Hunter College School of Social Work

New York, NY

Vanessa Rodriguez | Structural Emphasis

2009 - 2010

PRESENTATION OUTLINE

INTRODUCTION, BUILDING STATS, + OVERALL CONCEPT

1 **Proposal**

2 **Design of Chevron and Diagonal Braced Frames**
STRUCTURAL DEPTH STUDY I

3 **Ting Wall Façade**
STRUCTURAL DEPTH STUDY II

4 **Green Roof**
ENERGY SAVINGS BREATH

5 **Cost Analysis**
CONSTRUCTION MANAGEMENT BREATH

CONCLUSIONS, ACKNOWLEDGEMENTS, + QUESTIONS

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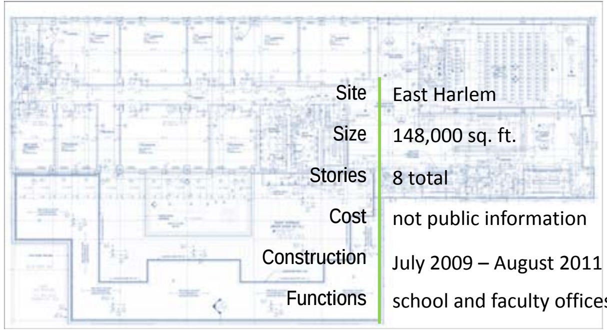
BUILDING STATISTICS



Site	East Harlem
Size	148,000 sq. ft.
Stories	8 total
Cost	not public information
Construction	July 2009 – August 2011
Functions	school and faculty offices

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ARCHITECTURAL CONCEPT

"The entrance lobby, conceived as an interior street, is glazed from floor to ceiling along 119th Street to provide a transparent and welcoming appearance from the exterior and to link the interior of the building to its neighborhood surroundings."

-Cooper Robertson & Associates

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FACADE

- Bottom band : two-aided curtain wall with both transparent panels and spandrel shadow boxes
- Middle: architectural precast concrete and brick-faced precast panel in stack bond pattern
- Top: four-sided structurally glazed curtain wall and 1”stucco on cmu substrate
- Similarly the South elevation has this same pattern of horizontal bands of varying material

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GREEN ROOFS

- The School of Social Work building will be LEED certified
- Green roofs located on the first and second floors
- These roofs vary from intensive to extensive green roofs

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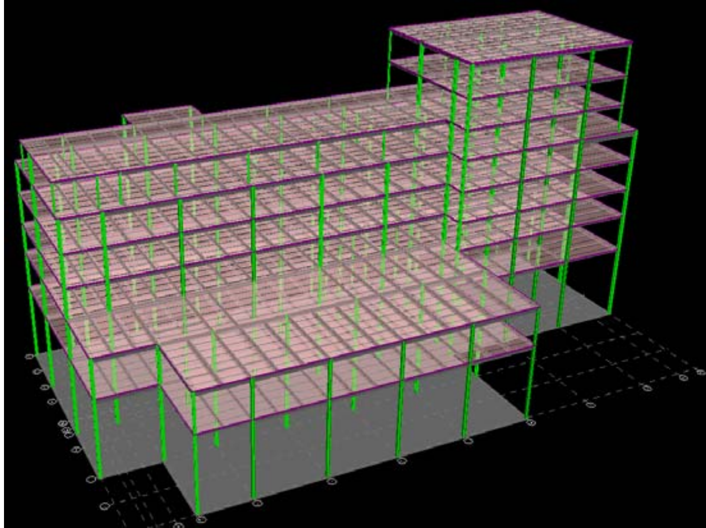
EXISTING STRUCTURAL SYSTEM

GRAVITY SYSTEM

- Bay sizes vary from 30'x28', 30'x 28'2", 30'x31'5" and 30'x36' from north to south respectively
- All columns in the superstructure are W14s
- There are non-composite beams as well as composite beams
- Non-composite beams are found where beam to beam, and beam to column connections are designed to transfer the reaction for a simply supported, uniformly loaded beam



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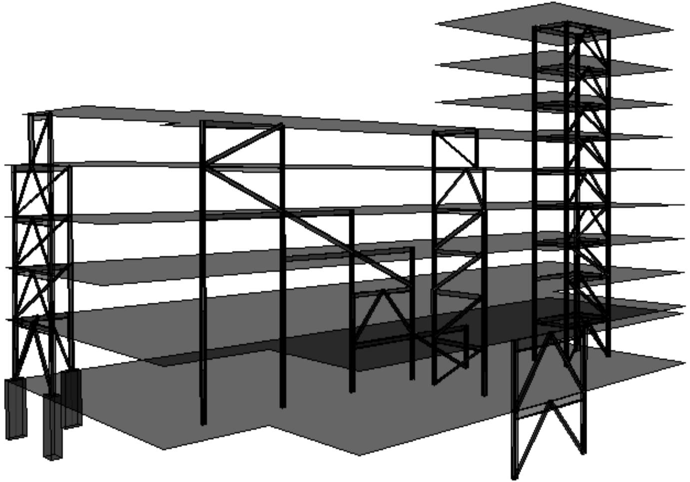
EXISTING STRUCTURAL SYSTEM

