Introduction

Andy Penev
Construction Management

CityCenterDC | Parcel 1
Washington, D.C.

Project Overview

Andy Penev
Construction Management

Size: 257,500 SF
Location: Washington, D.C.
Project Cost: $48 million
Contract Type: (4) GMP
Delivery Method: Design-Bid-Build
Schedule: 4/11 – 1/14

CityCenterDC
A Development by Hines | Archstone | The First Investor

Developer: Hines | Archstone

General Contractor: Clark/Smoot (JV)

Arch. of Record: Shalom Baranes Associates

Design Architect: Foster + Partners

Hines
ARCHSTONE
CLARK CONSTRUCTION
SMOOT CONSTRUCTION
shalom baranes associates
Foster + Partners

Project Overview

Analysis #1: SIPS
- Background Information
- New Phasing & SIPS
- Impact

Analysis #2: Electrical Redesign
- Background Information
- Redesign
- Impact

Analysis #3: Footbridge Installation
- Background Information
- Research
- Application
- Results

Final Recommendations

Acknowledgements

Analysis #1: SIPS

- Create a new phasing and sequencing plan for typical floor and implement through a Short Interval Production Schedule.

Analysis #2: Construction Analysis of Electrical Redesign

- Propose an alternative electrical distribution system design and analyze its construction impacts.

Analysis #3: Alternative Footbridge Installation

- Provide an alternative footbridge installation method to reduce cost and constructability issues.

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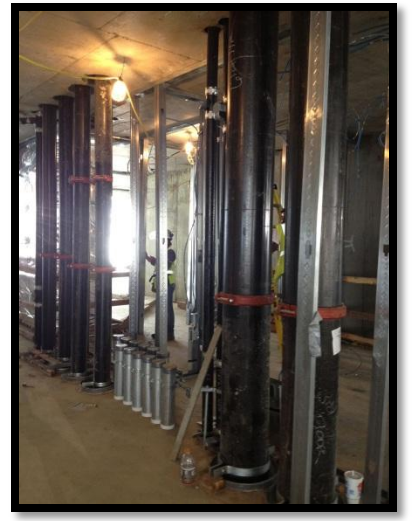
Analysis #1

Short Interval Production Schedule (SIPS)

Background Information

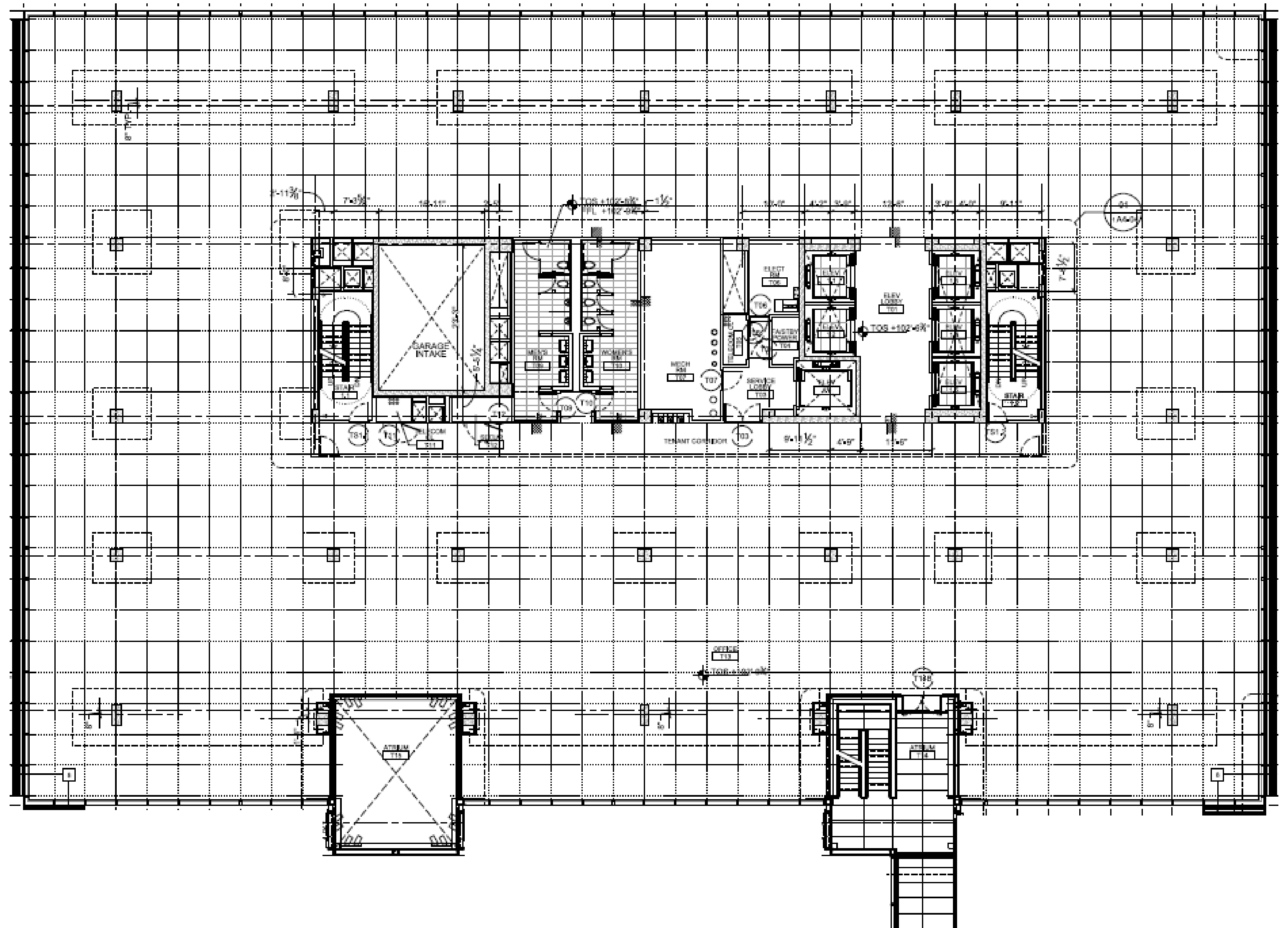
Framing & Plumbing Rough In



Risers

Mechanical Duct

AHU



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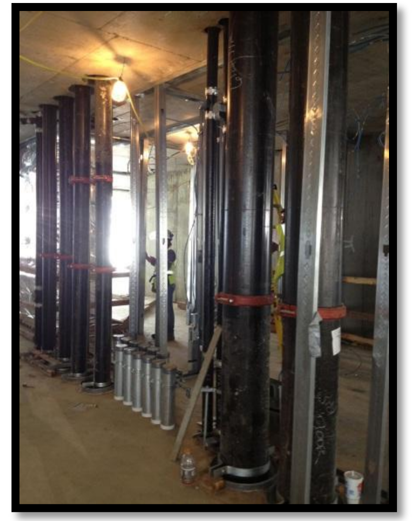

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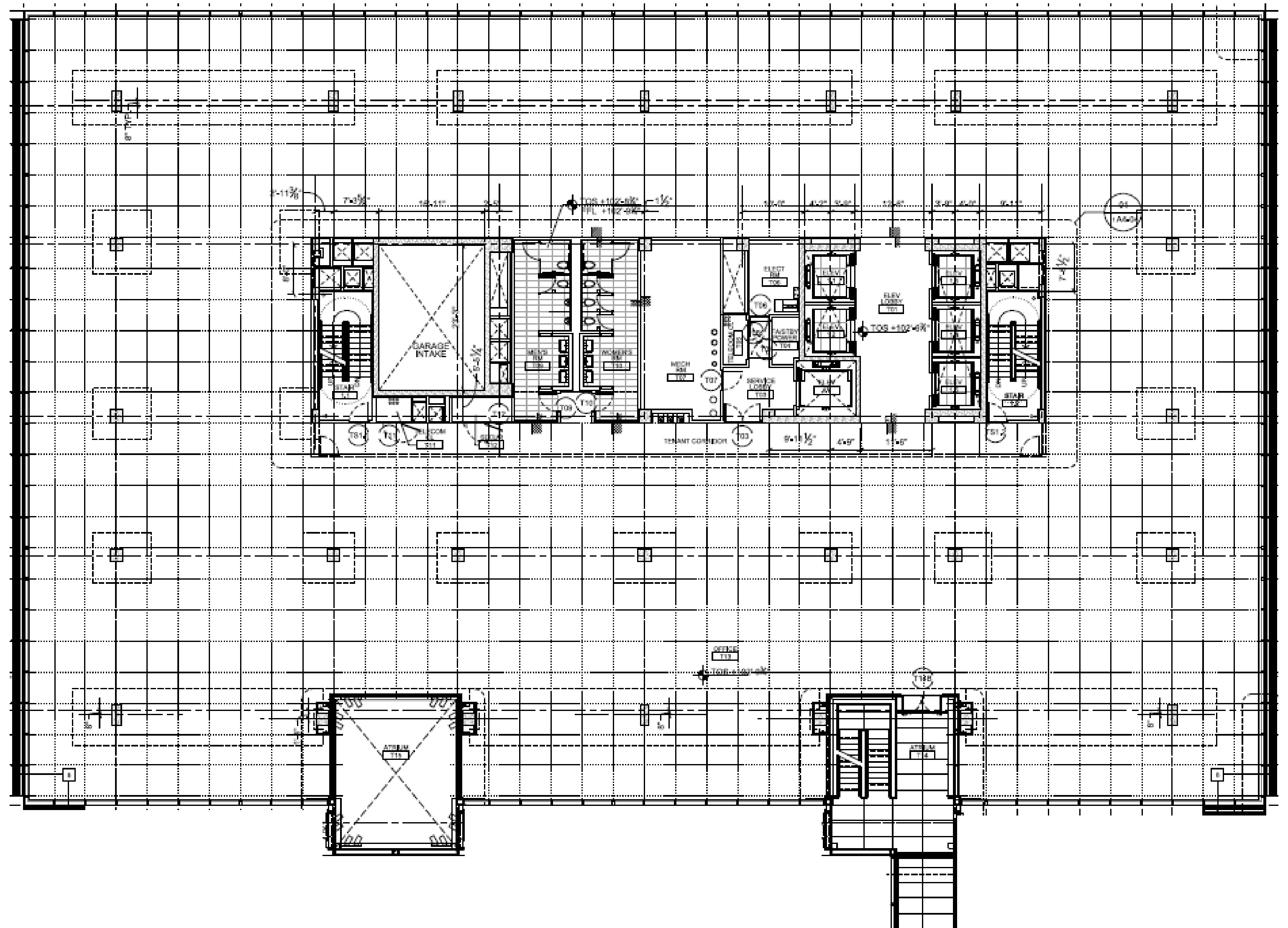
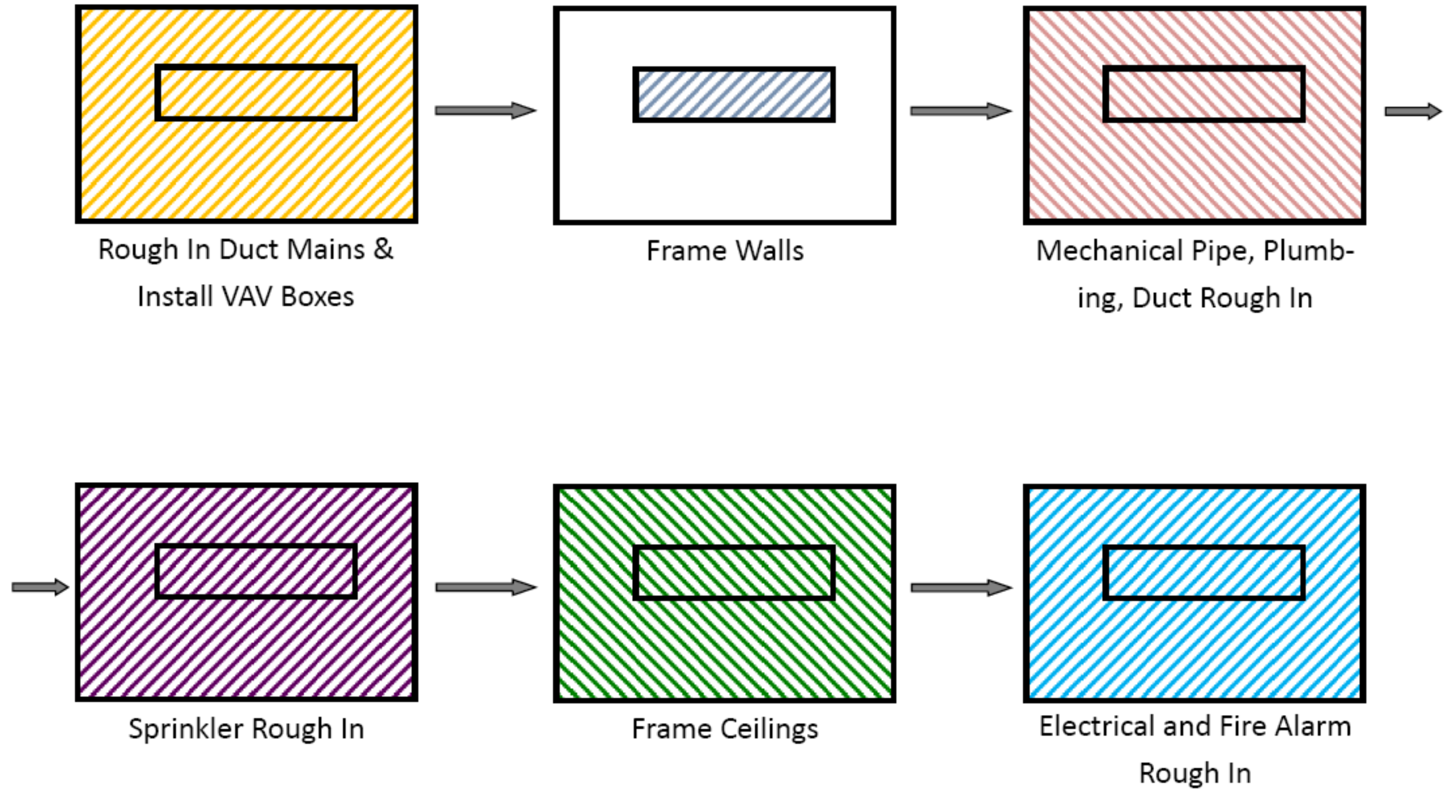
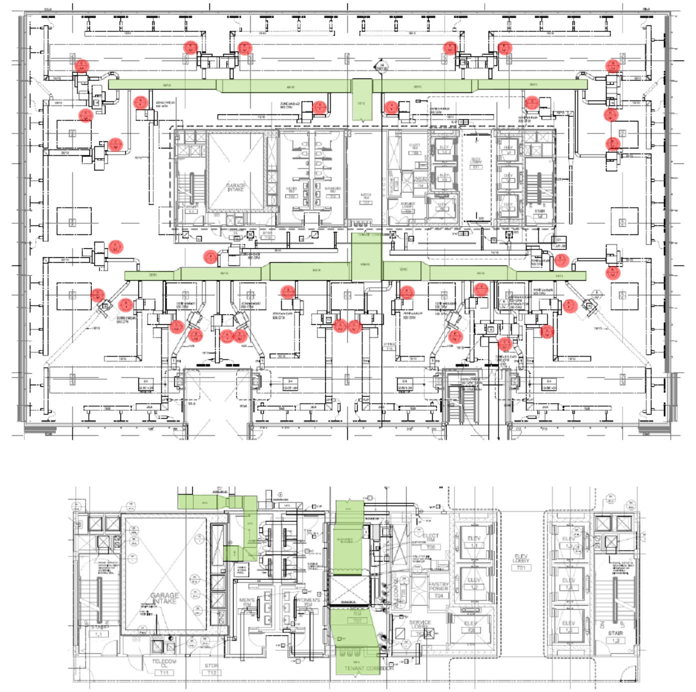
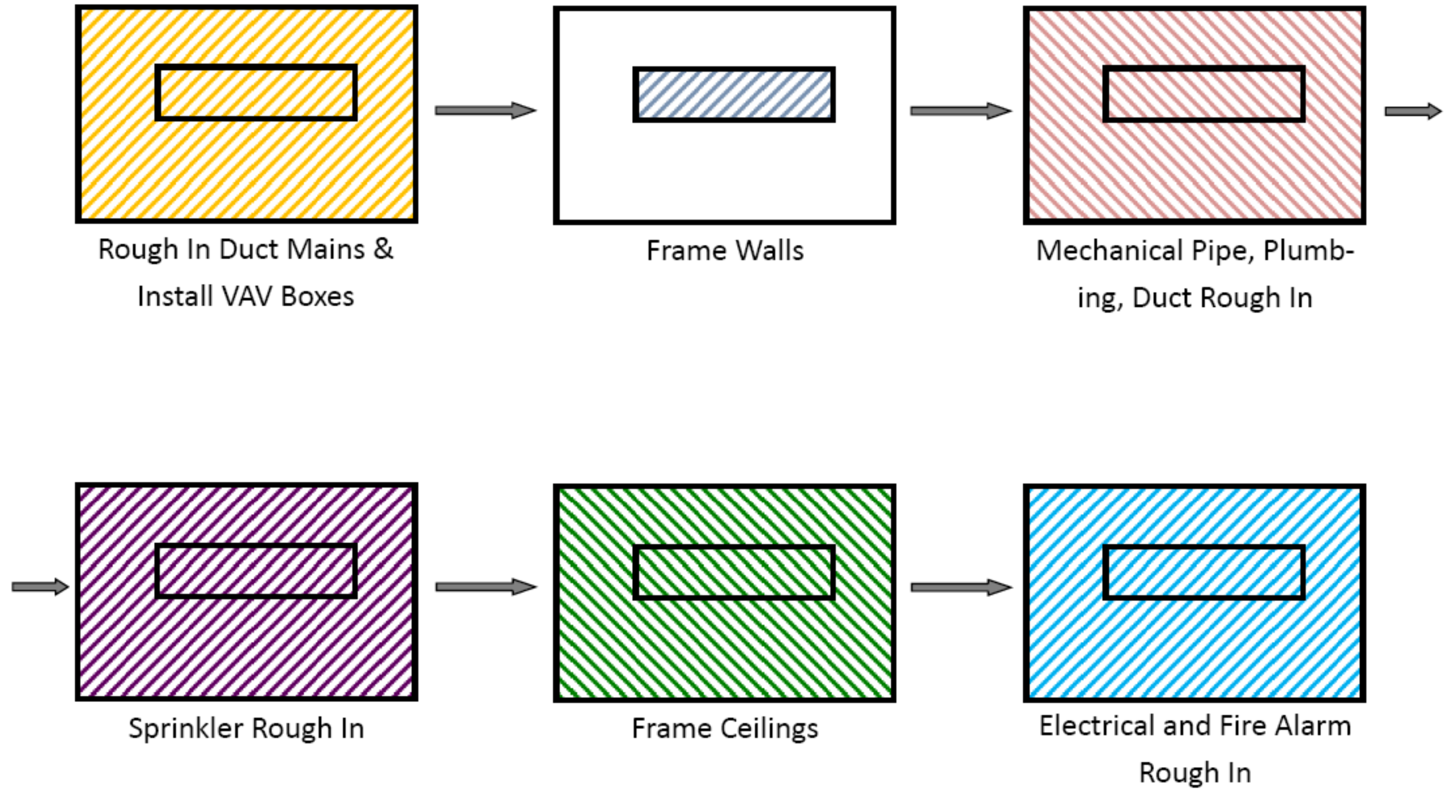




