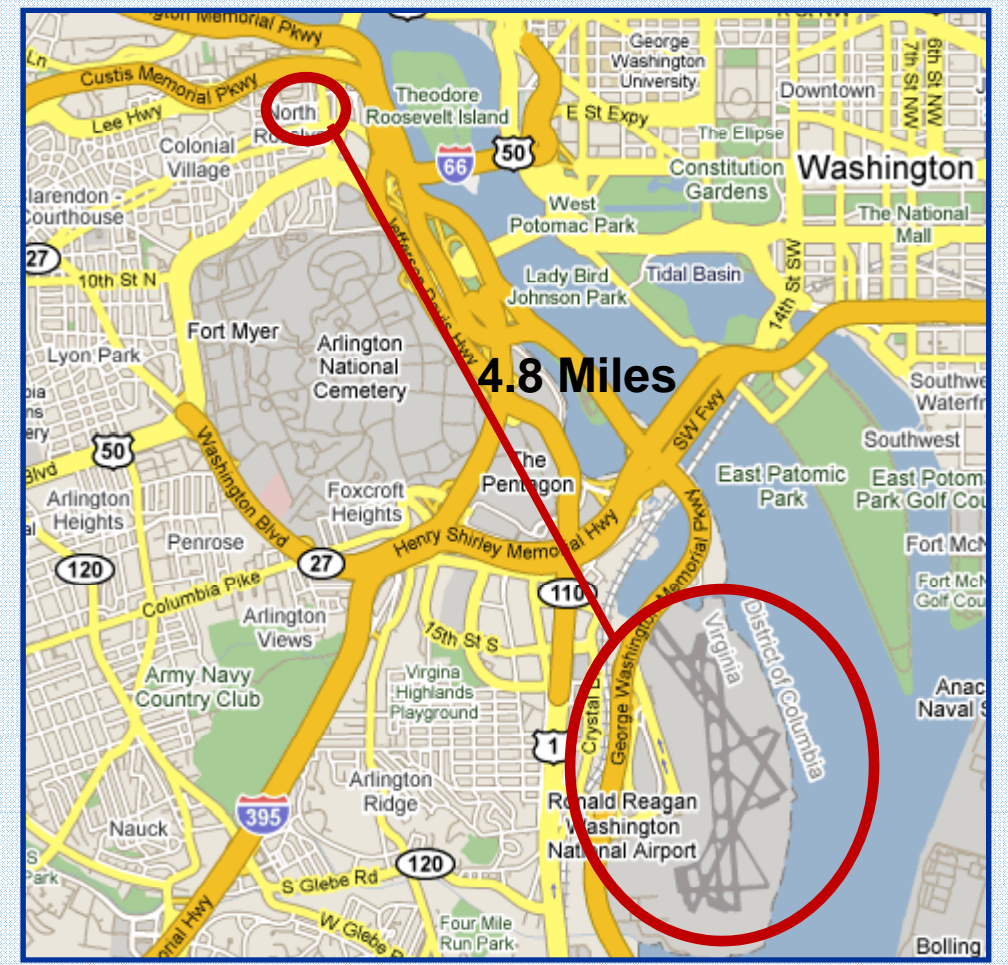
Many details like supports for the window wall were not designed....so **WHY** Post Tension Concrete?

#### Federal Aviation Administration:

- Has final decision on height due to proximity to Reagan National Airport
- Only 4.8 Miles from site to airport

#### Why PT Concrete?

- Building is currently at +409.70 (within 1/8" of the FAA allowance)
- Larger floor to floor heights allows for the desired ceiling heights in the units by the owner
- Allows for an extra floor to be squeezed into the building from the thinner slabs
- Extra money from sales of the units  
**\$17.6 Million**



Map of Arlington, VA





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## Direct Design Method (Structural Breadth)

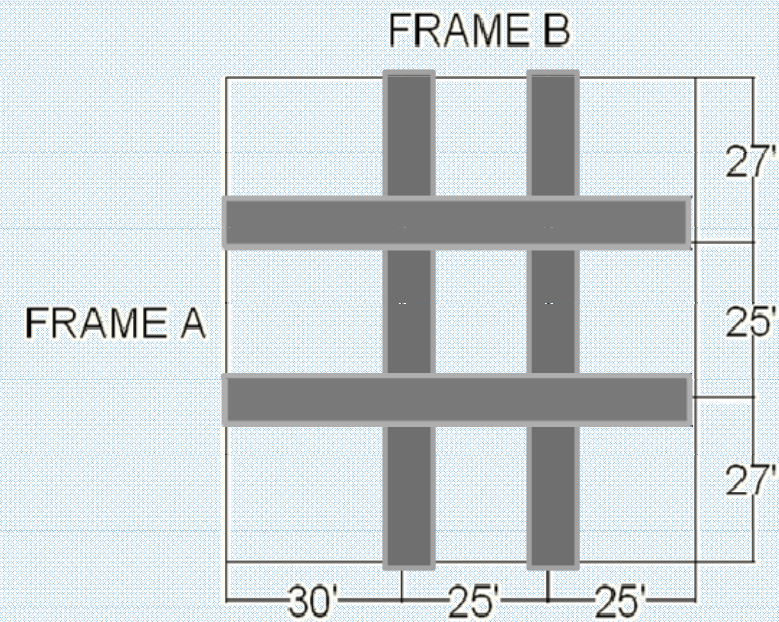
Used to find thickness of concrete slab and amount of steel needed to create a reinforced concrete slab