LATERAL LOAD RESISTING SYSTEM

- The lateral system is made up of braced frames and moment frames
- Column splices at four feet above floor level
- Vertical members attached using moment connections



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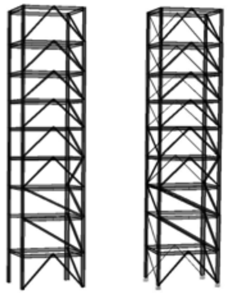
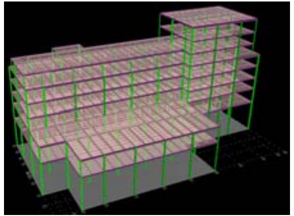
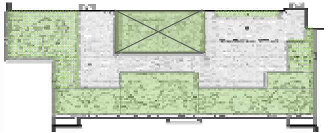
PROPOSAL
REASONS AND GOALS

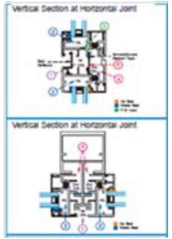
- Disadvantages of existing lateral system
- Design building facade for energy efficiency
- Design gravity system for New Facade

- Energy efficiency
- Reduction in labor cost
- Reduction in erection time
- Overall cost savings









PRESENTATION OUTLINE

DESIGN OF CHEVRON AND DIAGONAL BRACED FRAMES

DESIGN GOALS AND ASSUMPTIONS

Design Goals

- Obtain initial sizes using relative stiffness method
- Use chevron braces for frame at grid 3 and diagonal member for frame at grid H to maintain symmetry
- Confirm that strength and drift criteria has been satisfied
- Design and detail the typical braced frame connection

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DESIGN OF CHEVRON AND DIAGONAL BRACED FRAMES

DESIGN GOALS AND ASSUMPTIONS

Design Assumptions

- P-delta effects considered
- Girders sizes were kept the same
- Rigid diaphragm action as a result of the metal deck with concrete topping
- Diaphragms modeled with added mass value in accordance with loading diagrams
- Wind and seismic loads were determined according to ASCE 7-05

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DESIGN OF CHEVRON AND DIAGONAL BRACED FRAMES

METHODOLOGY

1. Apply a looo kip load to an ETABS model to get relative stiffness since the redesigned frame is expected to resist the same amount of force as it did previously

2. The percentage of the force experienced by each level is then applied to a non-defined member structure on SAP

Eighth story

Grid	X Force	% X	Grid	Y Force	% Y
1	0	0	A	0	0
2	0	0	H	-676	68
3	-175	17	F	0	0
4	-824	82	J	-322	32
8	0	0			0
total=	-999			-998	

Eighth story

Grid	X Force	% X	Grid	Y Force	% Y
1	0	0	A	0	0
2	0	0	H	-676	68
3	-175	17	F	0	0
4	-824	82	J	-322	32
8	0	0			0
total=	-999			-998	

Seventh story

Grid	X Force	% X	Grid	Y Force	% Y
[illegible]	[illegible]	0	A	0	0
[illegible]	[illegible]	0	H	-660	66
[illegible]	[illegible]	21	F	0	0
[illegible]	[illegible]	79	J	-338	34
[illegible]	[illegible]	0			
total=	[illegible]			-998	

Sixth story

Grid	X Force	% X	Grid	Y Force	% Y
[illegible]	[illegible]	0	A	0	0
[illegible]	[illegible]	0	H	-660	66
[illegible]	[illegible]	23	F	0	0
[illegible]	[illegible]	77	J	-337	34
8	0	0			
total=	-1000			-997	

Fifth story

Grid	X Force	% X	Grid	Y Force	% Y
1	0	0	A	-6	1
2	-770	77	H	150	-15
3	80	-8	F	-354	35
4	-311	31	J	-788	79
8	0	0			
total=	-1001			-999	

Fourth story

Grid	X Force	% X	Grid	Y Force	% Y
1	-178	18	A	45	-4
2	-572	57	H	-34	3
3	-45	5	F	-463	46
4	-203	20	J	-549	55
8	0	0			
total=	-999			-1000	