New Phasing



- Identify Duct Mains
- Identify VAV Boxes



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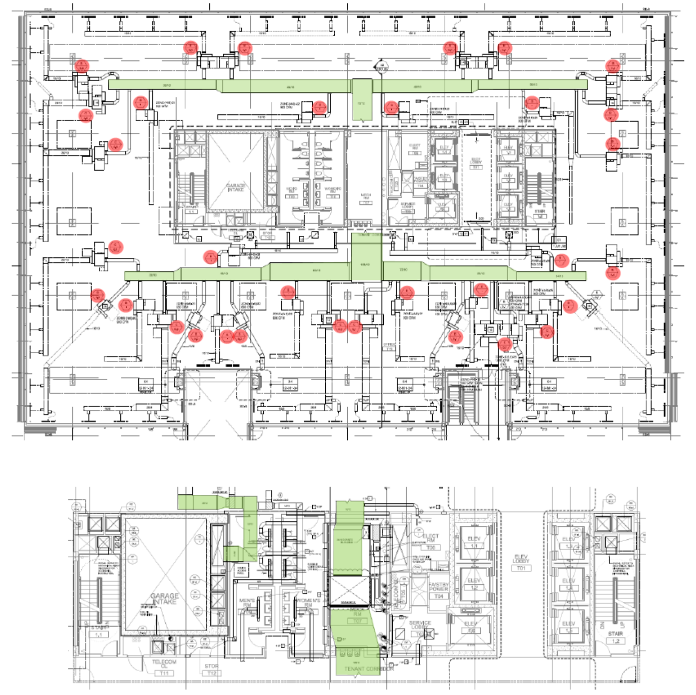

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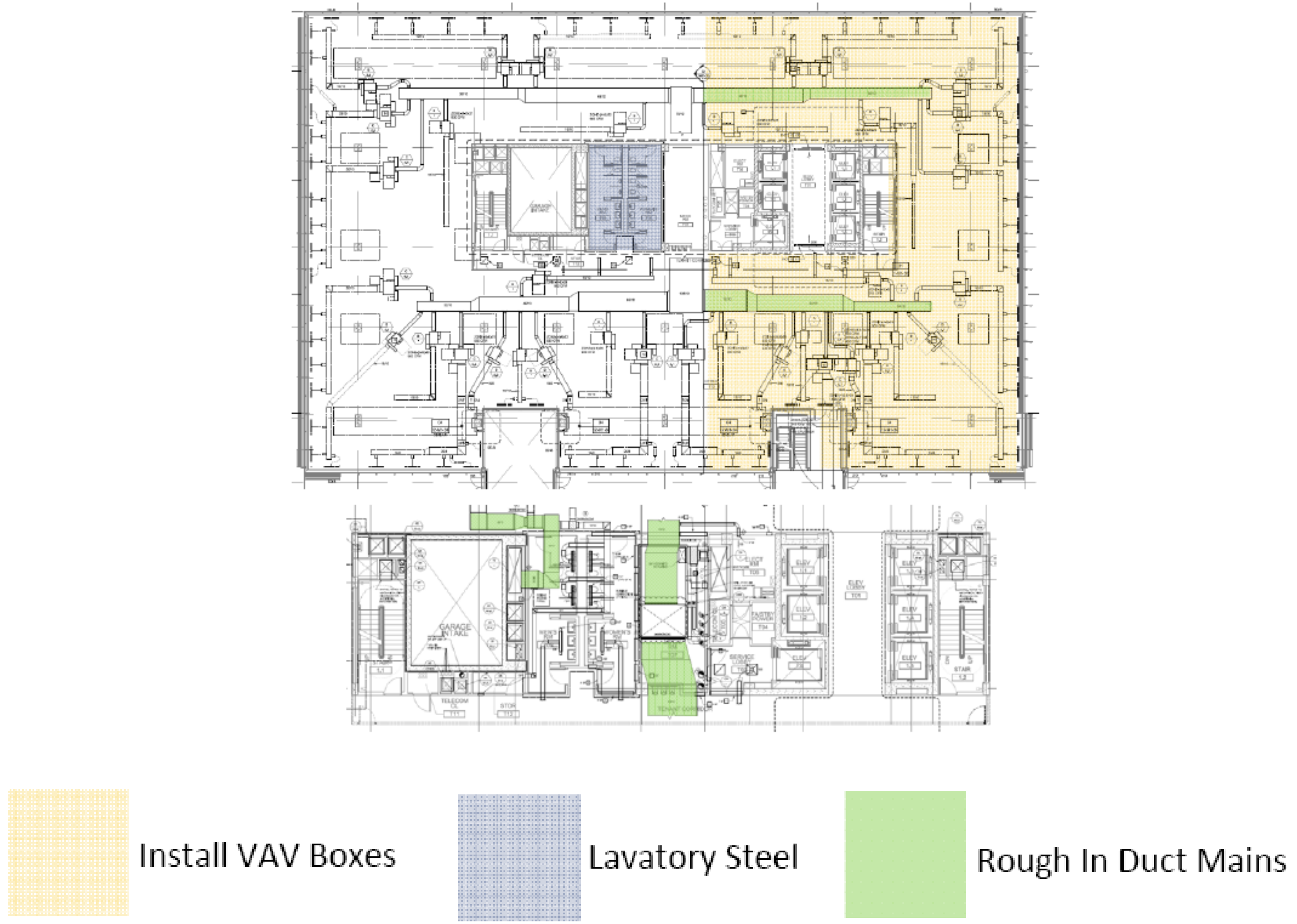
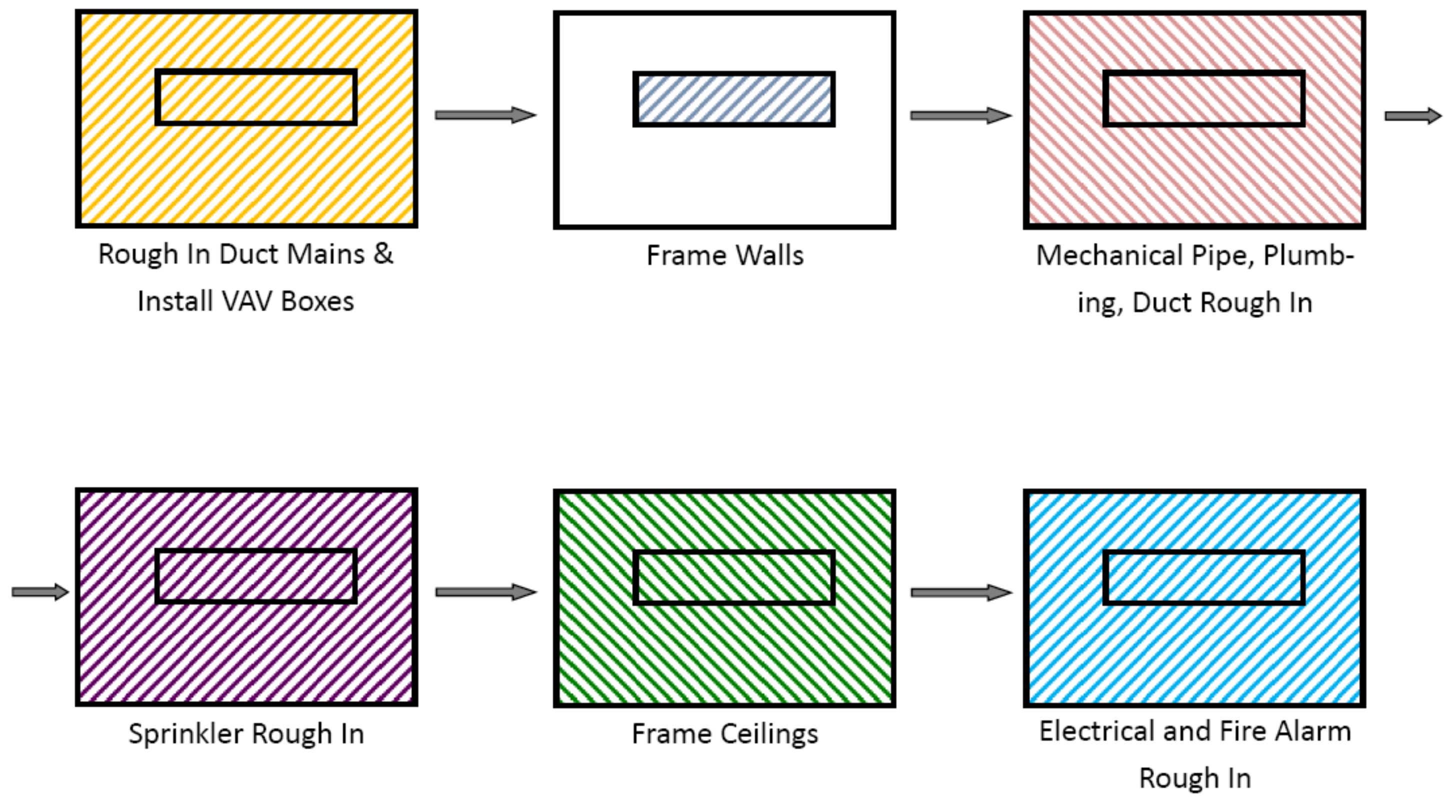
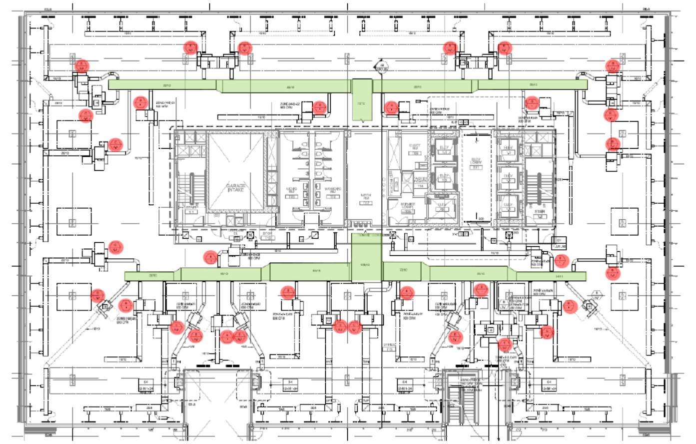
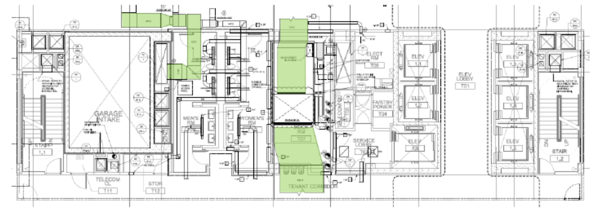




Analysis #1: SIPS

New Phasing





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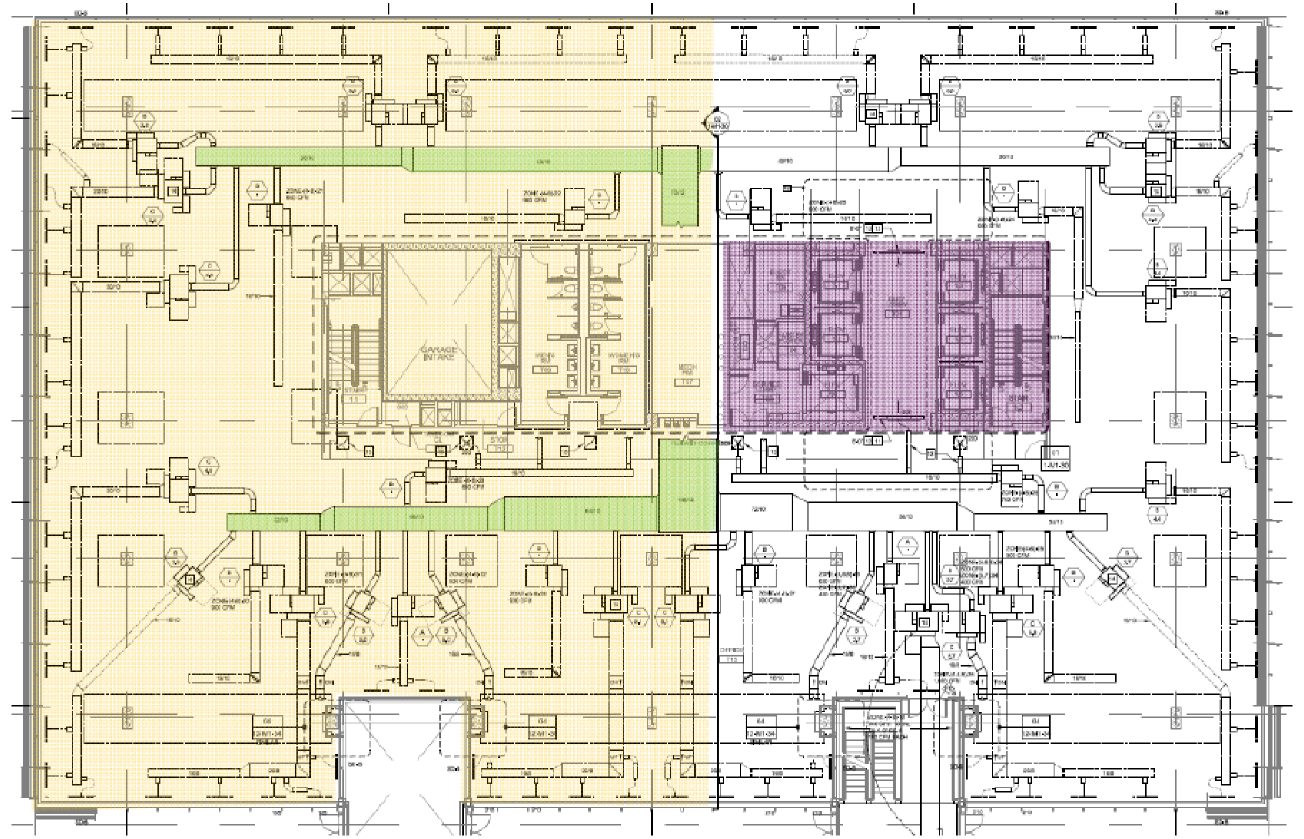
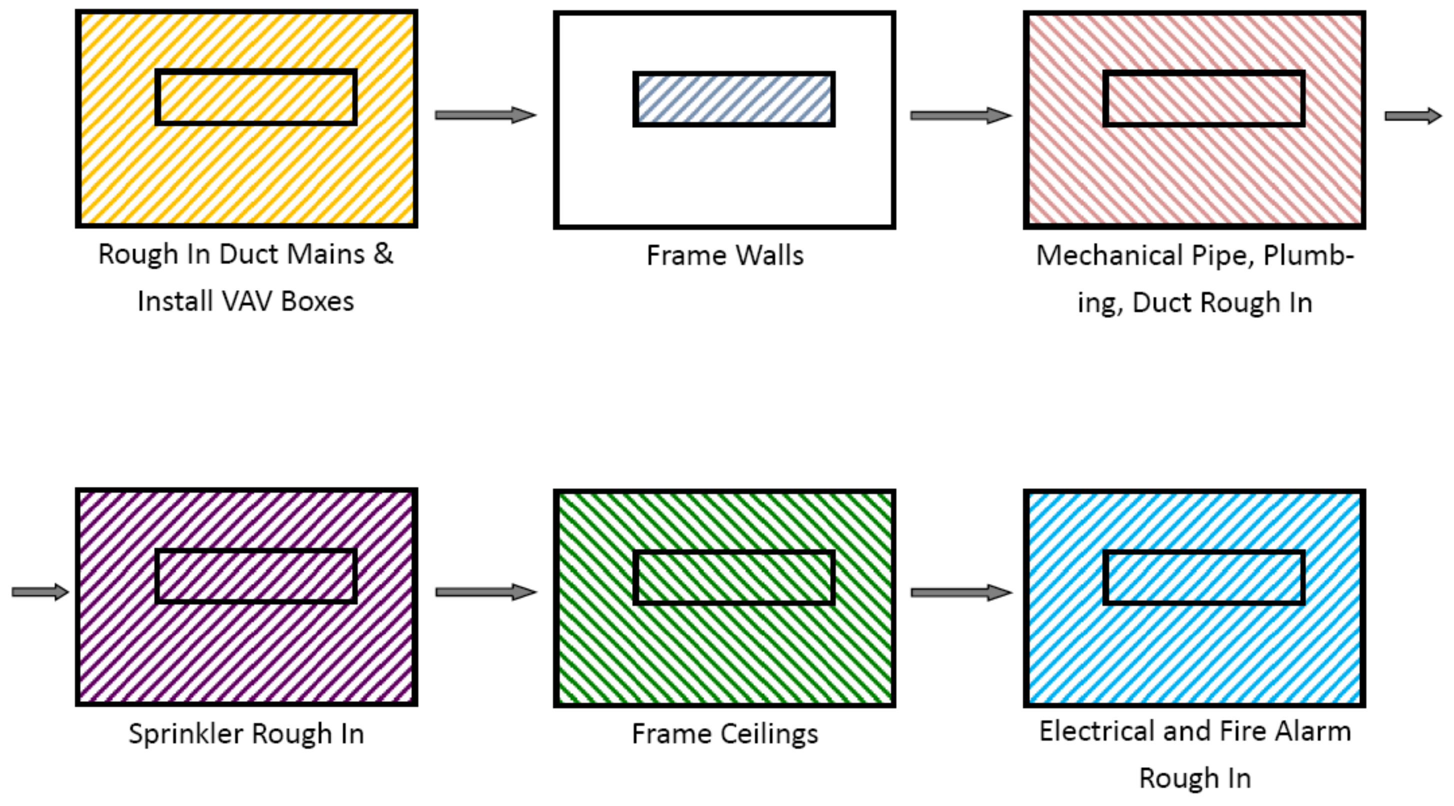


