JULIE DAVIS
STRUCTURAL OPTION
APRIL 9, 2008

CITY VISTA
WASHINGTON D.C.
ADVISOR: DR. MEMARI

BREADTH#1: CONSTRUCTABILITY

There are several constructability issues with the redesign of City Vista.

1. *ERECTION:* With pre-cast the erection of the structural system is much different from post tension. Members are set in place with a crane. This process caused forces in the member which can sometimes affect the design.
2. *LEEDS:* Pre-cast concrete allows for easier obtainment of a Leeds rating. An in-depth analysis was not performed, although advantages are discussed showing that LEEDS certification is more feasible with a pre-cast building.
3. *COST*: A Cost analysis was done to compare the gravity system cost of the PT and pre-cast system.
4. *SCHEDULING:* A simple schedule was also assembled to show potential time savings the precast system could provide.

ERECTION

Currently a saddle jib tower crane is being used at City Vista. After examining the cut sheets it is sufficient for erection of the pre-cast members.

Concerns:
Design of pre-cast members is influenced by storage and stripping, the number of pick points and location of the crane. All these variables create forces in the member need to be considered during design. For example the figure below shows a two point pick using a spreader beam. Predominantly line lifts will be used to assemble City Vista since all components have long spans and thin depths. As a result the inclined lines created by the two pick point creates a moment due to pΔ affects. Eccentric moments created by picks not at the center of the member are also an issue. As a safe practice a minimum **safety factor of 1.2** is applied to all pre-cast products, this factor accounts for stripping and dynamic forces.

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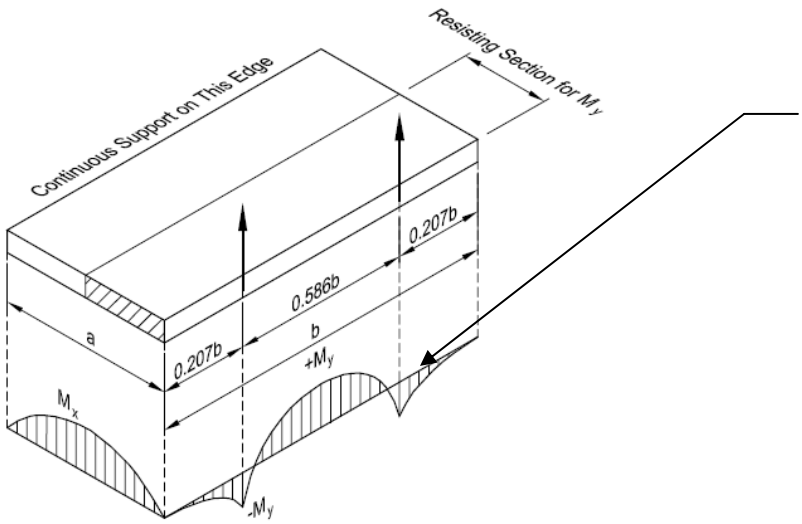


Here is an example of the forces that can be seen during erection of the gravity system.