### Assumptions for Design

- 20" x 20" columns
- Per ASCE 7-05 Table 4.1, Live Load = 40 psf
- Dead Load (Concrete Self Weight) = 137.5 psf
- The slab would be #6 Rebar at 60 ksi

Using  $l_n/33 = 10.9"$

Concrete Slab = 11" Thick





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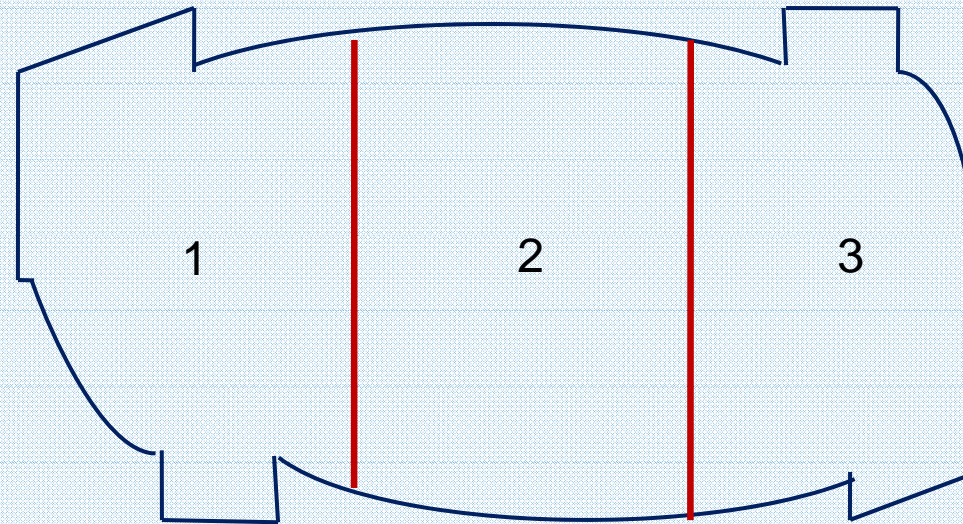
Questions?



## Post Tension Concrete Schedule

### Original Construction Schedule

- Concrete erection from 12/28/07 to 9/8/08 (including roof top machine rooms)
- Included 10-11 day duration for each slab to be completed
- Each slab is broken into 3 sections
- Concrete pour for each zone would occur during 1 day and would take 5 hours





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## Reinforced Concrete Schedule

There will be 2 different options for reinforced concrete that will be explored due to the FAA height restrictions:

Option 1: Reinforced Concrete with adjusted story heights

Option 2: Reinforced Concrete removing one story



Flying Forms





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**Cost Comparison**

Structural Systems Cost Comparison for Turnberry Tower Arlington			
Structural System	Residential Units	Total Structural Cost	Cost per SF
Post Tension Concrete	247	\$20,658,837	\$27.55
Reinforced Concrete – Option 1 (Adjusting Story Height)	247	\$22,975,867	\$30.63
Reinforced Concrete – Option 2 (Removing 1 Story)	235	\$22,651,046	\$30.20

**Average Costs**

Concrete: \$125 / cubic yard  
 Rebar: \$1000 / ton  
 PT Cable: \$1.15 / pound

(prices obtained from concrete subcontractor during 4<sup>th</sup> quarter of 2008)

**Construction Cost of Post Tension Concrete System**

Description	Qty	Unit	Material	Labor	Equipment	Total Cost
Cast In Place Concrete including placing and stripping formwork, placing rebar, placing concrete, and finishing concrete	37351	CY	\$273.65	\$257.21	\$22.23	\$20,658,837
<b>TOTAL</b>					<b>\$27.55 per SF</b>	

**Construction Cost of Reinforced Concrete System (Adjusting Story Height)**

Description	Qty	Unit	Material	Labor	Equipment	Total Cost
Cast In Place Concrete including placing and stripping formwork, placing rebar, placing concrete, and finishing concrete	44072	CY	\$241.88	\$257.21	\$22.23	\$22,975,867
<b>TOTAL</b>					<b>\$30.63 per SF</b>	

**Construction Cost of Reinforced Concrete System (Removing One Floor)**

Description	Qty	Unit	Material	Labor	Equipment	Total Cost
Cast In Place Concrete including placing and stripping formwork, placing rebar, placing concrete, and finishing concrete	43355	CY	\$243.01	\$257.21	\$22.23	\$22,651,046
<b>TOTAL</b>					<b>\$30.20 per SF</b>	





## Schedule Comparison

### Presentation Outline

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### IN THE END:

#### Post Tension Concrete

**Start:** December 28<sup>th</sup>, 2007  
**End:** September 8<sup>th</sup>, 2008

#### Reinforced Concrete

**Start:** December 28<sup>th</sup>, 2007  
**End:** September 2<sup>nd</sup>, 2008 – Option 1 (adjusting story height)  
**End:** August 18<sup>th</sup>, 2008 – Option 2 (removing one story)

Option 1: Saves 4 Days

Option 2: Saves 16 Days

Concrete Schedule: Post Tension vs. Reinforced

Task Name	Duration	Start	Finish	2008																	
				Half 1, 2008							Half 2, 2008										
				N	D	J	F	M	A	M	J	J	A	S	O	N	D				
Structure Tower Floor 2	32 days	Fri 12/28/07	Mon 2/11/08																		
Floor 2 - Reinforced Concrete	38 days	Fri 12/28/07	Tue 2/19/08																		
Structure Tower Floor 3	14 days	Wed 1/30/08	Mon 2/18/08																		
Floor 3 - Reinforced Concrete	16 days	Mon 2/4/08	Mon 2/25/08																		
Structure Tower Floor 4	11 days	Thu 2/14/08	Thu 2/28/08																		
Floor 4 - Reinforced Concrete	14 days	Thu 2/14/08	Tue 3/4/08																		
Structure Tower Floor 5	11 days	Wed 2/20/08	Wed 3/5/08																		
Floor 5 - Reinforced Concrete	13 days	Mon 2/25/08	Wed 3/12/08																		
Structure Tower Floor 6	10 days	Mon 3/3/08	Fri 3/14/08																		
Floor 6 - Reinforced Concrete	14 days	Mon 3/10/08	Thu 3/27/08																		
Structure Tower Floor 7	15 days	Mon 3/10/08	Fri 3/28/08																		
Floor 7 - Reinforced Concrete	14 days	Wed 3/19/08	Mon 4/7/08																		
Structure Tower Floor 8	15 days	Mon 3/17/08	Fri 4/4/08																		
Floor 8 - Reinforced Concrete	13 days	Thu 3/27/08	Mon 4/14/08																		
Structure Tower Floor 9	12 days	Mon 3/31/08	Tue 4/15/08																		
Floor 9 - Reinforced Concrete	12 days	Fri 4/4/08	Mon 4/21/08																		
Floors 10-17	52 days	Tue 4/8/08	Wed 6/18/08																		
Structure Tower Floor 18	8 days	Fri 6/13/08	Tue 6/24/08																		
Floor 18 - Reinforced Concrete	12 days	Wed 6/11/08	Thu 6/26/08																		
Structure Tower Floor 19	8 days	Fri 6/20/08	Tue 7/1/08																		
Floor 19 - Reinforced Concrete	12 days	Thu 6/19/08	Fri 7/4/08																		
Structure Tower Floor 20	8 days	Mon 6/30/08	Wed 7/9/08																		
Floor 20 - Reinforced Concrete	12 days	Fri 6/27/08	Mon 7/14/08																		
Structure Tower Floor 21	8 days	Wed 7/9/08	Fri 7/18/08																		
Floor 21 - Reinforced Concrete	12 days	Mon 7/7/08	Tue 7/22/08																		
Structure Tower Floor 22	10 days	Wed 7/16/08	Tue 7/29/08																		
Floor 22 - Reinforced Concrete	12 days	Tue 7/15/08	Wed 7/30/08																		
Structure Tower Floor 23	7 days	Mon 7/28/08	Tue 8/5/08																		
Floor 23 - Reinforced Concrete	12 days	Wed 7/23/08	Thu 8/7/08																		
Structure Tower Floor 24	7 days	Mon 8/4/08	Tue 8/12/08																		
Floor 24 - Reinforced Concrete	12 days	Thu 7/31/08	Fri 8/15/08																		
Structure Tower Floor 25	12 days	Mon 8/11/08	Tue 8/26/08																		
Floor 25 - Reinforced Concrete	12 days	Fri 8/8/08	Mon 8/25/08																		
Structure Tower Floor 26	12 days	Fri 8/22/08	Mon 9/8/08																		
Floor 26 - Reinforced Concrete	12 days	Mon 8/18/08	Tue 9/2/08																		

Post Tension Concrete ■  
Reinforced Concrete ■



**Conclusion & Recommendation**

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	Post Tension Concrete	Reinforced Concrete (Adjusting Story Height) Option 1	Reinforced Concrete (Reducing One Story) Option 2
<b>System Cost</b>	\$20.8 M	\$21.0 M	\$21.8 M
<b>Schedule:</b>			
<b>Begin</b>	12/28/2007	12/28/2007	12/28/2007
<b>End</b>	9/8/2008	9/2/2008	8/18/2008
<b>Cost vs. PT</b>	-	\$2.3 M	\$1.05M
<b>Schedule vs. PT</b>	-	- 4 Days	16 Days

**System to Use: Post Tension Concrete**

- Most Cost Effective System (even with PT blowouts)
- Maximum amount of units to sell
- Desired Floor to Ceiling Height
- Schedule is not impacted drastically
- More time needs to be spent to join systems