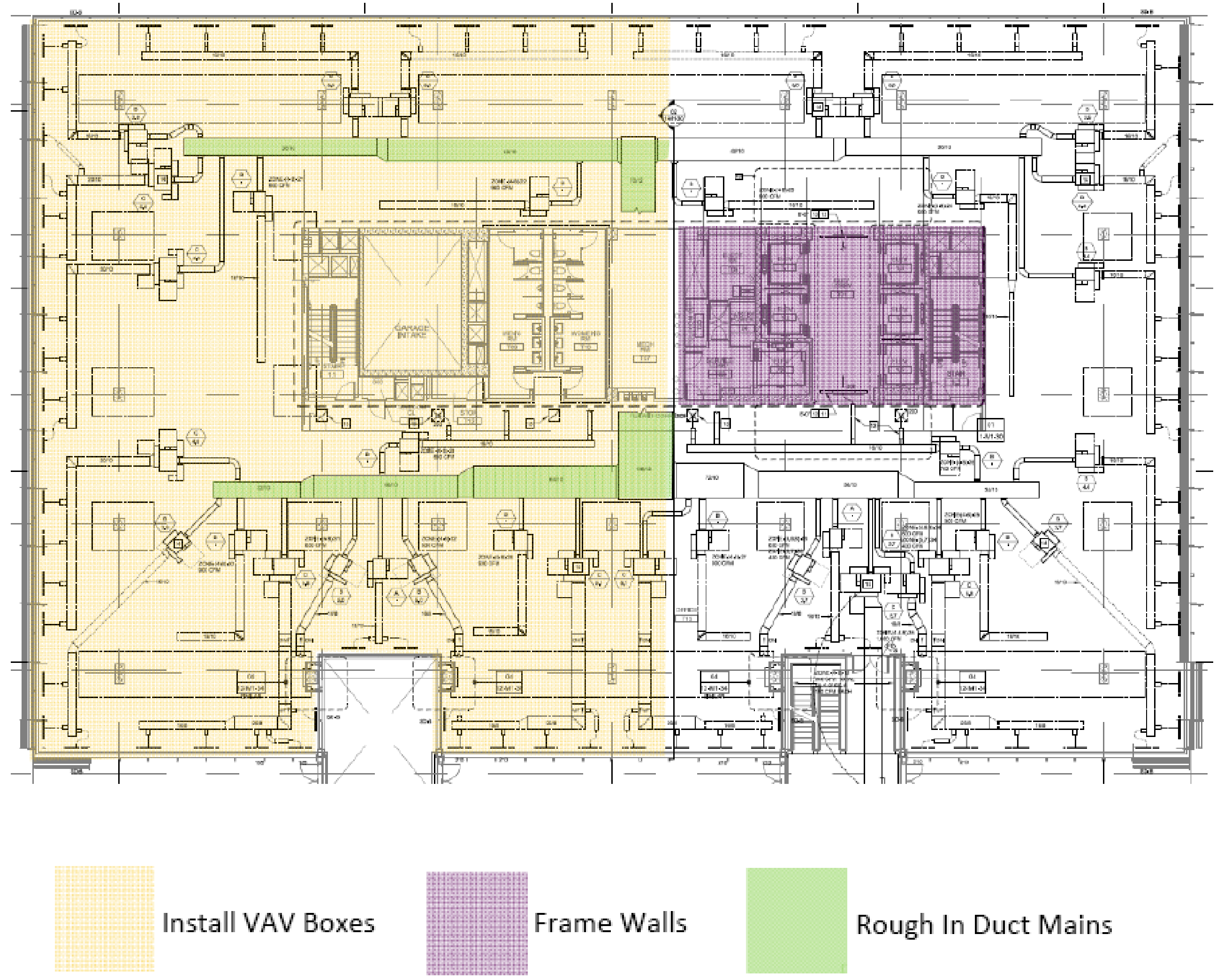
Install VAV Boxes — Frame Walls — Rough In Duct Mains

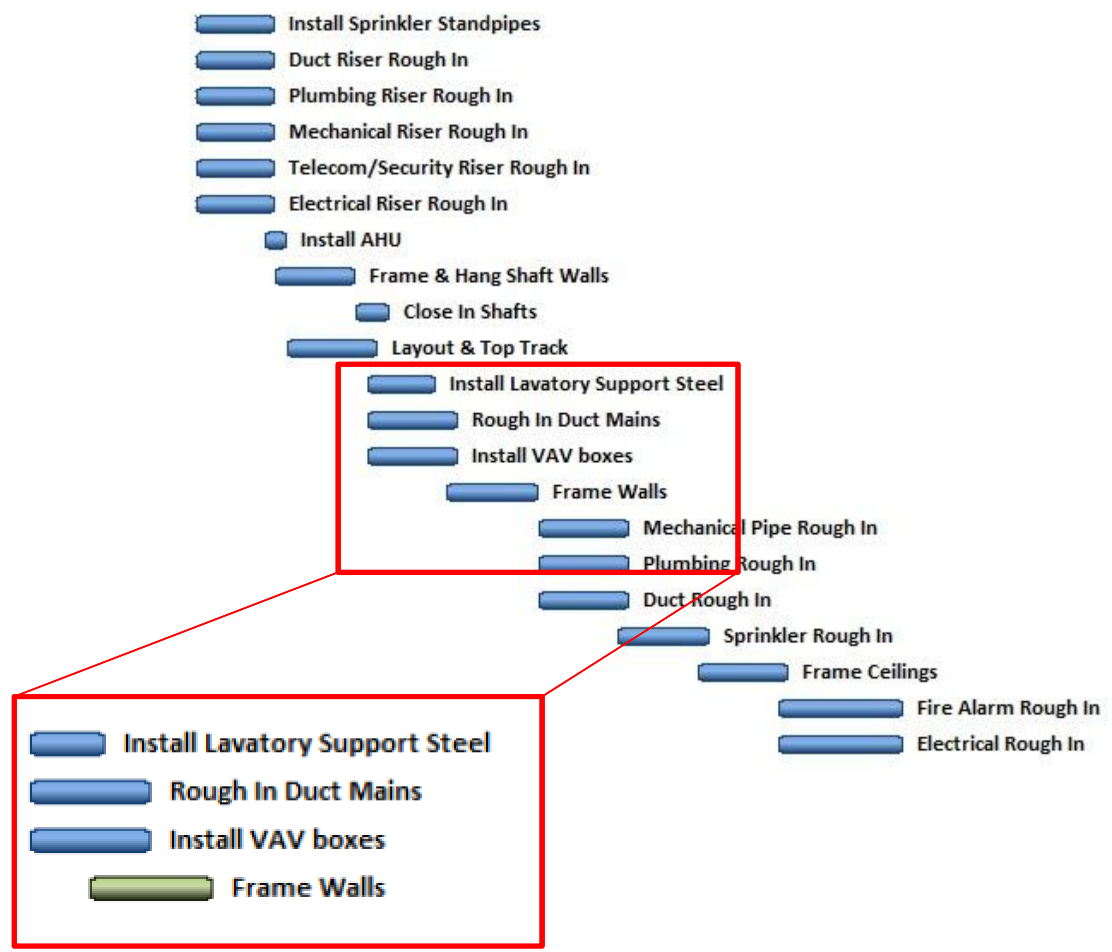


New Phasing

- Create zones on each floor
- Crew stays in zone for given amount of time
- Creates efficient use of space
- Entire floor space is used

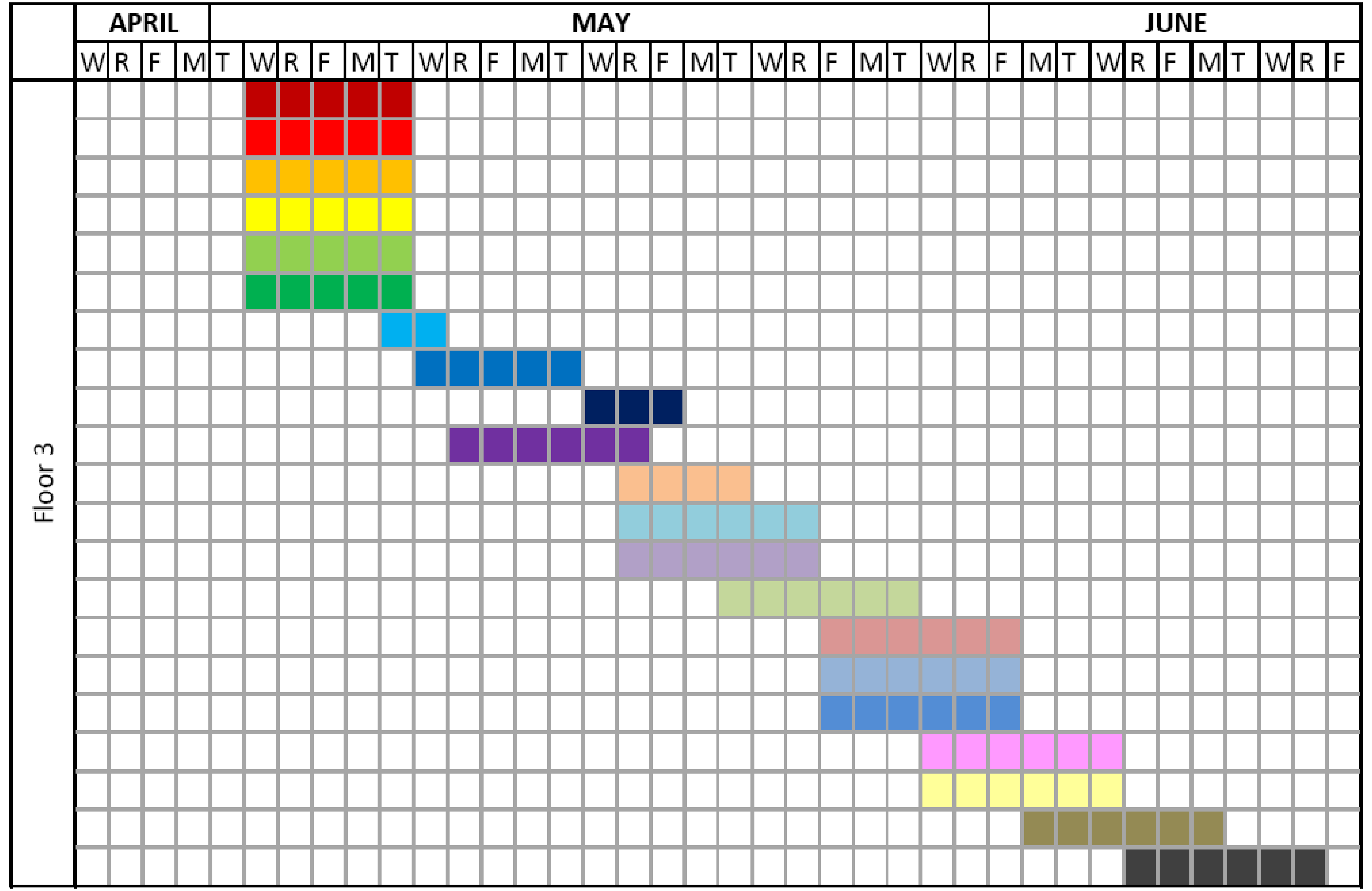
Important:
- Clean up
- Timely completion
- Material management





SIPS

Activity	Color	Activity	Color
Install Sprinkler Standpipes		Rough In Duct Mains	
Duct Riser Rough In		Install VAV boxes	
Plumbing Riser Rough In		Frame Walls	
Mechanical Riser Rough In		Mechanical Pipe Rough In	
Telecom/Security Riser Rough In		Plumbing Rough In	
Electrical Riser Rough In		Duct Rough In	
Install AHU		Sprinkler Rough In	
Frame & Hang Shaft Walls		Frame Ceilings	
Close In Shafts		Fire Alarm Rough In	
Layout & Top Track		Electrical Rough In	
Install Lavatory Support Steel			

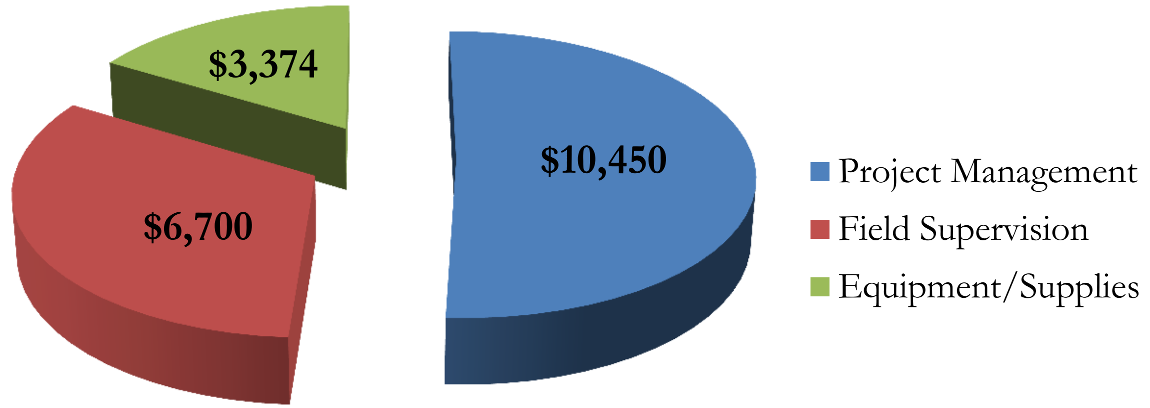


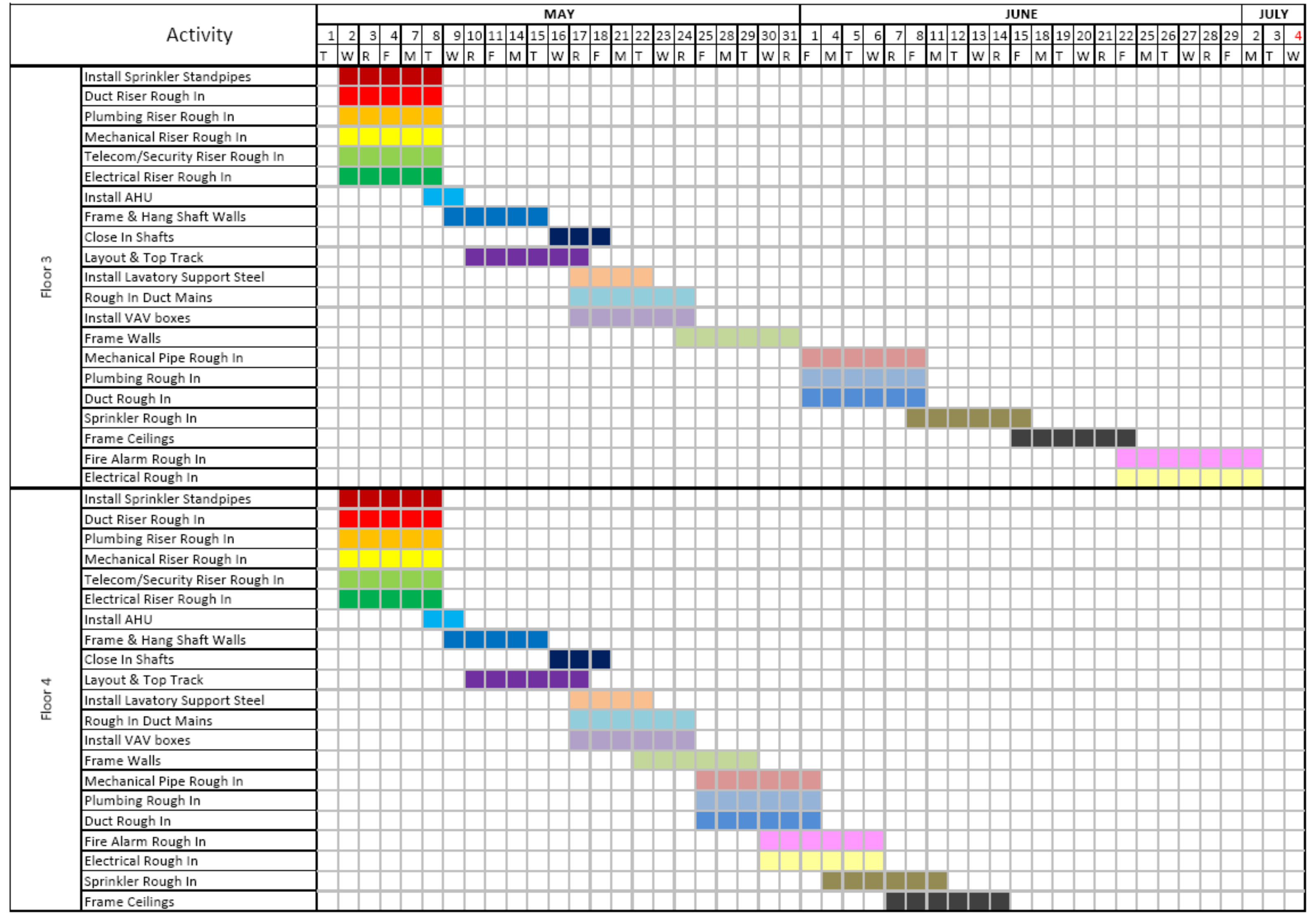
Short Interval Production Schedule

- Same crew
- Same duration
- Reorganization
- Overlapping activities
- Float on second half of activities