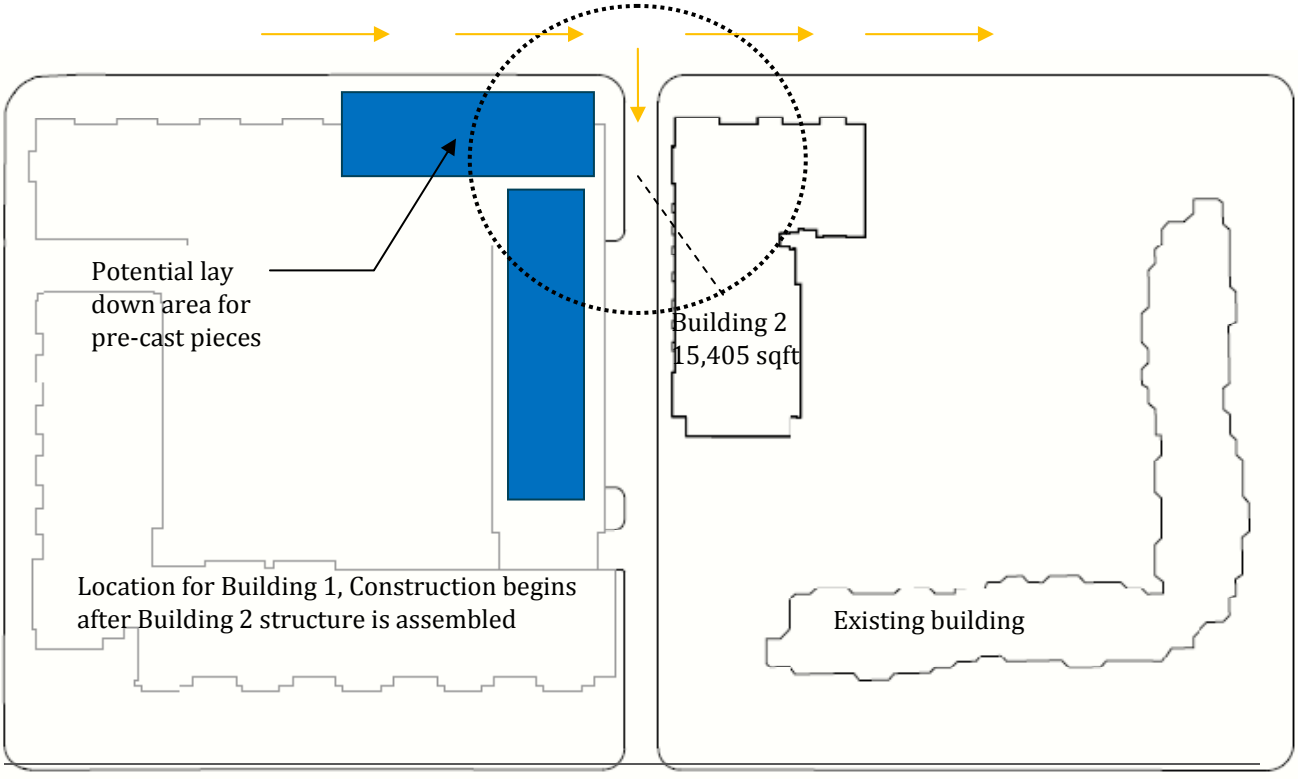
As shown in the figure a moment is seen in the component from lifting. For example a 29IT24 beam, self weight : 500plf , length: 26ft.

M_{xmax} = 49 in-kips

M_{ymax} = 46.73 in-kips

Although these moments are insignificant when compared to the flexural moments, although it could be a concern

Smooth erection at City Vista: Building 2 superstructure is erected before Building 1, as a result a lay down area is available (see diagram below). Currently the crane is located between the two buildings on the pedestrian bridge footings which double as crane footing.



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LEED POTENTIAL

LEEDS ASSESMENT
Sustainability is the development that meets the needs of the present without compromising the ability of future generations to meet their own needs.
Pre-Cast concrete is a sustainable practice because it uses:
1. Integrated design
2. Materials efficiency
3. Reduces waste, site disturbance, and noise

Integrated design, when you examine a building as a whole not as individual parts. By doing this you can concentrate on energy efficiency, durability, environmental impacts, and cost.
Material efficiency is the combination of reducing energy and emissions created by building materials.
Reductions, is reducing the amount of material and toxic waste created when buildings are built.

WHY?

- *Operation Cost:* $0.60-1.50 sqft vs. $1.80 sqft of conventional buildings.
- Lower energy cost translates into smaller cooling equipment → lower first cost for equipment.
- Green design first cost ranges from 0-2% more than conventional buildings.
- This 2% increase → 10 times the initial cost in operation cost.

HOW?

- Material savings when precast panels are used for interior walls. This eliminates the need for drywall and additional framing.
- Eliminate duct work when hollow core planks voids are used as ducts.
- Concrete is a durable material therefore reducing maintenance.

LEED RATING AT CITY VISTA:
As discussed above a pre-cast building can obtain 23/26 points required for green certification, but exactly how is this accomplished by simply changing the method of concrete casting from onsite post tension to offsite pre-tension.