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## Supply Water System

### Problem:

- CPVC Pipe installation is very time consuming compared to other methods
- CPVC Pipe connections require glue based products that emit Volatile Organic Compounds (VOC's)

### Goal:

- Research alternative systems that could be used in the place of CPVC Pipe
- Look at an alternative system that could accelerate the installation process and reduce cost
- Examine the LEED impact the VOC's given off by the glue for the CPVC Pipe have on the rating of the building



CPVC Piping





## Existing System

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### Hybrid: CPVC with Copper

- Copper is used as risers through the building
- CPVC branches off of the copper and delivers water to each unit
  - Size varies between 1" and ½"
  - Pipe is connected using glue, which emits VOC's
  - Hangs from of hangers that were embed into the slabs above



CPVC piping in ceiling space





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## Suggested System: Propress (Mechanical Breadth)

### Propress System

- Uses copper pipes that are mechanically connected with Propress fittings
  - Much faster to install than glue for CPVC Pipe (more pipe installed per day)
  - Does not emit any VOC's
  - No soldering required



Connecting Copper Pipe with Propress system





# CPVC Pipe vs. Propress System

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Comparing CPVC vs. Propress Supply Water Systems (Per Typical Unit)									
CPVC System					Propress System (2006)				
Cost of Supply Water System to Units in Turnberry Tower Arlington									
CPVC System					Propress System (2006)				
Cost Per Fitting	Total Cost for 24 Units	Man Hours per Unit	Total Hours for 24 Units	Cost Per Fitting	Total Cost for 24 Units	Man Hours per Unit	Total Hours for 24 Units		
\$8,424	\$2,080,728	102	25,194	\$9,072	\$2,240,784	85	20,995		
Time Savings Using Propress System over CPVC System (Man Hours)							4,199		
Cost Savings Using Propress System over CPVC System (\$)							(\$160,056)		
Misc. Components	\$56.90	0	\$0	\$57	Misc. Components	\$54.57	0	\$0	\$55
<b>Total</b>	<b>\$1,670</b>	<b>102</b>	<b>\$6,754</b>	<b>\$8,424</b>	<b>Total</b>	<b>\$3,428</b>	<b>85</b>	<b>\$5,644</b>	<b>\$9,072</b>

Note: Cost of copper in 2006 was \$3.10 per pound





## LEED Impact

(Critical Industry Issue)

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### Credit 4.1 – Indoor Air Quality (Low Emitting Materials: Adhesives & Sealants)

- To qualify for this credit, must meet the following limits:
  - Adhesive Primer for Plastic 550 g/L
  - Contact Adhesive 80 g/L
- Point was obtained for this project, so the limits **WERE** met
- Only 1 point available for this credit

### LEED 2009

- No changes in LEED 2009 to obtain point
- Only 1 point available for this credit

### Future?

- Future editions may have restriction of 0 VOC's allowed
- May have building points for meeting certain VOC levels





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## Conclusion & Recommendation

### System to Use: CPVC System

- Savings in cost of at least \$160,000 for the entire building
- Has no LEED impact (products used fall within LEED limits)
- Less copper on site means the reduced risk of theft

### What about today???

If the project were designed today, Propress System should be used!

- Price of copper is lower than it was in 2006
- If the units were designed today, they would cost \$7518 which is less than CPVC

### Cost of Supply Water System to Units in Turnberry Tower Arlington

CPVC System				Propress System			
Cost Per Unit	Total Cost for 247 Units	Man Hours per Unit	Total Hours for 247 Units	Cost Per Unit	Total Cost for 247 Units	Man Hours per Unit	Total Hours for 247 Units
\$8,424	\$2,080,728	102	25,194	\$7,518	\$1,856,946	85	20,995
Time Savings Using Propress System over CPVC System (Man Hours)							4,199
Cost Savings Using Propress System over CPVC System (\$)							\$223,782





## Site Logistics Plan for Drywall Deliveries

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#### Problem:

- Delivery lane was either busy or in use by concrete deliveries
- East side of the site was not being utilized
- County Police Officers were threatening to issue stop work orders

#### Goal:

- Modify the site utility plan to allow for deliveries on the east side of the site
- Allow for drywall to be delivered during work hours to cut down on the overtime needing to be paid