Cost

- General Conditions
- Total Savings = $20,524





Schedule

- Decreased by 13 days

Constructability

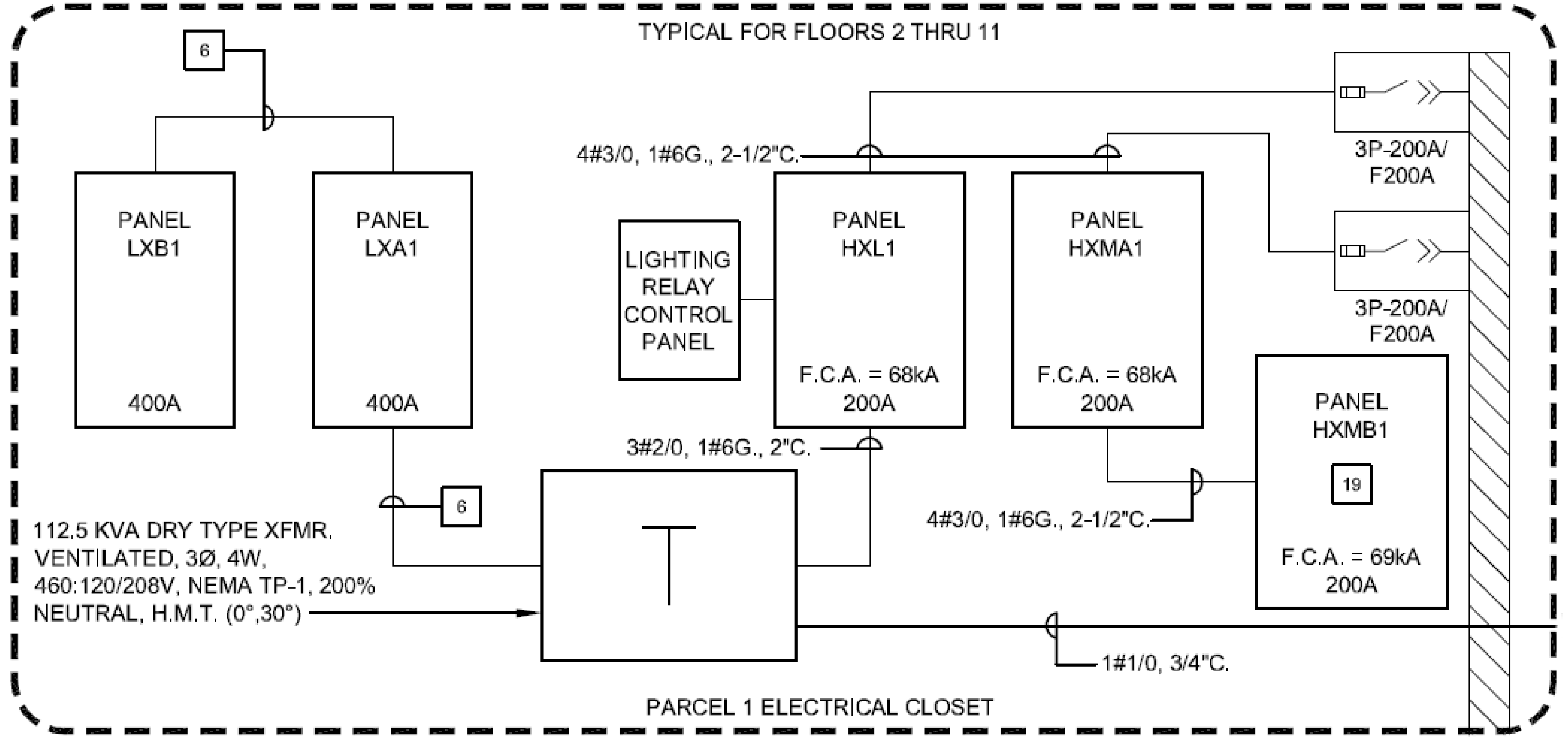
- Organization
- Collaboration
  - Delays
- Material Management
  - Deliveries

Analysis #2

Construction Analysis of Electrical Redesign

Background Information

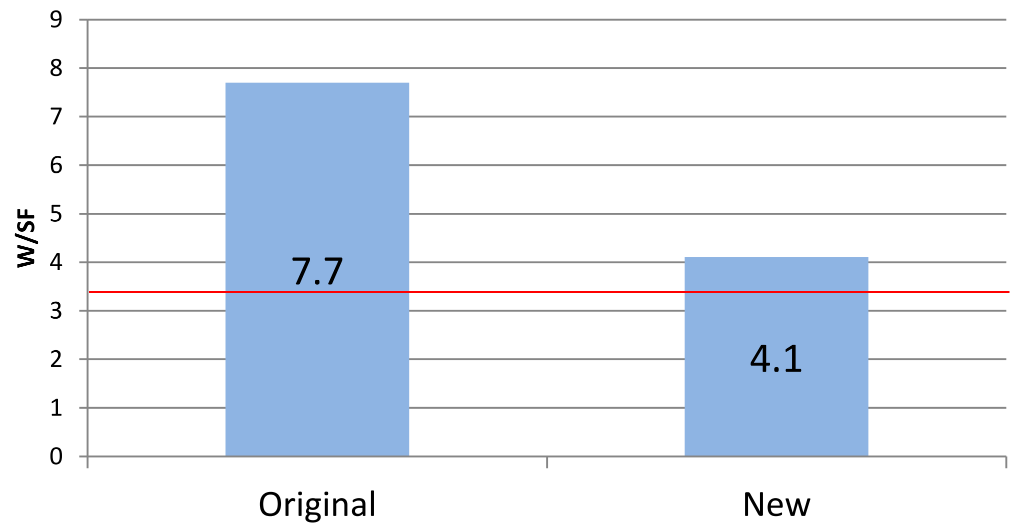
- 2 Switchboards (4000A & 3000A)
- Total kVA = 5,248
  - 20.4 W/SF
- Separate retail feed
- Lighting + Receptacle load = 2,092 kVA
  - 7.7 W/SF
- 4000A SWBD busway to electrical closets
  - Took most of lighting and receptacle loads (1,902 kVA)



SWITCHBOARD MS12A LOADS:	
RECEPTACLES & FUTURE RECEPTACLES	1,570 KVA
LIGHTING & FUTURE LIGHTING	332 KVA
ELEVATORS	0 KVA
MISCELLANEOUS	11 KVA
* AIR CONDITIONING	0 KVA
FPTD MOTORS	345 KVA
DOMESTIC WATER HEATING	24 KVA
* ELECTRIC HEAT	891 KVA
TOTAL	3,173 KVA
* NONCOINCIDENT LOADS	(3,982A @ 460V, 3Ø)

SWITCHBOARD MS12C LOADS:	
RECEPTACLES & FUTURE RECEPTACLES	70 KVA
LIGHTING & FUTURE LIGHTING	120 KVA
ELEVATORS	397 KVA
MISCELLANEOUS	178 KVA
* AIR CONDITIONING	660 KVA
FPTD MOTORS	25 KVA
WATER CHILLING UNITS	465 KVA
DOMESTIC WATER HEATING	14 KVA
* ELECTRIC HEAT	0 KVA
FIRE PUMP	146 KVA
TOTAL	2,075 KVA
* NONCOINCIDENT LOADS	(2,604A @ 460V, 3Ø)

Redesign



- ASHRAE Maximum Lighting Power Density = 0.9 W/SF
- Receptacle Load = 2.4 W/SF

Total= 3.3 W/SF

	kVA Load	FLA	Voltage	Phase	SWBD Size
Initial SWBD	3173	3982	480	3	4000A
Revised SWBD	2373	2978	480	3	3000A

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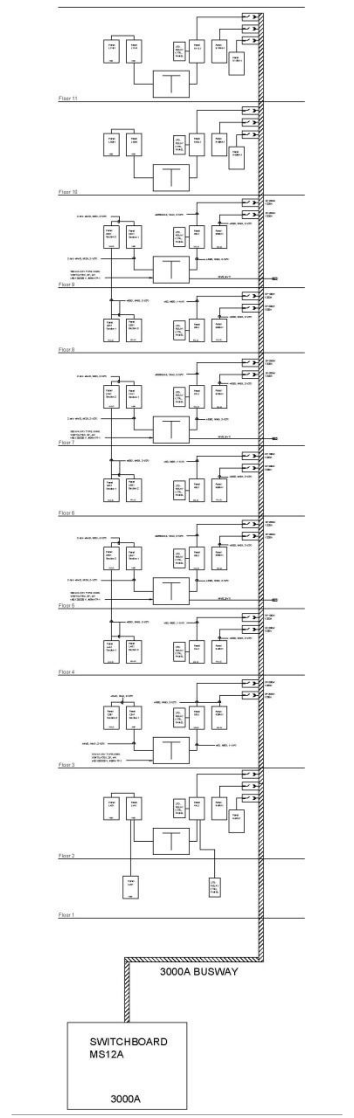
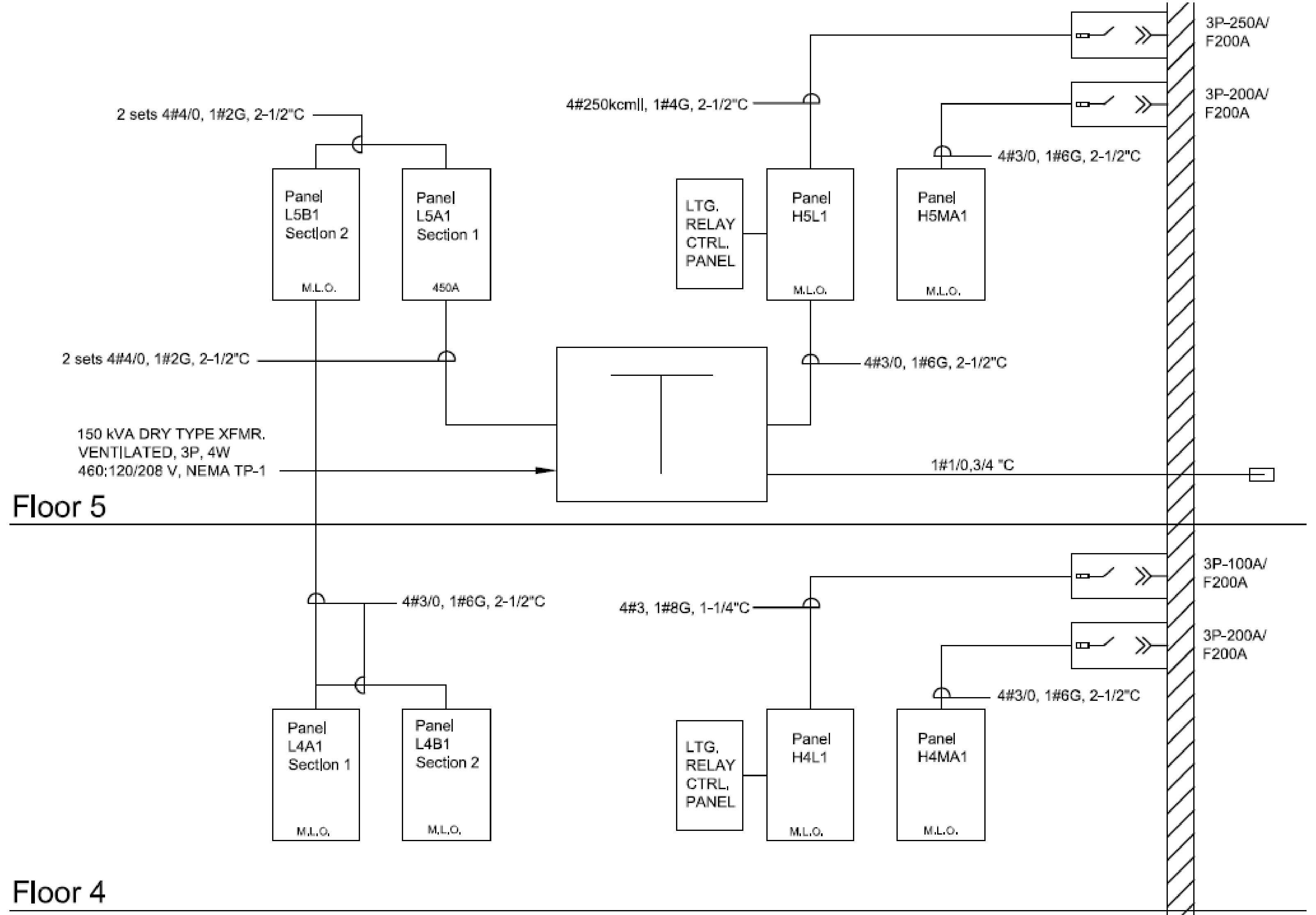
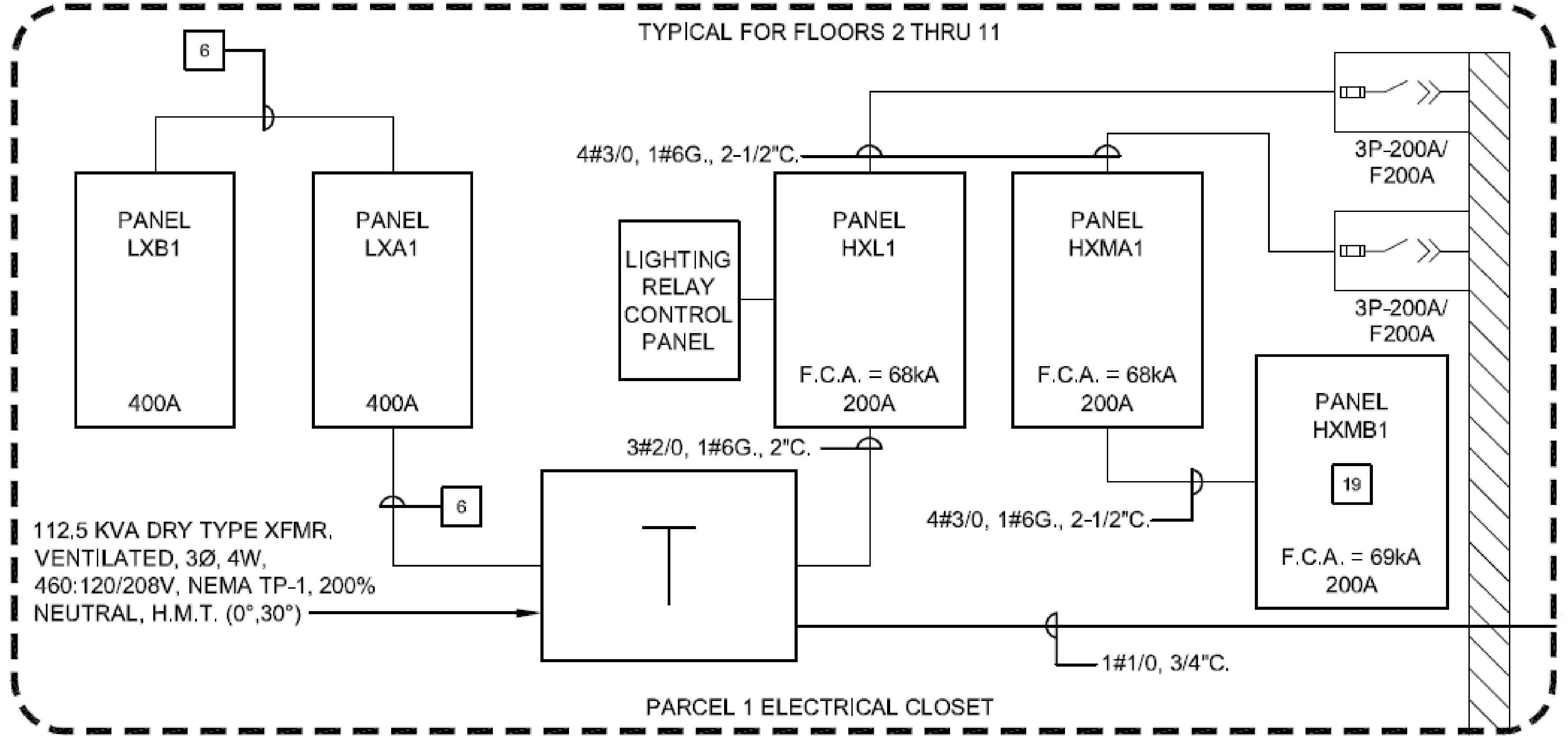
Redesign

- Eliminate XFMR on floors 4,6, & 8
  - Feed low voltage panels from floor above
- Floors 5,7, & 9 XFMR step up to 150kVa
- Feeders, plugs, breakers
- Coordination of cores
  - Fireproofing