- **Material Recourses:** Precast components can be reused when building is renovated or demolished, reducing air and land pollution caused by demolition. Corrosion resistance which in return means less maintenance. This is because precast is made under ideal circumstances so things like steel cover are carefully monitored.
- **Sustainable site:** The heat island effect is minimized by concrete because pre-cast concrete provides a reflective surface.
- **Production:** Pre-cast plants create little waste. About 2.5% of the volume used in production is disposed of, and 95% of the water used is reused for other process. Steel formworks are also reused over and over again.
- **Recycled Content:** Concrete is a recycled material, and reinforcing bars are 90% recycled material. 95% of the waste water and steel formworks are reused

- **Energy:** Hollow core plank voids can be used as a passive solar system. This can be done by using the voids themselves as ducts changing the planks thermal mass. Energy reduction during production can be accomplished through the use of slag cement or silica fume. These items would be waste if not utilized in concrete products.
- **Local Materials:** Most suppliers are within 200 miles of the site.
- **Reuse:** At the end of the useful life of the building pre-cast pieces can be unassembled and reused.

LEEDS SUMMARY	
Sustainable Site	
Site Development, restore habitat	1
Site Development, maximize open space	1
Heat island effect	1
Energy and Atmosphere	
Prerequisite: Minimum Energy Performance	
Optimize Energy Performance	1-10
Material and Resources	
Reuse, maintain 75% existing shell	1
Reuse, maintain 25% existing shell	1
Construction waste management divert 50% by wt. or vol.	1
Construction waste management divert 75% by wt. or vol.	1
Recycled Content (10% of material on project, based on cost)	1
Recycled Content (20% of material on project based on cost)	1
Local/Regional material (minimum of 10%, based on cost)	1
Local/Regional material (minimum of 20%, based on cost)	1
Indoor Environmental Quality	
Construction Indoor air quality , during construction	1

Innovation and Design Process	
High volume supplementary cementious materials	1
Apply for other credits demonstrating performance	1
Apply for other credits demonstrating performance	1
Apply for other credits demonstrating performance	1
LEED accredited professional	1
TOTAL	23

Figure 27 #: LEED Checklist for pre-cast building , courtesy of www.PCI.org

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COST ANALYSIS:

Pre-Cast Gravity System Cost Analysis:

Pre-Cast System — Page 1 of 1

Quantity	Assembly Number	Description	Unit	Ext. Material O&P	Ext. Installation O&P	Extended Total O&P	Labor Type
84.85	B10102152200	Concrete beam, precast, 12" x 16", 200 PLF, 15...	L.F.	$ 4,072.80	$ 1,654.58	$ 5,727.38	Standard Union
84.847	B10102152800	Concrete beam, precast, 12" x 16", 200 PLF, 20...	L.F.	$ 5,387.78	$ 1,092.83	$ 6,480.61	Standard Union
510	B10102144600	Concrete T beam, precast, 24" x 30", 360 PLF, ...	L.F.	$ 111,180.00	$ 8,445.60	$ 119,625.60	Standard Union
272.5	B10102145750	Concrete T beam, precast, 24" x 30", 865 PLF, ...	L.F.	$ 60,495.00	$ 5,014.00	$ 65,509.00	Standard Union
70.47	B10102152300	Concrete I beam, precast, 12" x 20", 300 PLF, 1...	L.F.	$ 8,232.52	$ 1,305.65	$ 9,538.17	Standard Union
224.58	B10102152900	Concrete I beam, precast, 12" x 20", 300 PLF, 2...	L.F.	$ 26,051.28	$ 3,096.96	$ 29,148.24	Standard Union
235.94	B10102154000	Concrete I beam, precast, 12" x 28", 435 PLF, 2...	L.F.	$ 32,559.72	$ 2,597.70	$ 35,157.42	Standard Union
29,481.64	B10102302900	Precast concrete plank, 2" topping, 8" total thic...	S.F.	$ 240,275.37	$ 135,910.36	$ 376,185.73	Standard Union
940	B10102071500	Precast concrete column, 20" sq, tied, eccentric...	V.L.F.	$ 81,780.00	$ 8,630.60	$ 90,410.60	Standard Union
300	B10102071350	Precast concrete column, 18" sq, tied, eccentric...	V.L.F.	[illegible]	[illegible]	[illegible]	Standard Union
				$ 583,934.47	$ 169,412.48	$ 753,346.95	

Pre-Cast System : a typical floor

Materials: $583,934.00
Installation: $ 169,412.00

TOTAL : $ 753,347.00 / FLOOR

Analysis was done using the program cost works by RSMeans. Values were drawn from Commercial/ New construction cost book released in 2008. A stand union labor was assumed and no mark ups were included.