Third story

Grid	X Force	% X	Grid	Y Force	% Y
1	-87	9	A	45	-5
2	-832	83	H	-24	2
3	6	-1	F	-456	46
4	-88	9	J	-563	56
8	0	0			
total=	-1000			-1000	

Second story

Grid	X Force	% X	Grid	Y Force	% Y
1	-143	14	A	32	-3
2	-653	65	H	-2	0
3	-32	3	F	-397	40
4	-171	17	J	-636	64
8	0	0			
total=	-1000			-1000	

First story

Grid	X Force	% X	Grid	Y Force	% Y
1	-95	9	A	-103	10
2	-479	48	H	-50	5
3	-22	2	F	-347	35
4	-105	10	J	-488	49
8	-297	30			
total=	-999			-998	

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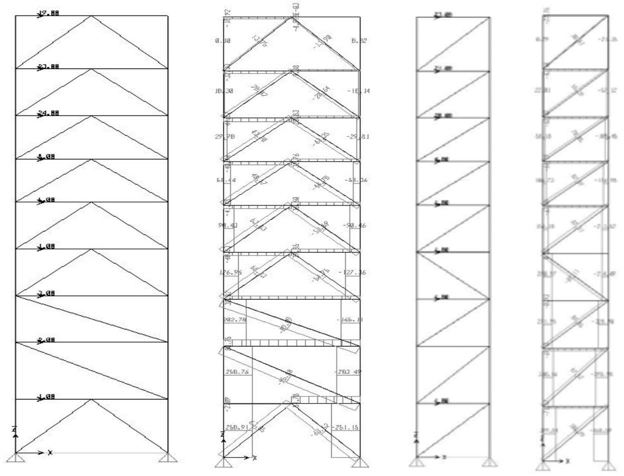
METHODOLOGY

3. The axial forces are then found on the bracing members and are sized accordingly

4. The new lateral system is modeled in ETABS. Drift limits are checked for the previous controlling wind case; which was 100 percent of the wind in the North/South or East/West direction. Seismic limits are also checked.



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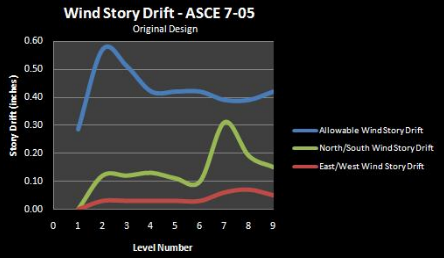

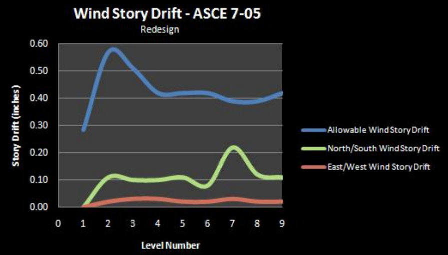

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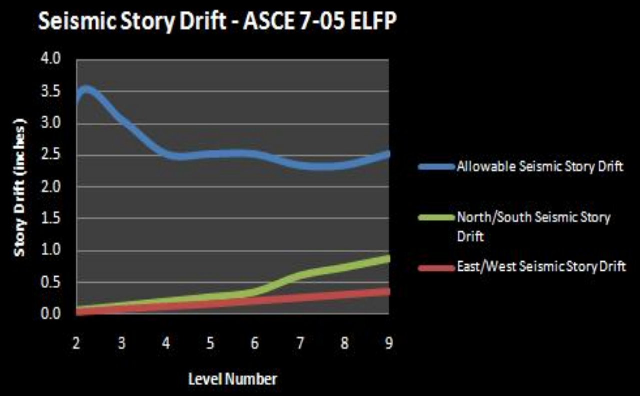
DESIGN OF CHEVRON AND DIAGONAL BRACED FRAMES

METHODOLOGY

- Drift values were found to be most significant in the East/West loading direction of the building
- None of the Ө-values exceeded 0.10
- P-delta effects are small enough to be negligible

$$\theta = \frac{P_x \Delta}{V_x h_{sx} C_d}$$

Level	Px (kips)	Vx (kips)	Δ (inches)	hsx (ft.)	hsx (in.)	Ө	Ө ≤ 0.10 ?
Roof	736	36	0.88	-	-	-	-
8	1254	54	0.74	14	168	0.031	YES
7	1752	69	0.61	13	156	0.031	YES
6	3129	99	0.35	13	156	0.022	YES
5	4662	123	0.27	14	168	0.019	YES
4	6185	138	0.2	14	168	0.016	YES
3	7749	147	0.13	14	168	0.013	YES
2	11449	154	0.06	17	204	0.007	YES
1	15388	-	0	19	228	-	-