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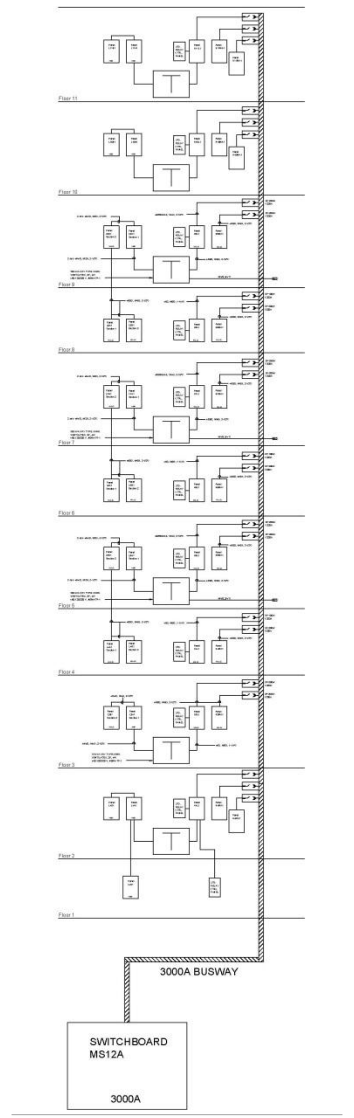
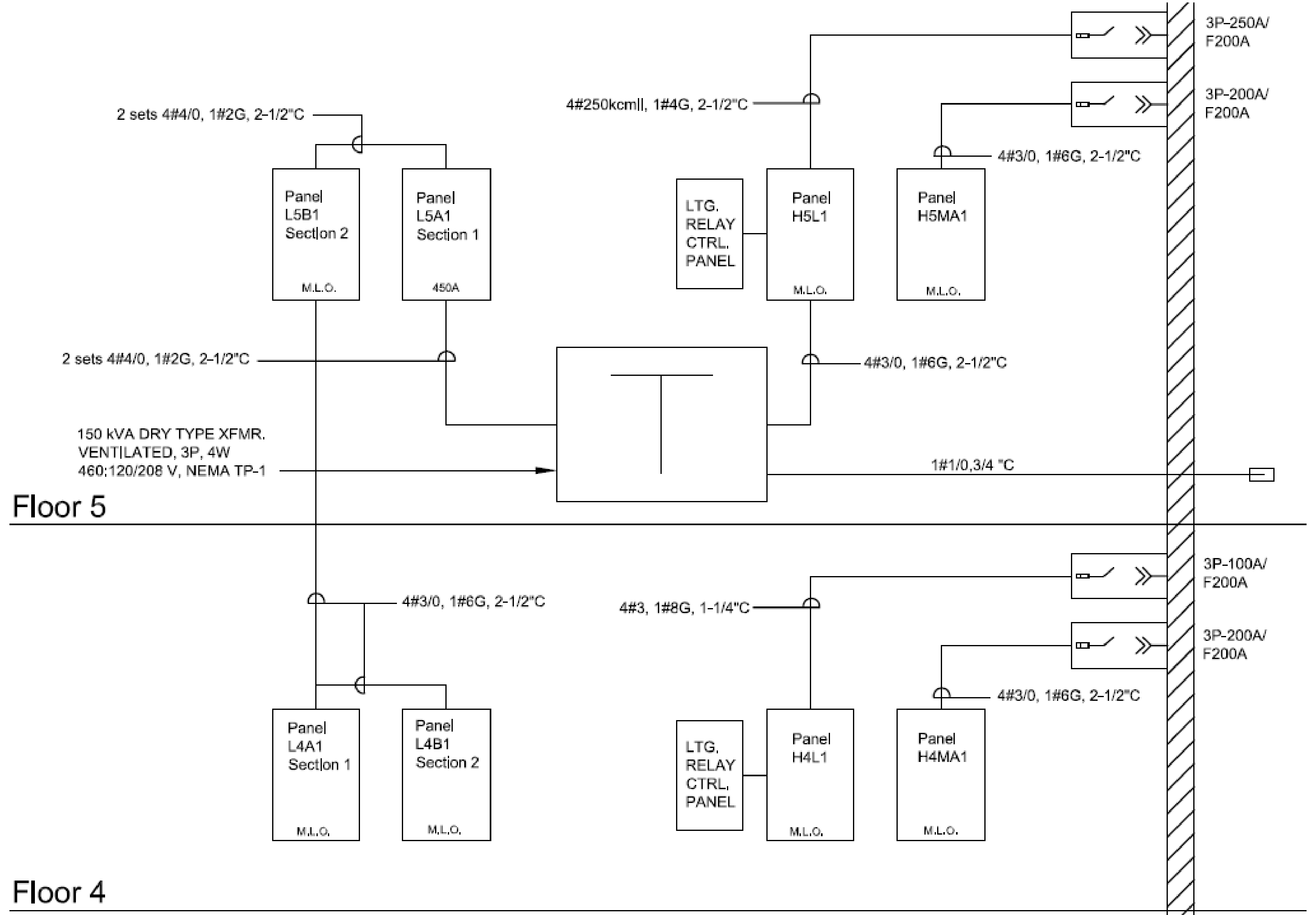
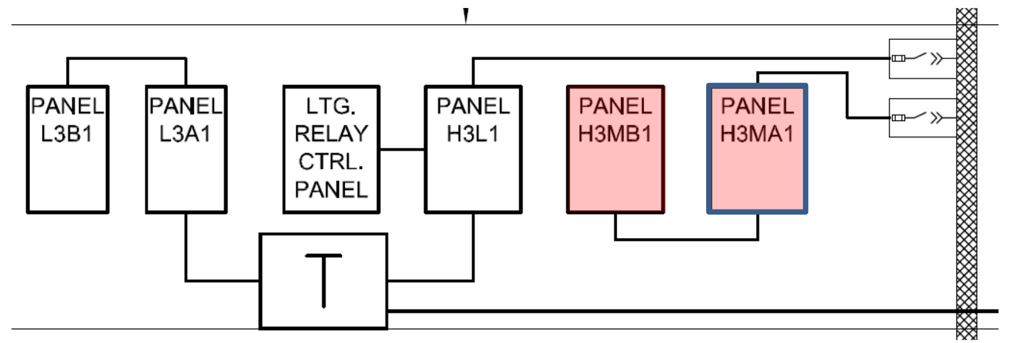




- Consolidation of HVAC panels



- Smaller XFMR from reduced loads on 3rd floor
  - Feeders

Results

Schedule

ELECTRICAL RISER ROUGH IN	Hours per Floor	Crew Size
Original Design (5 day duration)	76	2
Redesign Floor w/ XFMR	79.75	2
Redesign Floor w/o XFMR	31.42	1*

ELECTRICAL ROUGH IN	Hours per Floor	Crew Size
Original Design	149	4
Redesign Floor w/ XFMR	142.33	4
Redesign Floor w/o XFMR	148.33	4

Total labor hours saved: **182**

- Dependency
- Resource allocation

Results

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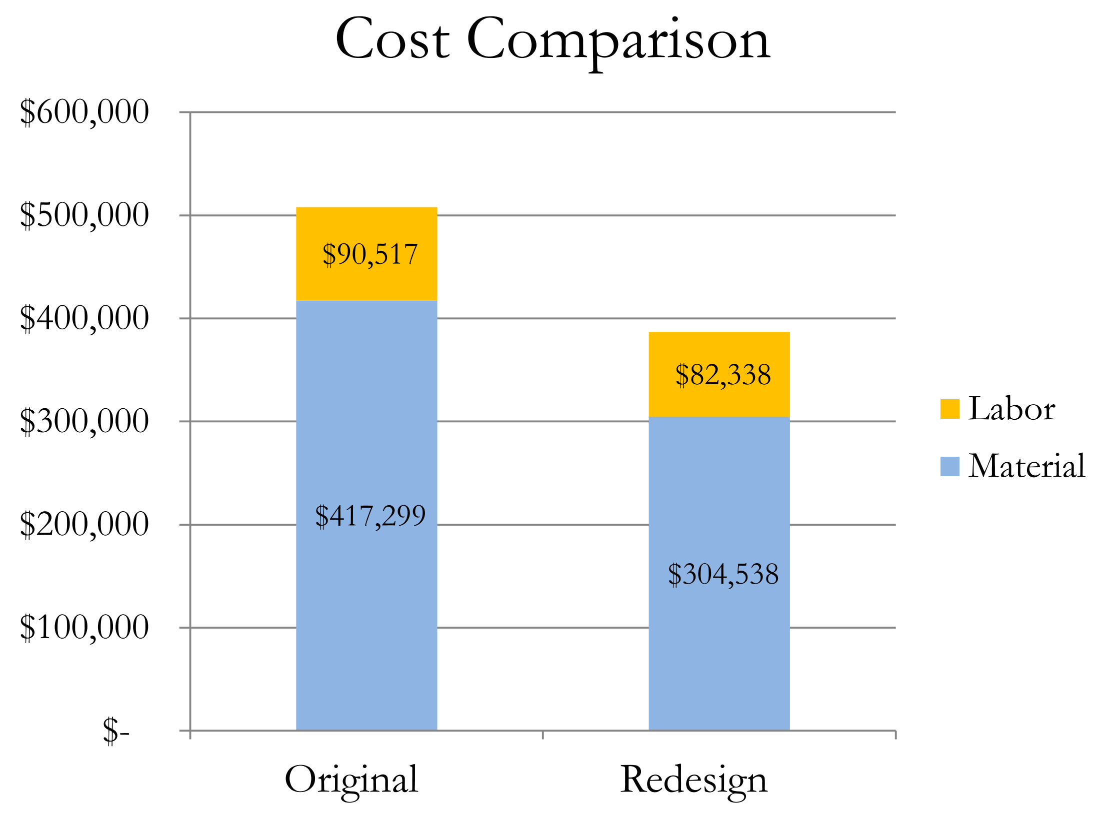
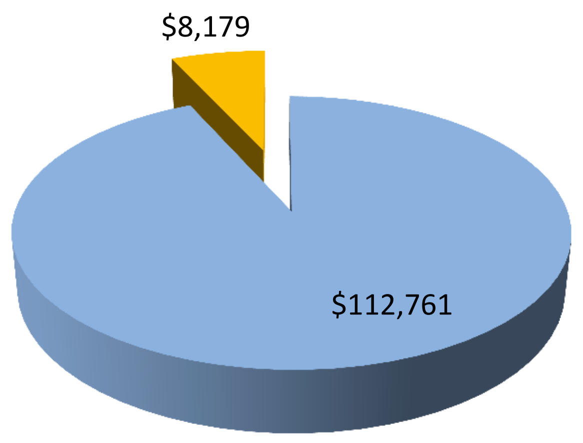


Savings = **$120,940**



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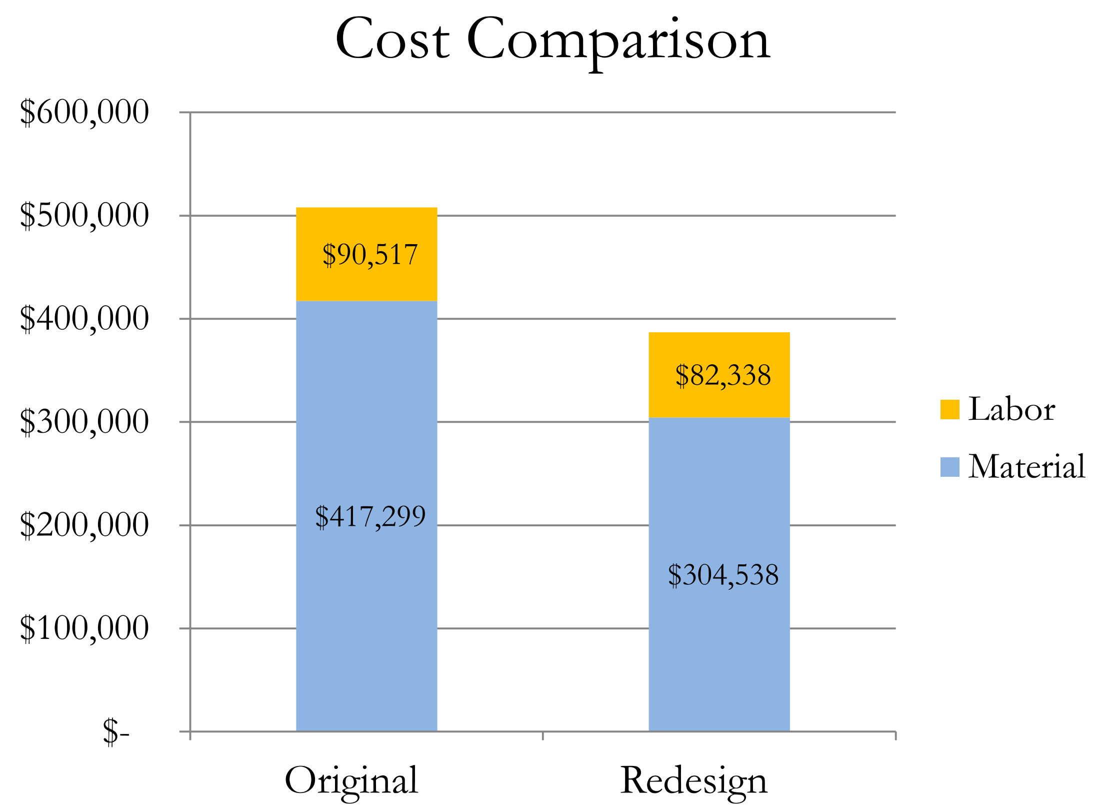

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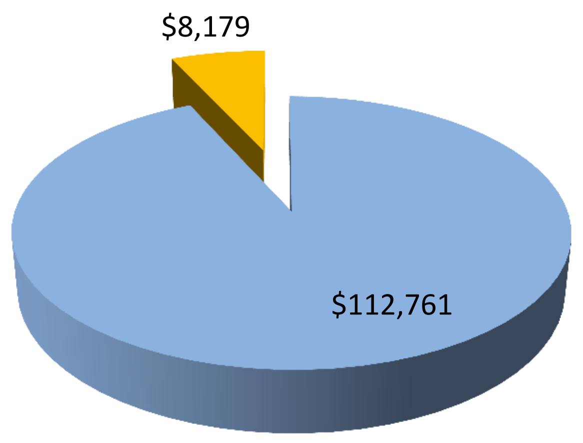


Constructability

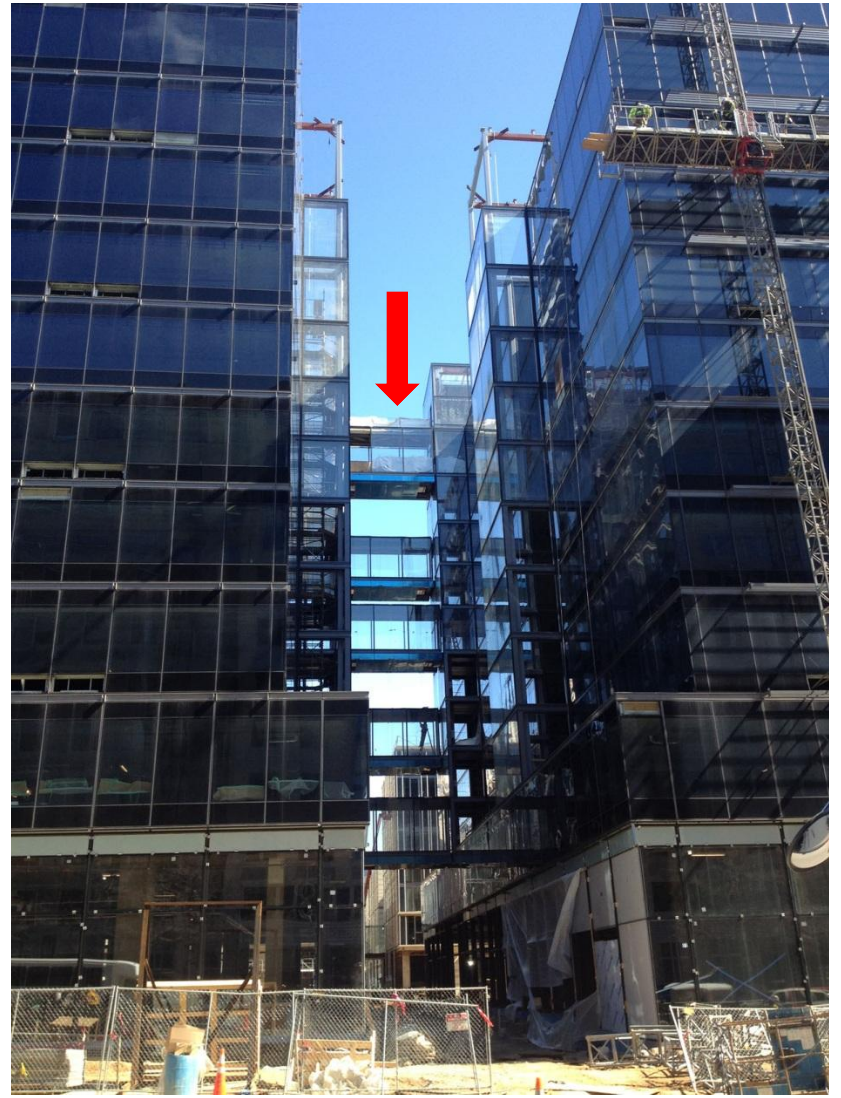
Item	Labor Hours
4000A Busway (59.4 lb/ft)	719.9
3000A Busway (42.7 lb/ft)	626
Labor Savings	93.9

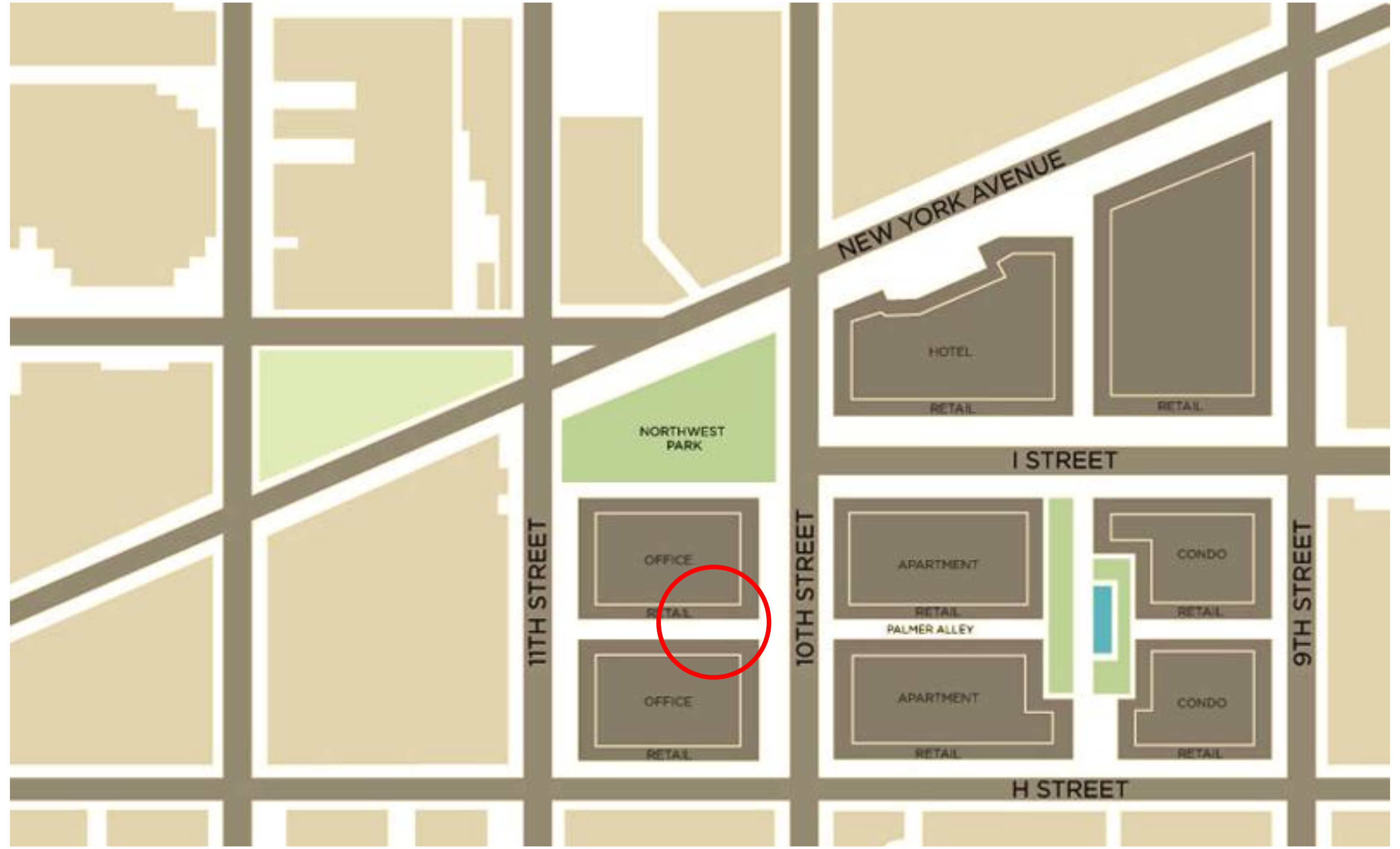
- Horizontal bus runs quicker with lighter material
- Less panels
- Less XFMRs
- Less cluttered electrical closet
- Coring coordination
- Fireproofing