Exterior View  
From East





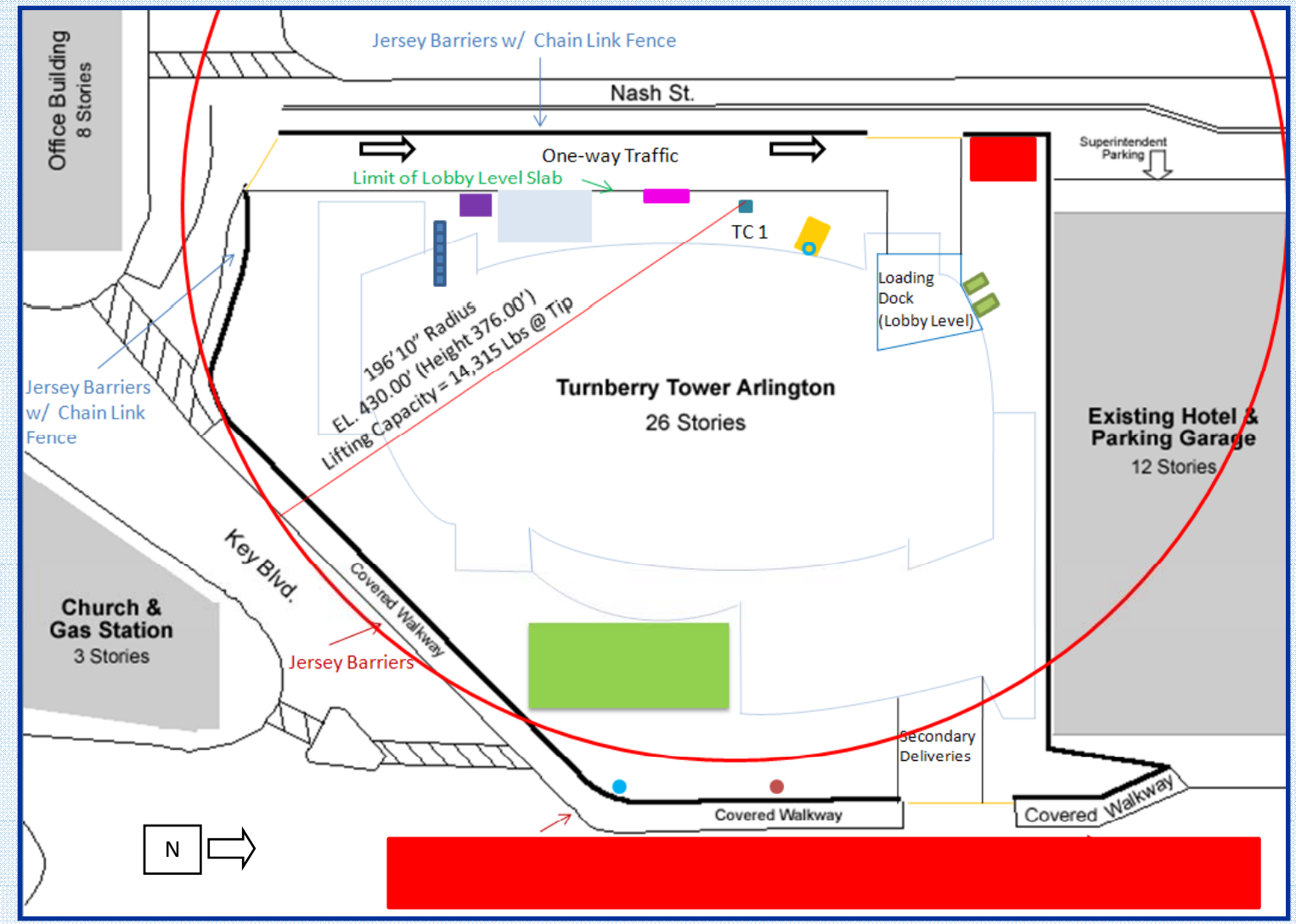
**Existing Site Plan**

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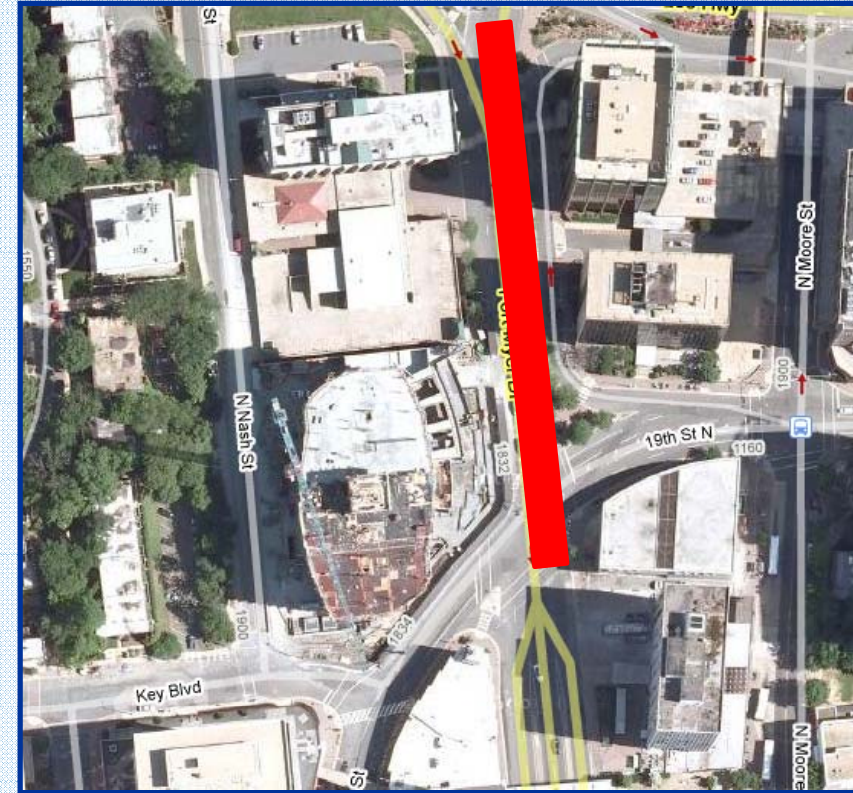
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## Referring to Arlington County about use of Fort Myer Dr.