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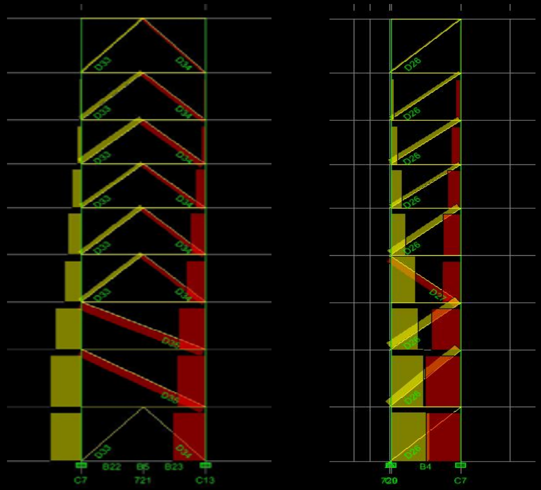
DESIGN OF CHEVRON AND DIAGONAL BRACED FRAMES

METHODOLOGY

5. Redesigned members are checked for strength capacity.

Braced Frame Schedule					
Concentrically Braced Frames on Grid 3					
Story	HSS	Axial Capacity		Axial Stress	
8	5x5x3/8	77.2	>	14	TRUE
7	5x5x3/8	77.2	>	19	TRUE
6	5x5x3/8	77.2	>	22	TRUE
5	5x5x3/8	77.2	>	14	TRUE
4	5x5x3/8	77.2	>	15	TRUE
3	5x5x3/8	77.2	>	13	TRUE
2	8x8x3/8	135	>	23	TRUE
1	8x8x3/8	135	>	18	TRUE
cellar	5x5x3/8	77.2	>	1	TRUE

Braced Frame Schedule					
Concentrically Braced Frames on Grid H					
Story	HSS	Axial Capacity		Axial Stress	
8	5x5x 3/8	70.3	>	18	TRUE
7	5x5x 3/8	70.3	>	26	TRUE
6	5x5x 3/8	96.3	>	28	TRUE
5	5x5x 3/8	96.3	>	21	TRUE
4	5.5x5.5x 3/8	96.3	>	33	TRUE
3	5.5x5.5x 3/8	96.3	>	40	TRUE
2	5.5x5.5x 3/8	96.3	>	45	TRUE
1	6x6x 3/8	128	>	43	TRUE
cellar	6x6x 3/8	128	>	2	TRUE



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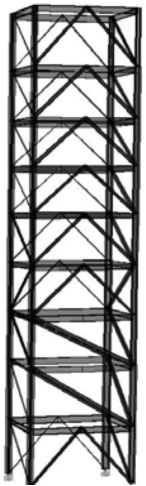
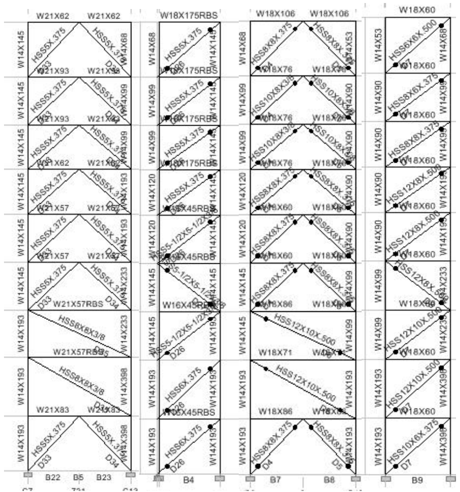
DESIGN OF CHEVRON AND DIAGONAL BRACED FRAMES

FINAL DESIGN

New Design				
w14x	quantity	total length	$/ft	total cost
53	1	14	$61.48	$860.72
68	1	26	$78.88	$2,050.88
74	1	14	$87.37	$1,223.18
90	1	26	$104.40	$2,714.40
99	1	26	$114.84	$2,985.84
120	1	14	$138.96	$1,945.44
145	2	62	$168.20	$10,428.40
193	5	148	$223.88	$33,134.24
233	1	33	$274.94	$9,073.02
398	1	33	$469.64	$15,498.12
HSS				
5x5x3/8	11	1146.2	$65.10	$74,617.62
5.5x5.5x3/8	3	402.8	$72.55	$29,223.14
6x6x3/8	2	274	$79.97	$21,911.78
8x8x3/8	2	189.6	$90.60	$17,177.76
			total:	$222,844.54