Total Cost :

[$753,347 * 6] + [$647,372*5] =

** The two different floor prices take into consideration the double height columns **

Approx. TOTAL = **$ 7,756,942.00**

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Post Tension Gravity System cost Analysis:

PT. System : a typical floor

Materials: $18,120.00
Installation: $ 286,465.00

TOTAL : $ 604,584.00 / FLOOR

Analysis was done using the program cost works by RSMeans. Values were drawn from Commercial/ New construction cost book released in 2008. A stand union labor was assumed and no mark ups were included.

Approx. TOTAL = **$ 5,150,425.00**

The post tension system cost considerably less. This is due to the additional beams needed to support the hollow planks. The post tensioned slab and planks with topping price is competitive with one another. The same can be said when comparing the pre-cast and cast in place conventionally reinforced columns. Economically a post tensioned flat plate building is considerably cheaper.

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SCHEDULE

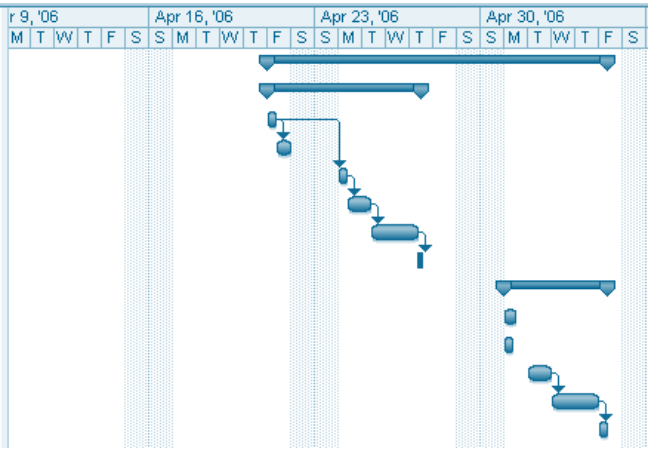
Pre-Cast System:
Typical erection of pre-cast is 400m^2 /week of pre-cast = 62,000 in^2 /week

Typical Floor :

Member	Quantity	Total Area
Column #1 [20x20]	24	66.69 in^2
Column #2 [16x16]	10	17.68 in^2
Column #3 [24x24]	23	92 in^2
L-Beams	31	9424 in^2
T-Beams	34	16 320 in^2
R-Beams	9	1728 in^2
Planks	200	50,600 in^2
TOTAL		**78,249 in^2**

A two floor schedule was done in Microsoft project to reflect this erection pace, while taking into consideration the double floor column height. This analysis shows erection pace of 2 floor in ***9 Days.***

Task Name	Duration	Start	Finish	Predecessor
Structural System	**10.25 days?**	**Fri 4/21/06**	**Fri 5/5/06**	
Floor 1	**4.5 days**	**Fri 4/21/06**	**Thu 4/27/06**	
Columns	0.25 days	Fri 4/21/06	Fri 4/21/06	
L-Beams	0.75 days	Fri 4/21/06	Fri 4/21/06	3
R-Beams	0.25 days	Mon 4/24/06	Mon 4/24/06	3
T-Beams	1 day	Mon 4/24/06	Tue 4/25/06	5
Hollow Core Planl	2 days	Tue 4/25/06	Thu 4/27/06	6
Topping	0.25 days	Thu 4/27/06	Thu 4/27/06	7
Floor 2	**4.25 days?**	**Mon 5/1/06**	**Fri 5/5/06**	
L-Beams	0.5 days?	Mon 5/1/06	Mon 5/1/06	
R-Beams	0.25 days	Mon 5/1/06	Mon 5/1/06	
T-Beams	1 day?	Tue 5/2/06	Tue 5/2/06	
Hollow Core Planl	2 days	Wed 5/3/06	Thu 5/4/06	12
Topping	0.25 days	Fri 5/5/06	Fri 5/5/06	13



Pre-Cast erection saves about 5.5 days in the schedule. Not a significant difference when considering the higher cost of the system.