Aerial View of Arlington, VA

- Fort Myer Drive is deemed a main access road
  - Must be clear for traffic flow during both morning and afternoon rush hour
  - County was more strict because of problems that occurred during excavation





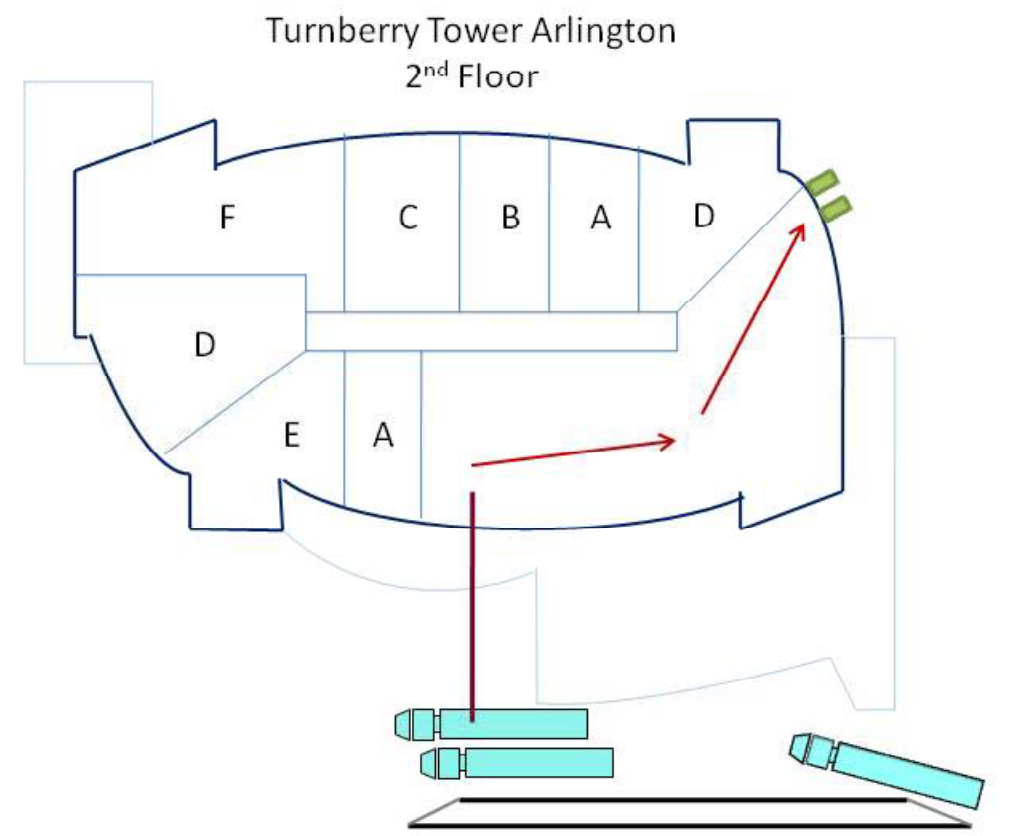
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### Modifying the Site Plan for Drywall Deliveries





## Conclusion & Recommendation

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#### How would the 2<sup>nd</sup> Level be affected?

- 2<sup>nd</sup> Level will not be affected thanks to SIPS (Could be used as lay down area)
- Level 7 is being erected with concrete with activity on the 2<sup>nd</sup> Level begins
- Reshores are only required 3 levels below the working deck
- Level 3 will be used as the mock up for MEP clashes