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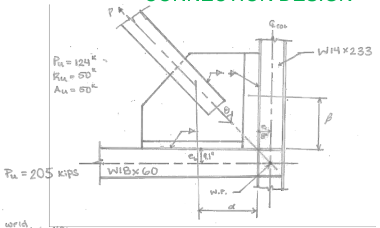
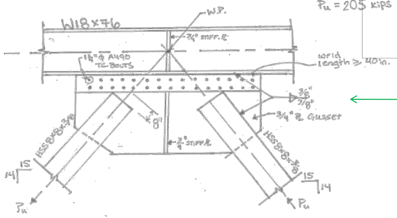
CONNECTION DESIGN





Uniform Force Method:
Special Case 3

$$\alpha - \beta tan\theta = e_b tan\theta - e_c$$

Interface Foces prior to special case two		
Connection ID	Shear (kips)	Axial (kips)
Gusset-to-column	40.4	30.8
Gusset-to-beam	67.8	35
Beam-to-column	85	80.8

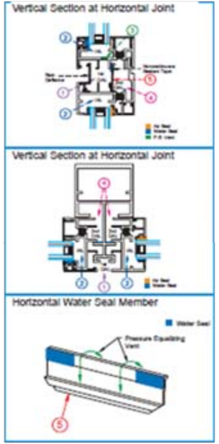
Interface Forces applying special case two			
Connection ID	Shear (kips)	Axial (kips)	Moment (ft-k)
Gusset-to-column	75.4	30.8	-
Gusset-to-beam	0	67.8	51.3
Beam-to-column	50	80.8	-

PRESENTATION OUTLINE

TINGWALL FACADE

Ting Wall Sustainability points toward LEED

- Sustainable site : 14pts
- Water efficiency: 5pts
- Energy and atmosphere: 17 pts
- Materials and resources: 13 pts
- Indoor environmental quality: 15 pts
- Innovation and Design Process : 5pt



1. **1st Outer Airloop™ (1st OAL)**
   The 1st Outer Airloop™ is a wet loop designed with instantaneous drainage capability. A continuous perimeter airspace, open to the exterior air, is formed in the panel extrusion frame around each individual panel and between adjacent panels on all sides.
2. **Inner Airloop™ (IAL)**
   The inner Airloop™ is a dry loop. This airspace is formed between the perimeter extrusion and the facing material of each panel. Horizontal cavities are connected to vertical cavities through miter-matched corners, allowing pressure-equalized air around all sides within each individual panel.
3. **Pressure Equalization Vent**
   The Inner Airloop™ is pressure equalized with the exterior air via vent holes connecting the Inner Airloop™ with the 1st Outer Airloop™ , beyond the water path.
4. **2nd Outer Airloop (2nd OAL)**
   The 2nd Outer Airloop™ is also a dry loop. This airspace is formed around each panel -- between adjacent panels and between panels and mullions. This airspace is pressure equalized via a noncontinuous sealant tape attached to the horizontal water seal member (#5), which connects the 1st Outer Airloop and the 2nd Outer Airloop™ , beyond the water path.

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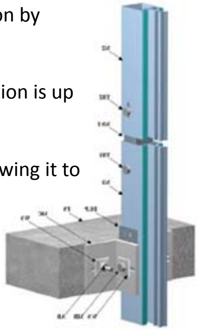
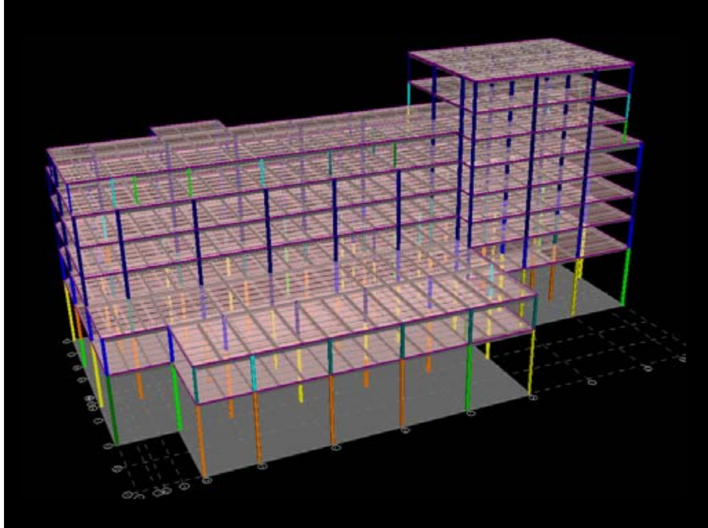
TINGWALL FACADE

PERIMETER STRUCTURAL FRAMING ADJUSTMENT

- Wind load forces are transferred into the mullion by mechanical inter-lock
- Tolerance for inter-floor spandrel beam deflection is up to ¾" deflection
- Each Ting Wall panel is structurally isolated allowing it to use panel drifts to absorb the story drift
- Slotted casement allows vertical and horizontal movement independent of each other