Analysis #3

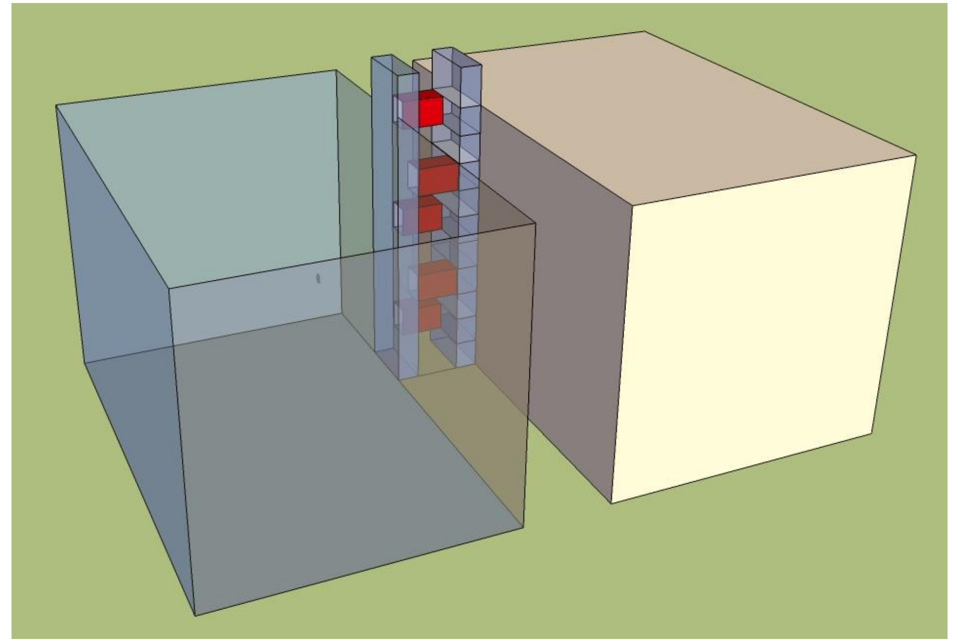
Alternative Footbridge Installation

Background Information





- 5 footbridges in between office buildings
  - Steel
  - Curtain wall
  - On floors 3,5,7,9, & 11



Analysis #3: Footbridges

Background Information

CityCenterDC | Parcel 1
Washington, D.C.

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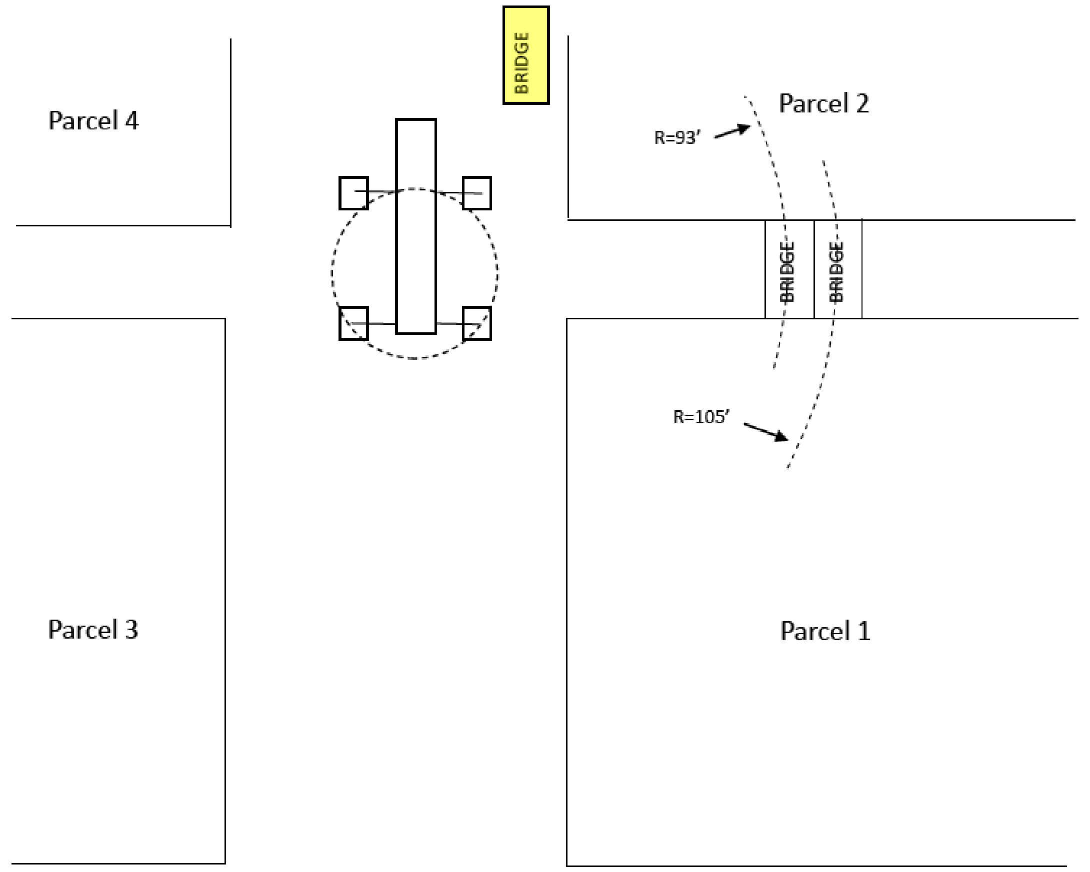
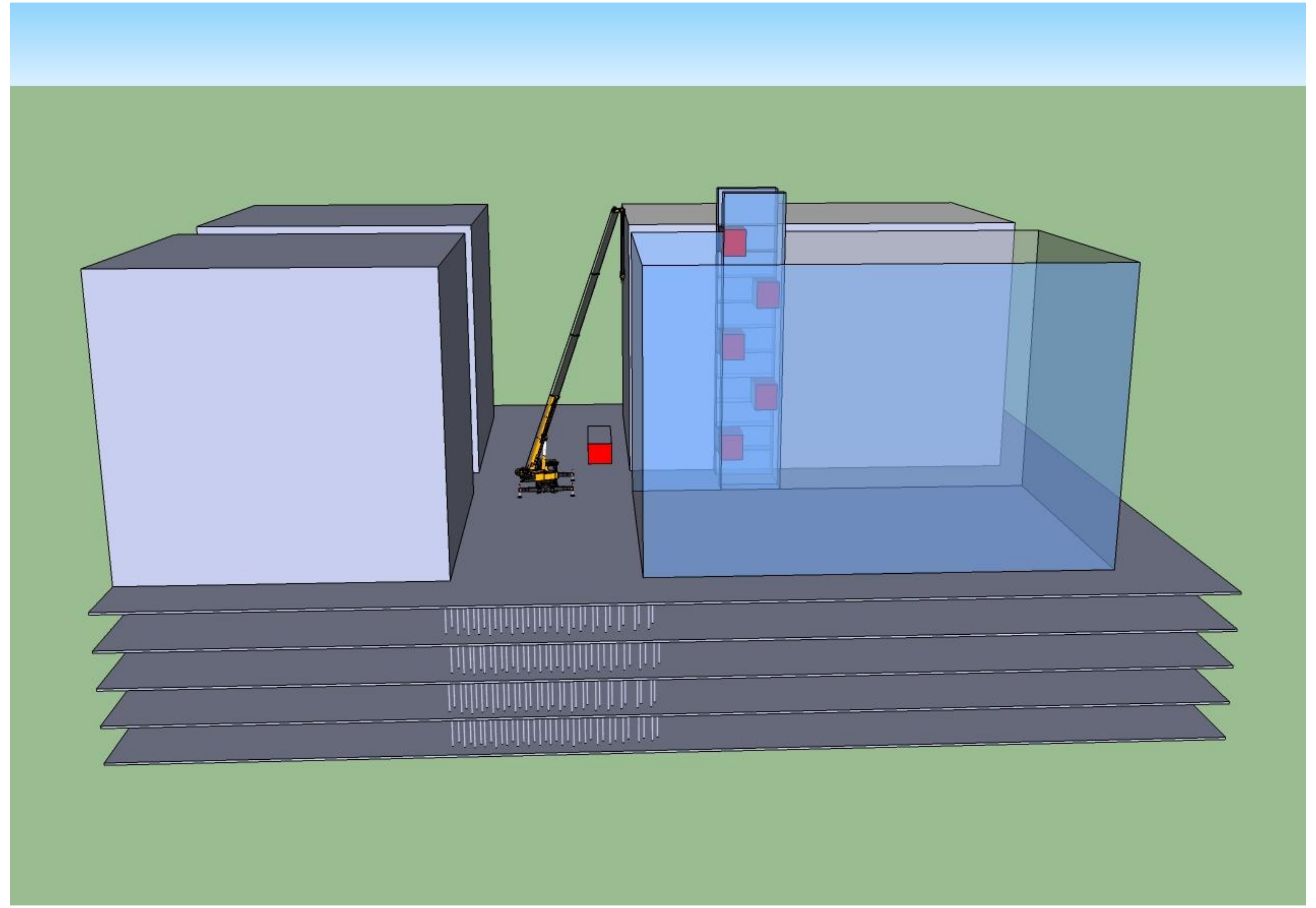
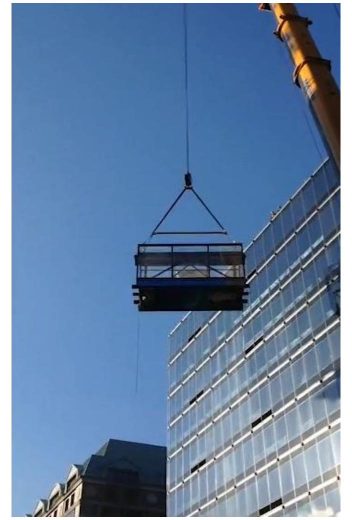
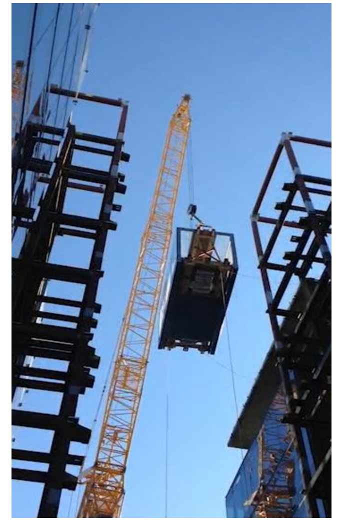


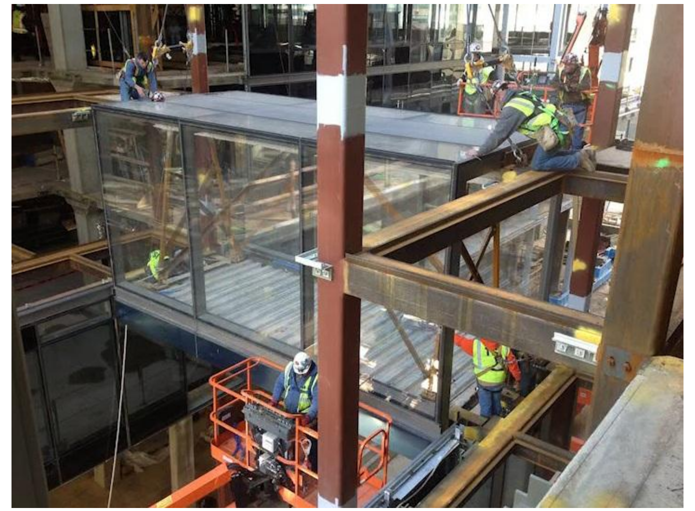


Bridges
- Prefabrication
- Including curtain wall
- Too much risk building in place
- 20' long/each
- 36,666 lbs./each

Crane
- 500 ton mobile
- 220,500 lbs counterweight
- 138' jib length
- 51,717 lifting capacity
- Shoring underneath



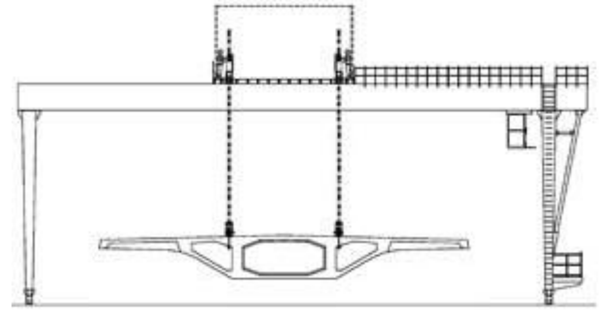




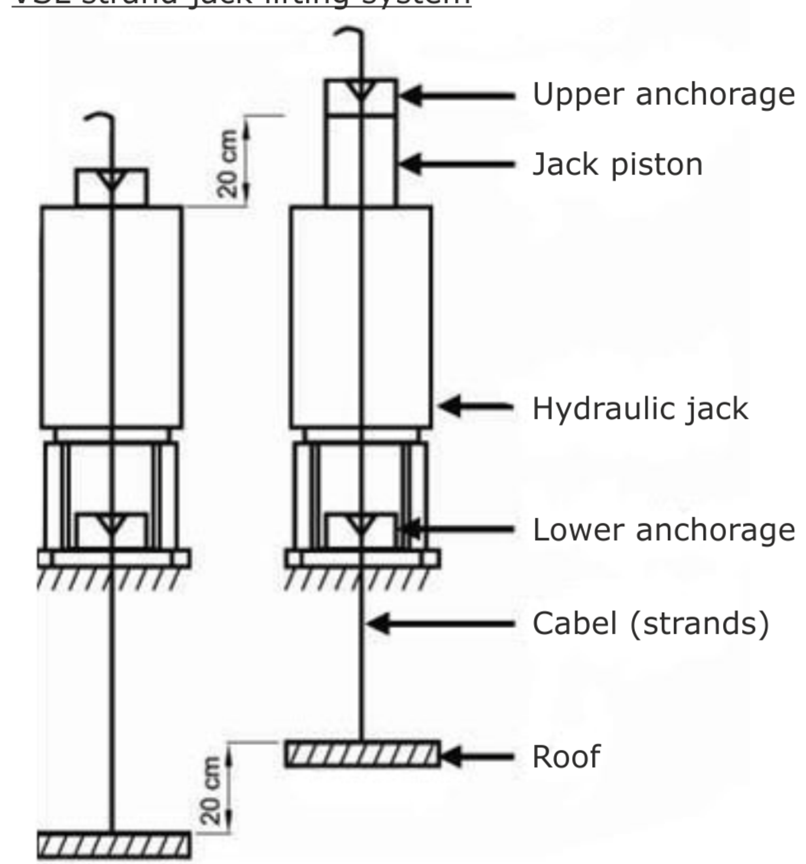
VSL Heavy Lifting

"For projects where notable weight, dimensions, or space limitations exclude the use of cranes or other conventional handling." (VSL)

- Hydraulic jacks
  - Piston
  - Tensile member
- Gauges and control systems
  - Synchronized movement
- 20 m/hr
- Up to 10,000 tons



VSL strand jack lifting system



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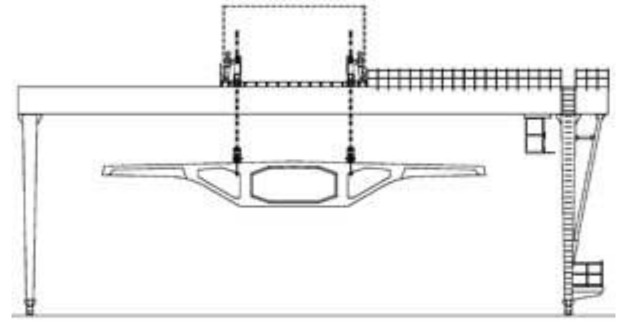