#### How will the material hoist be affected?

- When tower crane is not being used, more use of outriggers

#### **Recommendation: Use the Modified Site Plan if Arlington County would approve**

- Will allow for other deliveries to the site besides drywall

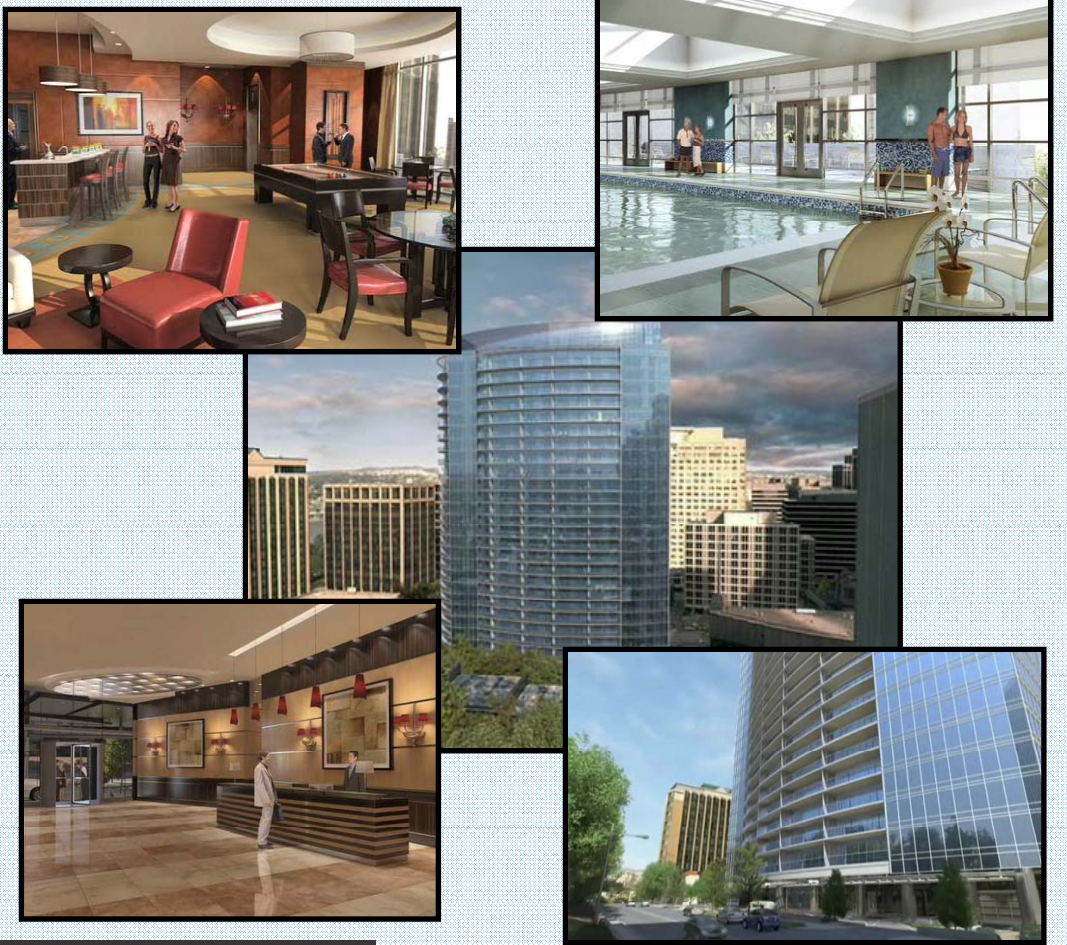




## Summary & Conclusions

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### Analysis 1 – Window Wall Attachment with Reinforced Concrete

**Recommendation: Use designed Post Tension Slabs**

- Cheapest System (even with PT blowouts)
- Maximum amount of units to sell
- Desired Floor to Ceiling Height
- Schedule is not impacted drastically

### Analysis 2 – Supply Water System

**Recommendation: Use designed CPVC Pipe System**

- Savings in cost of at least \$160,000 for the entire building
- Has no LEED impact (products used fall within LEED limits)
- Less copper on site means the reduced risk of theft
- If building was designed today, Propress system would be cheaper

### Analysis 3 – Site Logistics Plan for Drywall Deliveries

**Recommendation: Use Modified Site Plan if permitted by Arlington County**

- This site plan can save money as seen by the examples
- Will allow for other deliveries to the site besides drywall





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Penn State Architectural Engineering Faculty

- Dr. David Riley
- Professor Kevin Parfitt
- Professor Robert Holland
- Dr. Michael Horman

Facchina Construction  
(Formerly Facchina-McGaughan, LLC.)

- Tony Cortés
- Derek Dickenson
- Richard Roberts
- G. R. Nicholas Holland
- Josue Leon

J.J. Magnolia Plumbing

- Bill Stewart

Turnberry Limited

- Mark Babbitt
- Dave White

Facchina Development

- Robert Mitchell

Fellow AE students, especially

- Nicole Lucas
- Kim McKitish

Friends & Family

- Mom, Dad, and Joey





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**Cost Comparison**

**Post Tension Concrete**

Total Material Cost		
Item	Amount	Total Cost
Concrete	37,351 CY	\$4,668,875
Reinforcing Steel	3071 Tons	\$3,071,000
Miscellaneous Items		\$2,481,385
<b>TOTAL</b>		<b>\$10,221,260</b>
<b>TOTAL PER CY</b>		<b>\$273.65</b>

Construction Cost of Post Tension Concrete System						
Description	Qty	Unit	Material	Labor	Equipment	Total Cost
Cast In Place Concrete including placing and stripping formwork, placing rebar, placing concrete, and finishing concrete	37351	CY	\$273.65	\$257.21	\$22.23	<b>\$20,658,837</b>
<b>TOTAL</b>						<b>\$27.55 per SF</b>

Structural Systems Cost Comparison for Turnberry Tower Arlington			
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Reinforced Concrete (Removing 1 Story)			
Reinforced Concrete (Adjusting Story Height)			

**Average Costs**

- Concrete: \$125 / cubic yard
- Rebar: \$1000 / ton
- PT Cable: \$1.15 / pound

(prices obtained from concrete subcontractor during 4<sup>th</sup> quarter of 2008)





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- Questions?