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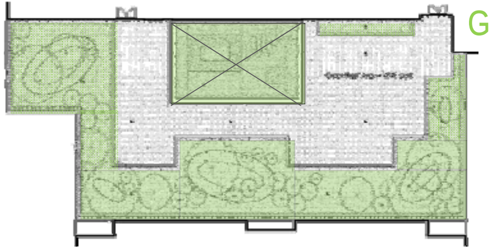

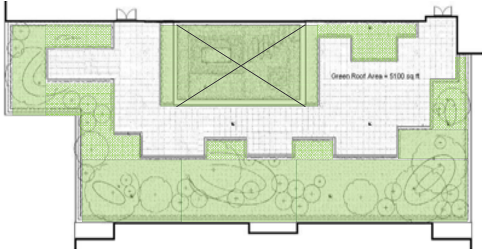

GREEN ROOF

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2 **Design of Chevron and Diagonal Braced Frames**
STRUCTURAL DEPTH STUDY I

3 **Ting Wall Façade**
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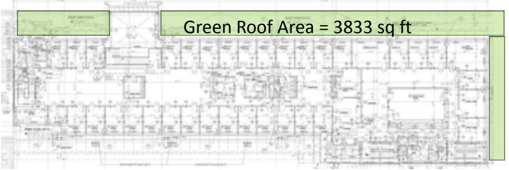
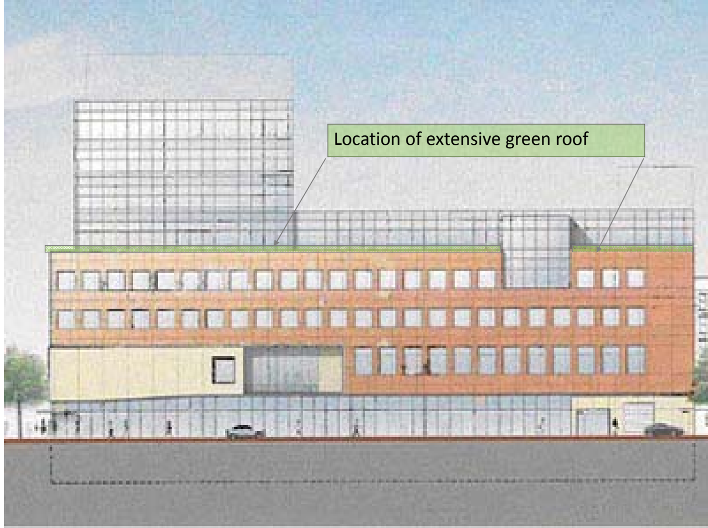
4 **Green Roof**
ENERGY SAVINGS BREATH

5 **Cost Analysis**
CONSTRUCTION MANAGEMENT BREATH

CONCLUSIONS, ACKNOWLEDGEMENTS, + QUESTIONS

GREEN ROOF





PRESENTATION OUTLINE

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GREEN ROOF

STORMWATER DETENTION TANK CAPACITY

•Volume of the tank is equal to 16, 000 gallons

•Regional 10-year, 24-hour rainfall, for New York City, this value is 5 inches

•Required storm water capacity before the redesign was 11823 gallons

•The new design calls for a 15000 gallon storm water tank

• Assuming that the current tank can handle the remaining 3000 gallons, the structural integrity of the dunnage platform will be checked to insure that it had handle the extra storm water load

Original Design of Second Level Green Roof	
Roof	
Green Roof Surface Area (sq ft)	4747
Rain Fall	
Regional 10 yr storm (inches of rainfall)	5
Growth Media	
Growth media depth (inches)	18
Dry Weight (pounds per cubic ft)	38
Saturated Weight (pounds per cubic ft)	62
Moisture Retention Fabric	
Moisture retention fabric dry weight/sq ft	0.11
Moisture retention fabric saturated weight/ sq ft	1.2
Drainage Core	
top diameter of cups (inches)	1.5
botttom diameter of cups (inches)	0.25
cup height	2
number of cups per sq ft	36
Water retained (gallons per sq ft)	4.67
Weight of retained water (lbs per square foot)	39.92
Total gallons retained	22151.44
Run off coefficient	-0.50
Storwater Tank Capacity required (gallons)	11075.72

Original Design of First Level Green Roof	
Roof	
Green Roof Surface Area (sq ft)	1222
Rain Fall	
Regional 10 yr storm (inches of rainfall)	5
Growth Media	
Growth media depth (inches)	8
Dry Weight (pounds per cubic ft)	38
Saturated Weight (pounds per cubic ft)	62
Moisture Retention Fabric	
Moisture retention fabric dry weight/sq ft	0.11
Moisture retention fabric saturated weight/ sq ft	1.2
Drainage Core	
top diameter of cups (inches)	1.5
botttom diameter of cups (inches)	0.25
cup height	2
number of cups per sq ft	36
Water retained (gallons per sq ft)	2.27
Weight of retained water (lbs per square foot)	18.92
Total gallons retained	2771.90
Run off coefficient	0.27
Storwater Tank Capacity required (gallons)	748.41