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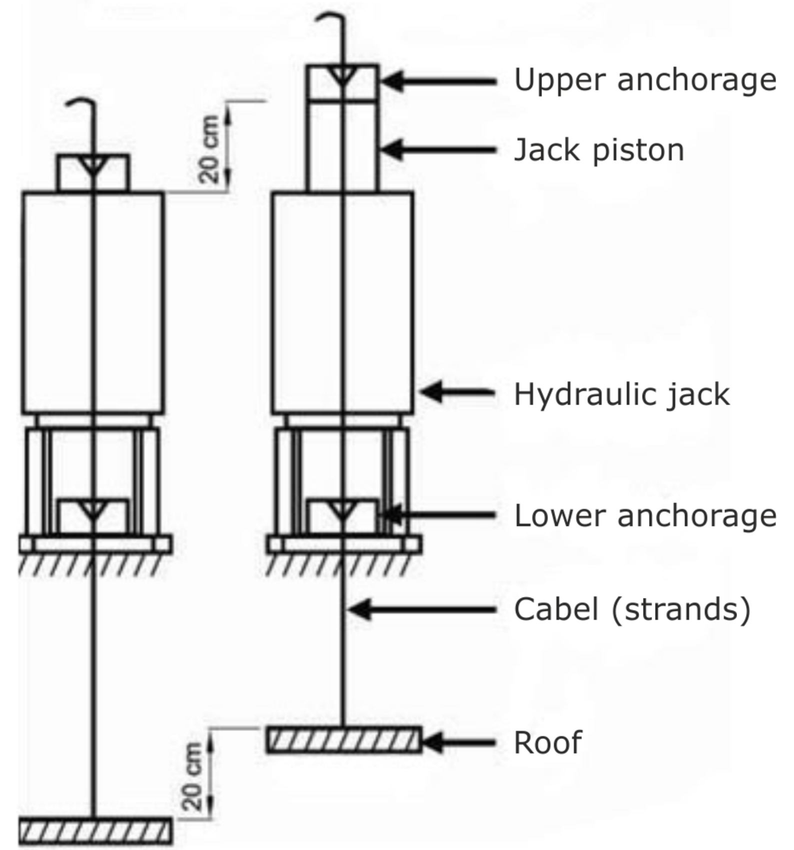
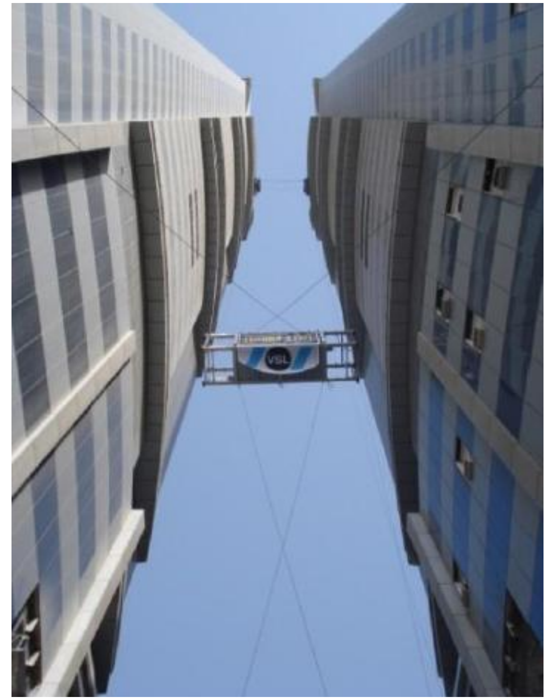


Damas Tower Footbridge



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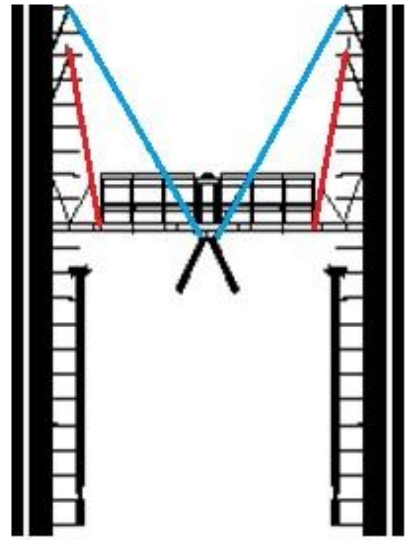
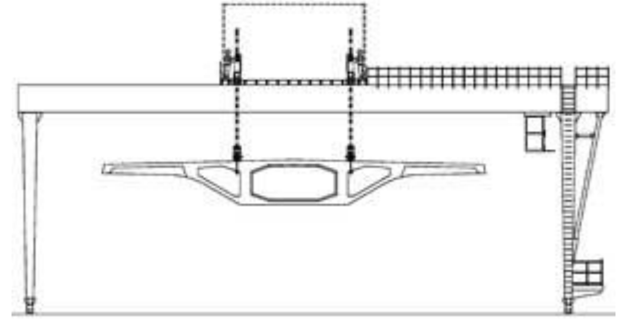
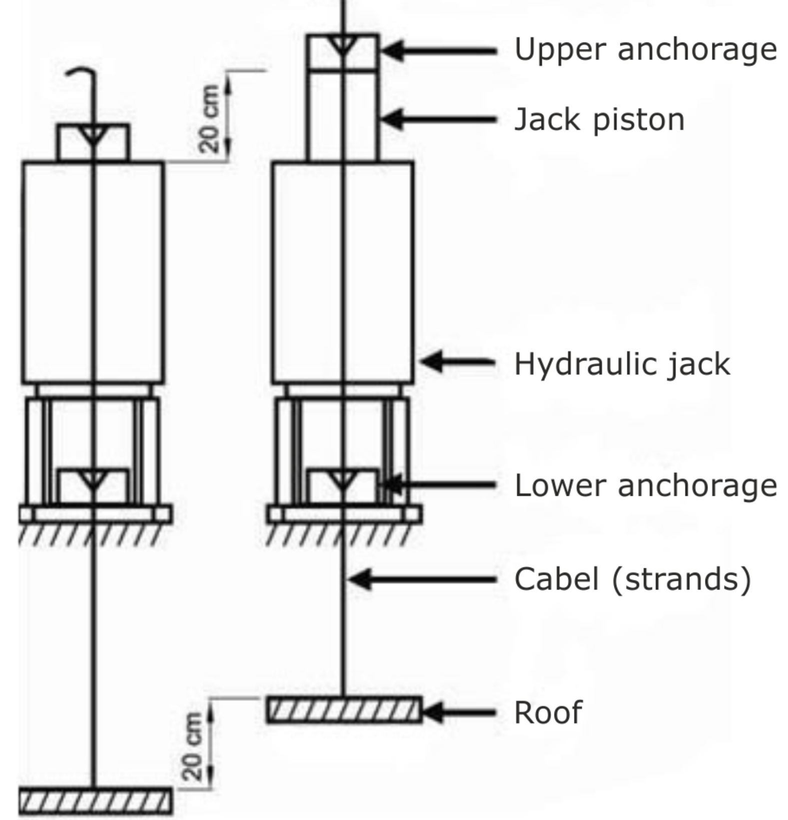


Petronas Towers

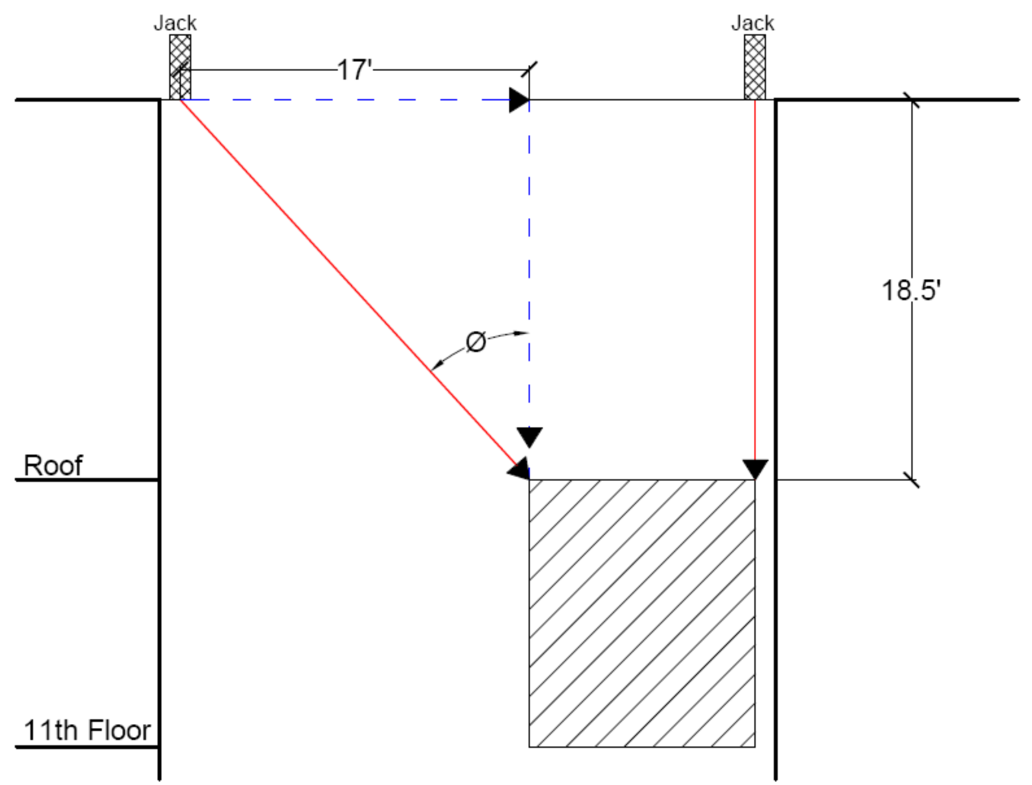
- Hydraulic jacks
  - Piston
  - Tensile member
- Gauges and control systems
  - Synchronized movement
- 20 m/hr
- Up to 10,000 tons

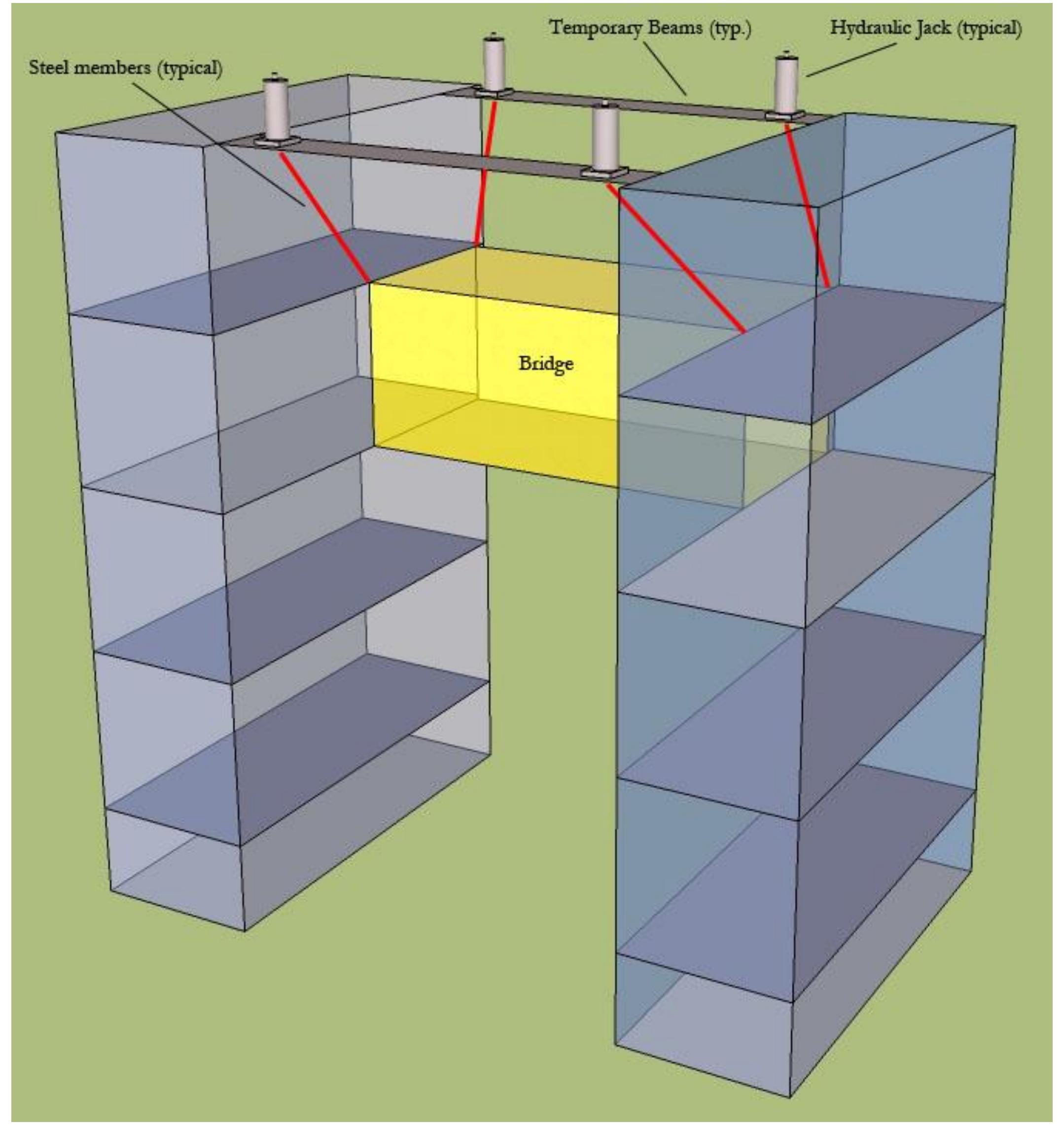


VSL strand jack lifting system

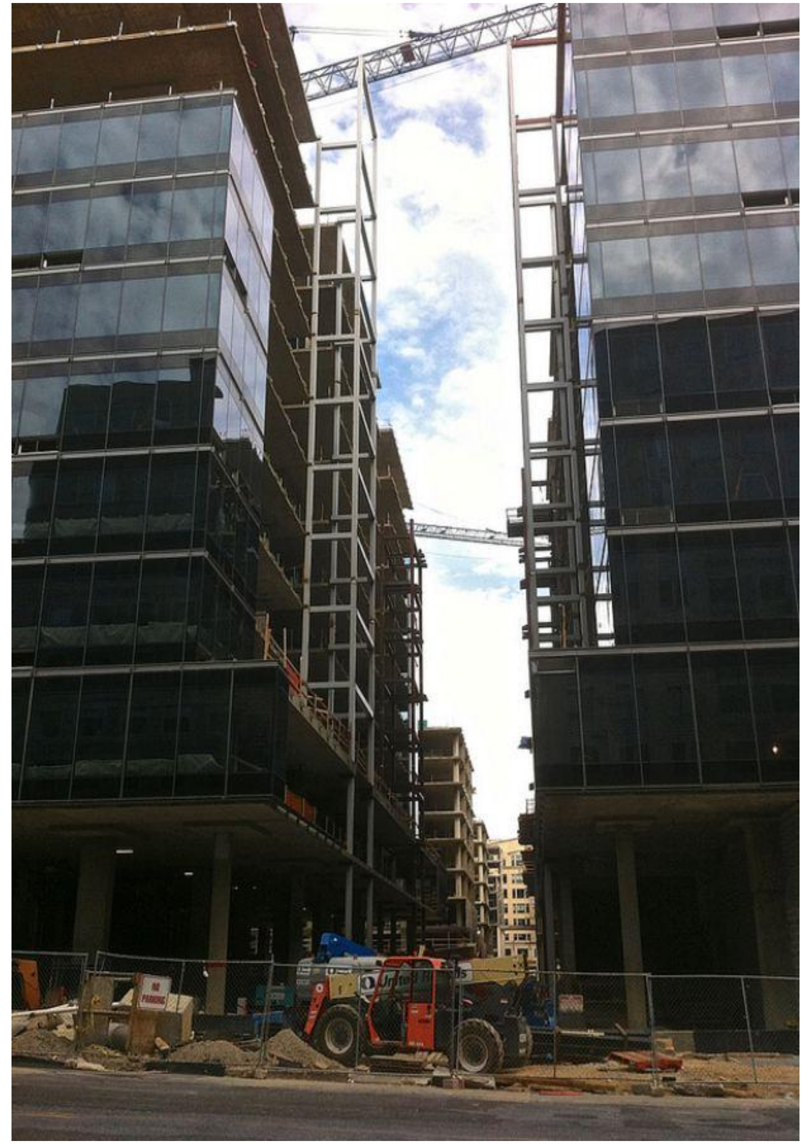


Application

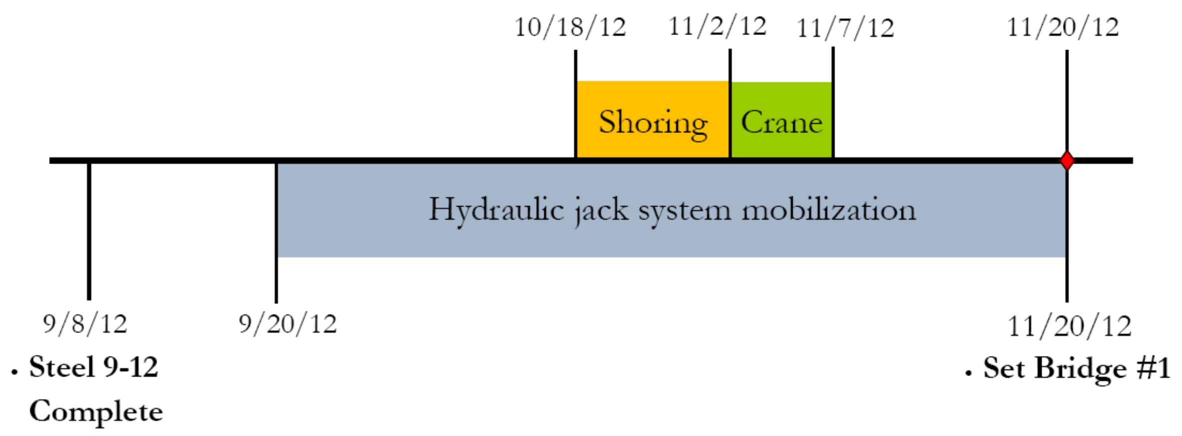




- 4 jacks
- Temporary beams span between atriums
- Structural Considerations
  - Steel strands
    - Max. force: 12.6 kips
  - Temporary beams
    - Moment: 25.2 ft k
  - Column buckling
    - F.S. = 3.4



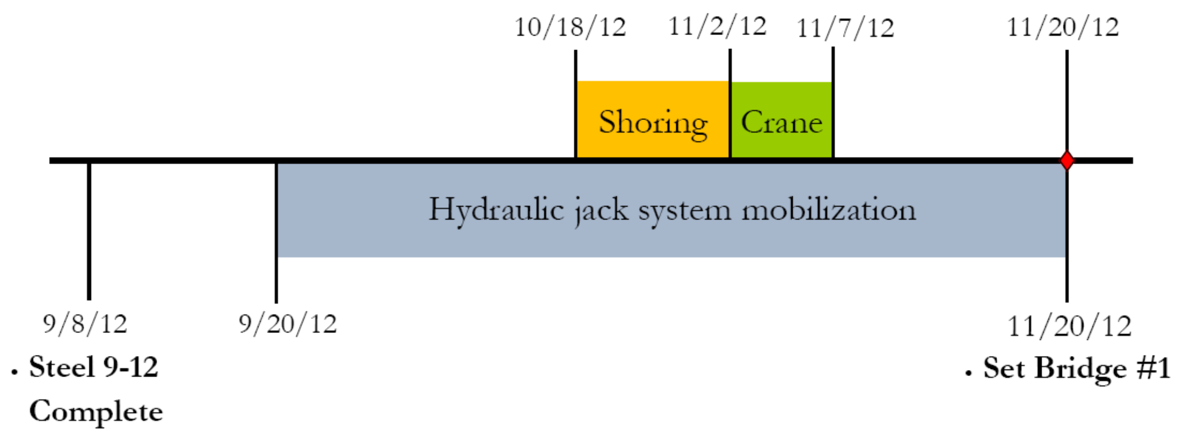
Schedule


10/18/12
11/2/12
11/7/12
11/20/12
Shoring
Crane
Hydraulic jack system mobilization
9/8/12
9/20/12
11/20/12
Steel 9-12 Complete
Set Bridge #1