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Post Tension System: Courtesy of Davis Construction

Activity ID	Activity Description	Orig Dur	Rem Dur	Early Start	Early Finish	Total Float
Building 2						
Concrete Structure						
Level 1						
02010010	Bldg 2 - Sitework / Foundations & SOG	80*	80*	29DEC05	20APR06	0
02010020	Install Test Piles	5	5	29DEC05	05JAN06	0
02010022	Install Test Probes, Test reports & Mobilize	14	14	06JAN06	25JAN06	0
02010024	Install Tower Crane Foundation	8	8	09FEB06	20FEB06	36
02010028	Erect Tower Crane	2	2	21FEB06	22FEB06	36
02010030	Start Auger Cast Piles - Bldg 2	0	0	26JAN06		0
02010035	Install Auger Cast Piles	20	20	26JAN06	22FEB06	0
02010040	Start Concrete Foundations - Bldg 2	0	0	23FEB06		0
02010045	F,R&P Pile Caps & Grade Beams	25	25	23FEB06	29MAR06	0
02010050	Selective Demo/Cut Site	25	25	24FEB06	30MAR06	0
02010055	Foundations / Slab on Grade - Bldg 2	41*	41*	23FEB06	20APR06	0
02010060	F,R&P Foundation Walls & Cols	25	25	03MAR06	06APR06	0
02010070	Backfill Foundation	10	10	10MAR06	06APR06	0
02010080	Rough-in Underground Plumbing	10	10	10MAR06	06APR06	0
02010085	Inspect Underground Plumbing	5	5	07APR06	13APR06	0
02010090	Rough-in Underground Electric	10	10	10MAR06	06APR06	0
02010095	Inspect Underground Electric	5	5	07APR06	13APR06	0
02010100	Prep & Pour Slab-on-Grade	5	5	14APR06	20APR06	0
02010110	Slab-on-Grade Complete - Bldg 2	0	0		20APR06	0
Level 2						
02020090	Start Concrete Structure - Bldg 2	0	0	21APR06		0
02020095	Concrete Structure (1st - Roof) - Bldg 2	60*	60*	21APR06	17JUL06	0
02020100	F,R&P Slabs, Walls & Cols - 2nd	7	7	21APR06	01MAY06	0
Level 3						
02030100	F,R&P Slabs, Walls & Cols - 3rd	5	5	02MAY06	08MAY06	0
Level 4						
02040100	F,R&P Slabs, Walls & Cols - 4th	5	5	09MAY06	15MAY06	0
Level 5						
02050100	F,R&P Slabs, Walls & Cols - 5th	5	5	16MAY06	22MAY06	3
Level 6						
02060100	F,R&P Slabs, Walls & Cols - 6th	5	5	23MAY06	30MAY06	5
Level 7						
02070100	F,R&P Slabs, Walls & Cols - 7th	5	5	31MAY06	06JUN06	8
Level 8						
02080100	F,R&P Slabs, Walls & Cols - 8th	5	5	07JUN06	13JUN06	12
Level 9						
02090100	F,R&P Slabs, Walls & Cols - 9th	5	5	14JUN06	20JUN06	15
Level 10						
02100100	F,R&P Slabs, Walls & Cols - 10th	5	5	21JUN06	27JUN06	16
Level 11						
02110100	F,R&P Slabs, Walls & Cols - 11th	5	5	28JUN06	05JUL06	16
Roof						
02RF0100	F,R&P Slabs, Walls & Cols - Main/PH Roof	8	8	06JUL06	17JUL06	16
02RF0195	Concrete Top-Out - Bldg 2	0	0		17JUL06	16
02RF0198	Dismantle Tower Crane 1 (NE)	0	0		05APR07	0

On average the current structure is assembled at a rate of 1 floor per week