Redesign of Second Level Green Roof	
Roof	
Green Roof Surface Area (sq ft)	5100
Rain Fall	
Regional 10 yr storm (inches of rainfall)	5
Growth Media	
Growth media depth (inches)	18
Dry Weight (pounds per cubic ft)	38
Saturated Weight (pounds per cubic ft)	62
Moisture Retention Fabric	
Moisture retention fabric dry weight/sq ft	0.11
Moisture retention fabric saturated weight/ sq ft	1.2
Drainage Core	
top diameter of cups (inches)	1.5
botttom diameter of cups (inches)	0.25
cup height	2
number of cups per sq ft	36
Water retained (gallons per sq ft)	4.67
Weight of retained water (lbs per square foot)	39.92
Total gallons retained	23798.68
Run off coefficient	-0.50
Storwater Tank Capacity required (gallons)	11899.34

Redesign of Fifth Level Roof - Extensive green roof	
Roof	
Green Roof Surface Area (sq ft)	3833
Rain Fall	
Regional 10 yr storm (inches of rainfall)	5
Growth Media	
Growth media depth (inches)	3.5
Dry Weight (pounds per cubic ft)	18
Saturated Weight (pounds per cubic ft)	34
Moisture Retention Fabric	
Moisture retention fabric dry weight/sq ft	0.11
Moisture retention fabric saturated weight/ sq ft	1.2
Drainage Core	
top diameter of cups (inches)	0.5
botttom diameter of cups (inches)	0.25
cup height	59/100
number of cups per sq ft	100
Water retained (gallons per sq ft)	0.72
Weight of retained water (lbs per square foot)	6.00
Total gallons retained	2757.78
Run off coefficient	0.77
Storwater Tank Capacity required (gallons)	2123.49

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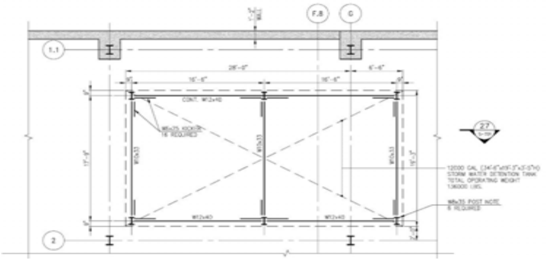
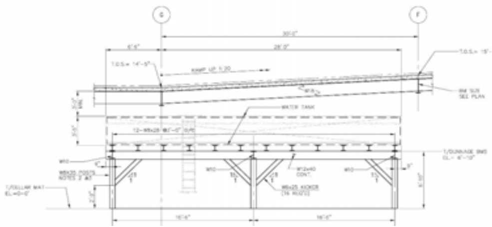
GREEN ROOF

STORMWATER DETENTION TANK CAPACITY

		12000 Gallon Tank	15000 Gallon Tank
Member Size	ΦMn (ft-k)	Mu (ft-k)	Mu (ft-k)
W8x28	69	34.4	41.2
W12x40	160.5	75	88.2
W10x33	101	75	88
W8x35	130	75	88.2
Member Size	ΦPn (k)	Pu (k)	Pu (k)
W8x35	429.5	46	53.6





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COST ANALYSIS

ENERGY SAVINGS

		Energy Savings Compared to a Conventional Roof			
		Electrical Savings	Gas Savings	Total Energy Cost Savings/roof	Total Energy Cost Savings/bldg
Original Design	First Floor	167.02 kWh /yr	31.21 Therms/yr	$79.99/yr	**256.96/yr**
	Second Floor	375.79 kWh/yr	70.22 Therms/yr	$179.97/yr	
	Fifth Floor	0	0	0	
New Design	First Floor	167.02 kWh /yr	31.21 Therms/yr	$79.99/yr	**429.94/yr**
	Second Floor	417.54kWh/yr	78.02 Therms /yr	$199.97/yr	
	Fifth Floor	313.16 kWh/yr	58.52 Therms/yr	$149.98/yr	