Monday, April 13<sup>th</sup>, 2009

**Cost Comparison**

**Option 1: Reinforced Concrete Adjusting Story Height**

Total Material Cost		
Item	Amount	Total Cost
Concrete	44072 CY	\$5,508,994
Reinforcing Steel	3983 Tons	\$3,398,200
Miscellaneous Items		\$1,753,108
<b>TOTAL</b>		<b>\$10,660,302</b>
<b>TOTAL PER CY</b>		<b>\$241.88</b>

Construction Cost of Reinforced Concrete System (Adjusting Story Height)						
Description	Qty	Unit	Material	Labor	Equipment	Total Cost
Cast In Place Concrete including placing and stripping formwork, placing rebar, placing concrete, and finishing concrete	44072	CY	\$241.88	\$257.21	\$22.23	\$22,975,867
				<b>TOTAL</b>		<b>\$30.63 per SF</b>

Structural Systems Cost Comparison for Turnberry Tower Arlington			
Structural System	Residential Units	Total Structural Cost	Cost per SF
Post Tension Concrete	247	\$20,658,837	\$27.55
Reinforced Concrete (Adjusting Story Height)	247	\$22,975,867	\$30.63
Reinforced Concrete (Removing 1 Story)			

**Average Costs**

- Concrete: \$125 / cubic yard
- Rebar: \$1000 / ton
- PT Cable: \$1.15 / pound

(prices obtained from concrete subcontractor during 4<sup>th</sup> quarter of 2008)





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**Cost Comparison**

**Option 2: Reinforced Concrete Removing One Story**

Total Material Cost		
Item	Amount	Total Cost
Concrete	43355 CY	\$5,419,369
Reinforcing Steel	3363 Tons	\$3,363,200
Miscellaneous Items		\$1,753,108
<b>TOTAL</b>		<b>\$10,535,677</b>
<b>TOTAL PER CY</b>		<b>\$243.01</b>

Construction Cost of Reinforced Concrete System (Removing One Floor)						
Description	Qty	Unit	Material	Labor	Equipment	Total Cost
Cast In Place Concrete including placing and stripping formwork, placing rebar, placing concrete, and finishing concrete	43355	CY	\$243.01	\$257.21	\$22.23	<b>\$22,651,046</b>
				<b>TOTAL</b>		<b>\$30.20 per SF</b>

Structural Systems Cost Comparison for Turnberry Tower Arlington			
Structural System	Residential Units	Total Structural Cost	Cost per SF
Post Tension Concrete	247	\$20,658,837	\$27.55
Reinforced Concrete (Adjusting Story Height)	247	\$22,975,867	\$30.63
Reinforced Concrete (Removing 1 Story)	235	\$22,651,046	\$30.20

**Average Costs**

- Concrete: \$125 / cubic yard
- Rebar: \$1000 / ton
- PT Cable: \$1.15 / pound

(prices obtained from concrete subcontractor during 4<sup>th</sup> quarter of 2008)





## Comparing Site Plans

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### Example of how the Modified Site Plan would help

Existing Site Logistics Plan			
# of Boards Stocked During 40 Hour Week	Cost for 4 Man Crew (Standard Wage)	# of Boards Stocked During Overtime	Cost for 4 Man Crew (1.5 Standard Wage)
400	\$22 per person per hour	600	\$33 per person per hour
<b>Total Cost for 4 Man Crew for 1000 Boards:</b>			<b>\$5,632</b>
Proposed Site Logistics Plan			
# of Boards Stocked During 40 Hour Week	Cost for 4 Man Crew (Standard Wage)	# of Boards Stocked During Overtime	Cost for 4 Man Crew (1.5 Standard Wage)
600	\$22 per person per hour	400	\$33 per person per hour
<b>Total Cost for 4 Man Crew for 1000 Boards:</b>			<b>\$4,880</b>

Note: Turnberry Tower Arlington has 91,000 sheets of drywall

Assuming that productivity increases by **20%** during a 40 hour week:

- \$750 saved per 1000 boards





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## Comparing Site Plans

### Example of how the Modified Site Plan would help

Existing Site Logistics Plan			
# of Boards Stocked During 40 Hour Week	Cost for 4 Man Crew (Standard Wage)	# of Boards Stocked During Overtime	Cost for 4 Man Crew (1.5 Standard Wage)
400	\$22 per person per hour	600	\$33 per person per hour
<b>Total Cost for 4 Man Crew for 1000 Boards:</b>			<b>\$5,632</b>
Proposed Site Logistics Plan			
# of Boards Stocked During 40 Hour Week	Cost for 4 Man Crew (Standard Wage)	# of Boards Stocked During Overtime	Cost for 4 Man Crew (1.5 Standard Wage)
1000	\$22 per person per hour	0	\$33 per person per hour
<b>Total Cost for 4 Man Crew for 1000 Boards:</b>			<b>\$3,520</b>

Note: Turnberry Tower Arlington has 91,000 sheets of drywall

Assuming that productivity increases and no overtime is needed in a 40 hour week:

- \$2000 saved per 1000 boards