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COST ANALYSIS

COST

Lateral System: $222,800 vs. $299,900

Ting Wall: : $2,771,500 vs. $3,227,100

Green Roof: $119,100 vs. $119,400

New Design				
w14x	quantity	total length	$/ft	total cost
53	1	14	$61.48	$860.72
68	1	26	$78.88	$2,050.88
74	1	14	$87.37	$1,223.18
90	1	26	$104.40	$2,714.40
99	1	26	$114.84	$2,985.84
120	1	14	$138.96	$1,945.44
145	2	62	$168.20	$10,428.40
193	5	148	$223.88	$33,134.24
233	1	33	$274.94	$9,073.02
398	1	33	$469.64	$15,498.12
HSS				
5x5x3/8	11	1146.2	$65.10	$74,617.62
5.5x5.5x3/8	3	402.8	$72.55	$29,223.14
6x6x3/8	2	274	$79.97	$21,911.78
8x8x3/8	2	189.6	$90.60	$17,177.76
			total:	$222,844.54

Original Design				
w14x	quantity	total length	$/ft	total cost
68	1	14	$78.88	$1,104.32
90	1	14	$104.40	$1,461.60
176	1	14	$202.18	$2,830.52
233	4	111	$274.94	$30,518.34
283	3	85	$328.28	$27,903.80
311	4	99	$360.76	$35,715.24
331	1	28	$410.00	$11,480.00
342	1	33	$429.20	$14,163.60
398	1	33	$469.64	$15,498.12
455	1	33	$536.90	$17,717.70
550	1	31	$638.00	$19,778.00
730	1	33	$846.80	$27,944.40
mom connections			$620/conn	$22,320.00
HSS				
5x5x3/8	11	573.1	$65.10	$37,308.81
5.5x5.5x3/8	3	201.4	$72.55	$14,611.57
6x6x3/8	2	137	$79.97	$10,955.89
8x8x3/8	2	94.8	$90.60	$8,588.88
			total:	$299,900.79

COST AND SCHEDULE SUMMARY

Green roof savings = $300

Lateral System Savings = $77, 100

Ting Wall Savings = $455, 600

Total Building Savings = $533,000

	New Gravity Frame Design	Original Gravity Frame Design
Adjusted for Location	$ 2, 309, 608	$ 2, 689, 200
Design Contingency (1.5%)	$ 34, 600	$ 40, 300
Escalation Contingency (3.5%)	$ 80, 800	$, 94, 100
Insurance (3%)	$ 69, 300	$ 80, 700
Bonds (10%)	$ 46, 200	$ 53, 800
Overhead and Profit (10%)	$ 221, 000	$ 268, 921
Total Structural Steel Cost	$ 2, 771, 500	$ 3, 227, 100

	Green Roof (New Design)	Green Roof + IRMA Roof (Original)
Material Cost	$164,770	$119,380
Tax Deduction	$4.50/sq ft = $ 45,698.	n/a (50% or more of roof needs to be green)
Total Cost	$119, 072	$119, 380

PRESENTATION OUTLINE

CONCLUSIONS

- Changes done to the gravity and lateral system, the green roofs, and the façade seem to have paid off with a savings of $533,000
- The green roof system payback period is in the order of a few hundred years
- Avoid moment frames whenever possible, using them only if necessary by the architect's design
- For moment frames it is better to go with heavier members to reduce to detailing of connections
- Columns were optimized for the gravity load, it is better to instead size the columns at 75% capacity as opposed to near 100%
- By designing at 75% capacity, the need for doubler plates is minimized

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CONCLUSIONS, ACKNOWLEDGEMENTS, + QUESTIONS

PROJECT TEAM

Owner	City University of New York
CM	Turner Construction Company
Architects	Cooper, Robertson & Partners SLCE Architects
Structural	Ysrael A. Seinuk, P.C.
MEP	WSP Flack + Kurtz
Lighting	SBLD Studio

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ACKNOWLEDGEMENTS

AE Faculty

Matthew Niskanen

Professor Ali Memari

Professor Robert Holland

Turner Construction Company

Professor M. Kevin Parfitt

AE Colleagues

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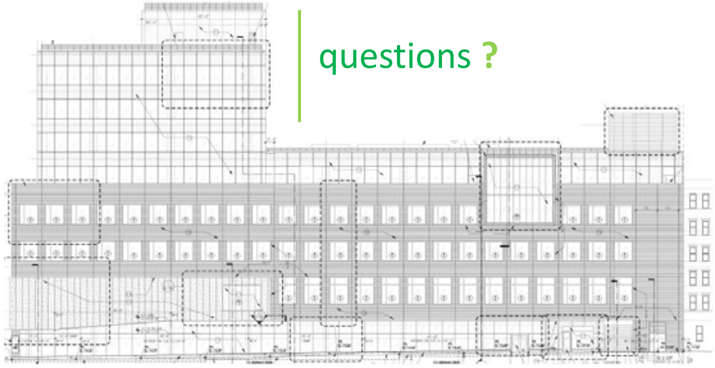

questions ?