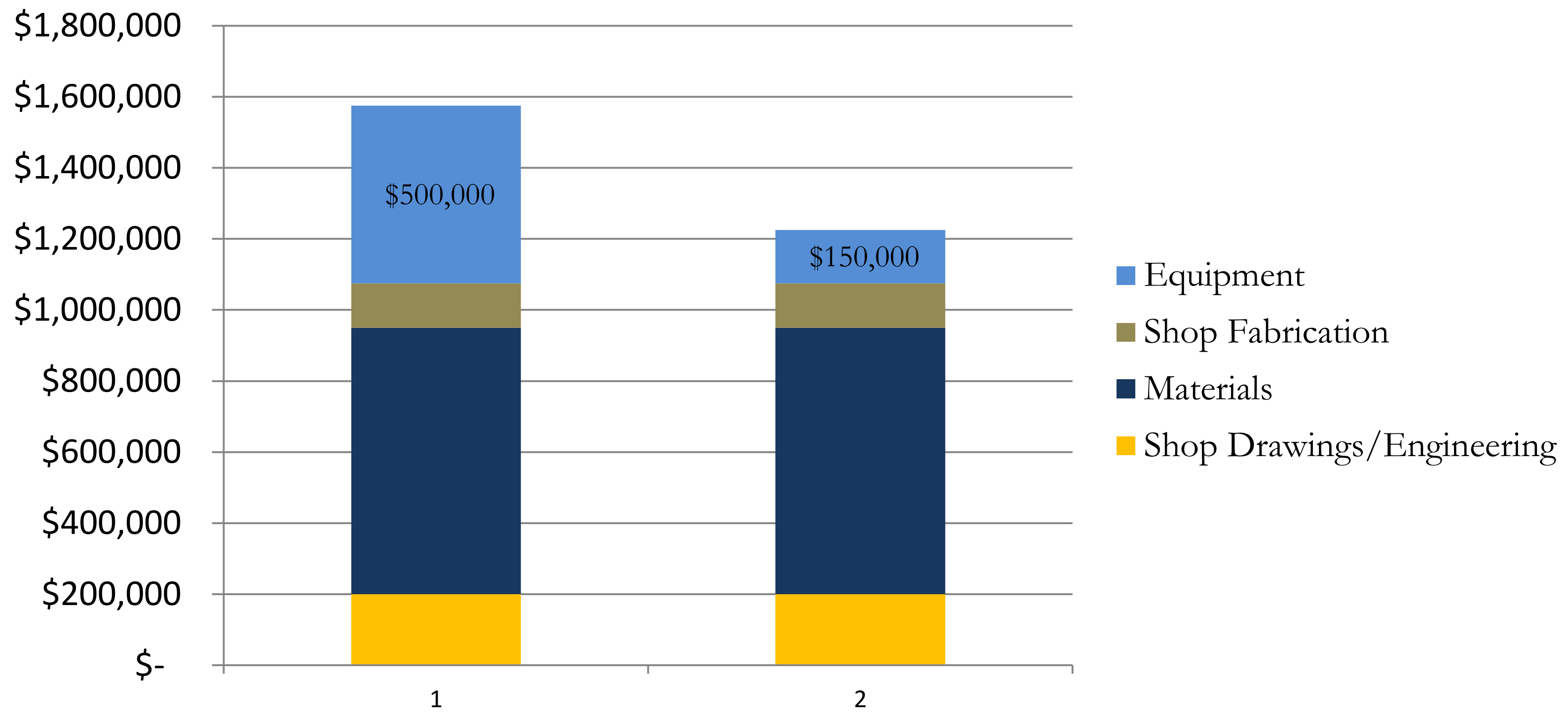
Results

Project Overview
Analysis #1: SIPS
Background Information
New Phasing & SIPS
Impact
Analysis #2: Electrical Redesign
Background Information
Redesign
Impact
Analysis #3: Footbridge Installation
Background Information
Research
Application
Results
Final Recommendations
Acknowledgements

Schedule



Cost



Constructability

- Guide cables
- Prefabricate bridges onsite
- 17 days/bridge
- On portable platform

Conclusion

Total Cost Savings: $491,464
+
Schedule Savings
+
Reduction of Constructability Concerns
+
Tenant Fit-Out
+
Efficiency

Analysis #1: SIPS

- Decrease schedule by 13 days
- General conditions savings
- Efficient use of floor space

Analysis #2: Construction Analysis of Electrical Redesign

- Material & labor savings
- Easier system to install
- Reduction of crew size

Analysis #3: Alternative Footbridge Construction

- Major equipment cost savings
- Fewer constructability concerns
- No schedule impact

Acknowledgements

Thank You!

Special Thanks

- Family & Friends
- CityCenterDC Project Team
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- Al Hedin
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- Matt Orosz
- Mike Current

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- Dr. Robert Leicht
- Dr. Richard Mistrick
- Bob Holland
- Ronald Dodson
- Kevin Parfitt

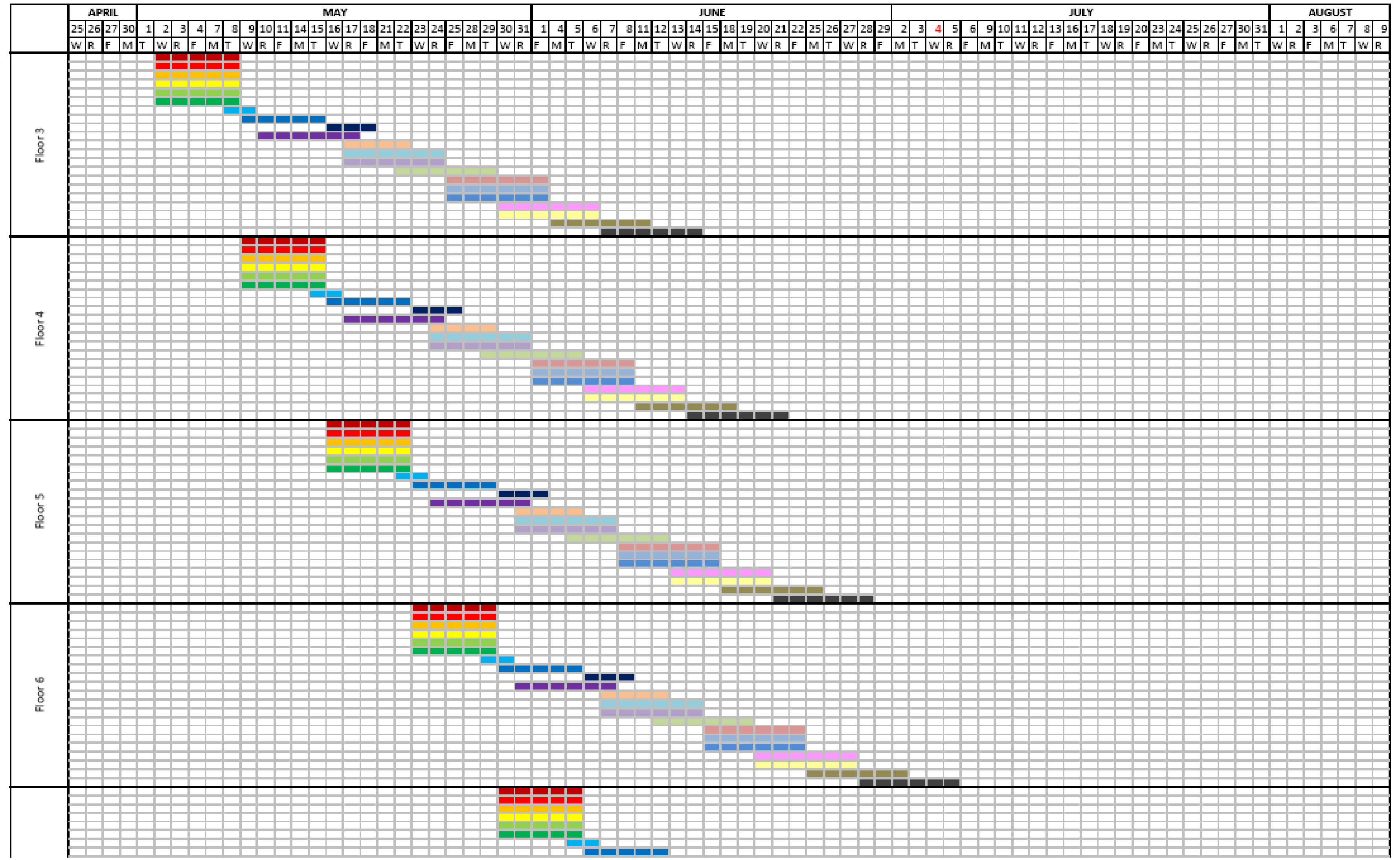
Industry

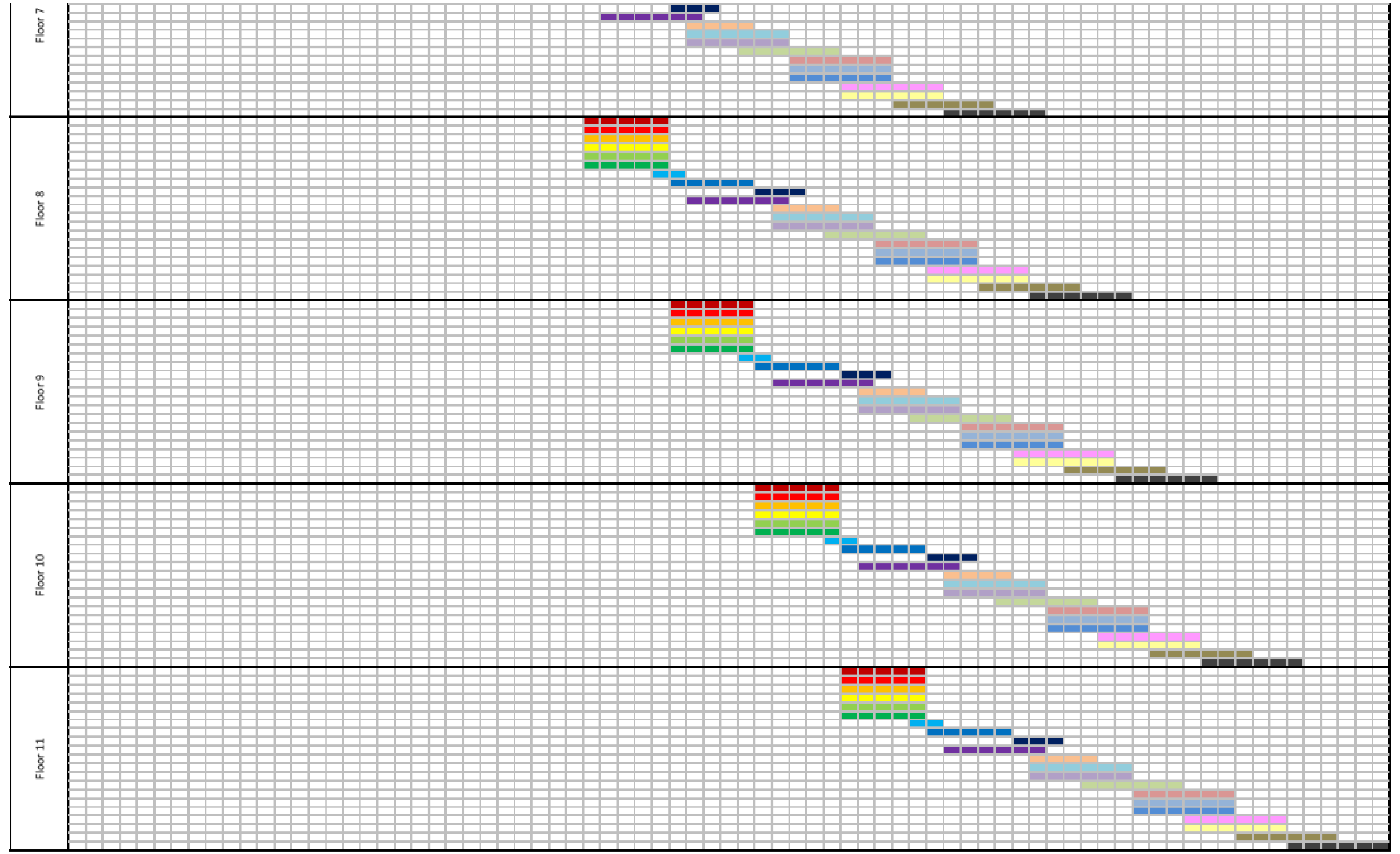
- Clark Construction
- Truland
- Hines
- TSI
- VSL

CityCenterDC | Parcel 1
Washington, D.C.

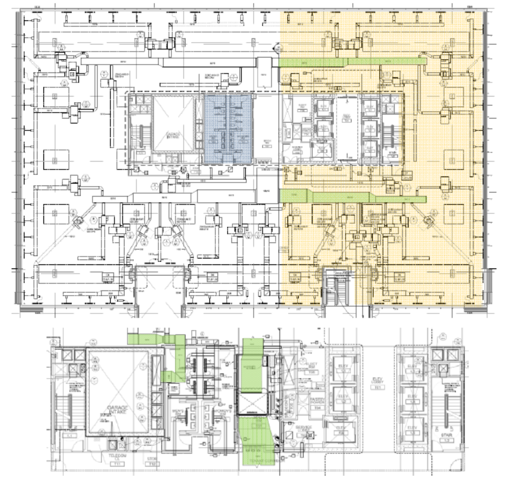
Appendix

6	Install AHU	2	5/29/2012	5/30/2012	2
6	Frame & Hang Shaft Walls	5	5/31/2012	6/6/2012	5
6	Close In Shafts	3	6/7/2012	6/11/2012	3
6	Layout & Top Track	5	6/1/2012	6/8/2012	6
6	Install Lavatory Support Steel	3	6/8/2012	6/13/2012	4
6	Rough In Duct Mains	5	6/8/2012	6/15/2012	6
6	Install VAV boxes	5	6/8/2012	6/15/2012	6
6	Frame Walls	5	6/15/2012	6/22/2012	6
6	Mechanical Pipe Rough In	5	6/22/2012	6/29/2012	6
6	Plumbing Rough In	5	6/22/2012	6/29/2012	6
6	Duct Rough In	5	6/22/2012	6/29/2012	6
6	Sprinkler Rough In	5	6/29/2012	7/6/2012	5
6	Frame Ceilings	5	7/6/2012	7/13/2012	6
6	Fire Alarm Rough In	5	7/13/2012	7/20/2012	6
6	Electrical Rough In	5	7/13/2012	7/20/2012	6
7	Install Sprinkler Standpipes	5	5/31/2012	6/6/2012	5
7	Duct Riser Rough In	5	5/31/2012	6/6/2012	5
7	Plumbing Riser Rough In	5	5/31/2012	6/6/2012	5
7	Mechanical Riser Rough In	5	5/31/2012	6/6/2012	5
7	Telecom/Security Riser Rough In	5	5/31/2012	6/6/2012	5
7	Electrical Riser Rough In	5	5/30/2012	6/5/2012	5
7	Install AHU	2	6/1/2012	6/5/2012	3
7	Frame & Hang Shaft Walls	5	6/7/2012	6/13/2012	5
7	Close In Shafts	3	6/14/2012	6/18/2012	3
7	Layout & Top Track	5	6/8/2012	6/15/2012	6
7	Install Lavatory Support Steel	3	6/15/2012	6/20/2012	4
7	Rough In Duct Mains	5	6/15/2012	6/22/2012	6
7	Install VAV boxes	5	6/15/2012	6/22/2012	6
7	Frame Walls	5	6/22/2012	6/29/2012	6
7	Mechanical Pipe Rough In	5	6/29/2012	7/6/2012	5
7	Plumbing Rough In	5	6/29/2012	7/9/2012	6
7	Duct Rough In	5	6/29/2012	7/9/2012	6
7	Sprinkler Rough In	5	7/9/2012	7/16/2012	6
7	Frame Ceilings	5	7/16/2012	7/23/2012	6
7	Fire Alarm Rough In	5	7/23/2012	7/30/2012	6
7	Electrical Rough In	5	7/23/2012	7/30/2012	6
8	Install Sprinkler Standpipes	5	7/7/2012	7/13/2012	5
8	Duct Riser Rough In	5	7/7/2012	7/13/2012	5
8	Plumbing Riser Rough In	5	7/7/2012	7/13/2012	5
8	Mechanical Riser Rough In	5	7/7/2012	7/13/2012	5
8	Telecom/Security Riser Rough In	5	7/7/2012	7/13/2012	5
8	Electrical Riser Rough In	5	6/6/2012	6/12/2012	5
8	Install AHU	2	6/14/2012	6/15/2012	2
8	Frame & Hang Shaft Walls	5	6/14/2012	6/20/2012	5
8	Close In Shafts	3	6/21/2012	6/25/2012	3
8	Layout & Top Track	5	6/15/2012	6/22/2012	6
8	Install Lavatory Support Steel	3	6/22/2012	6/27/2012	4



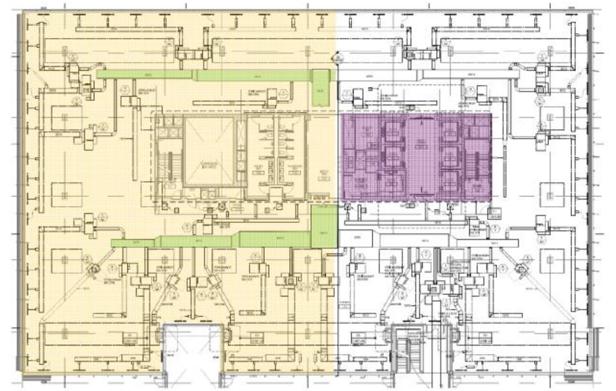


Appendix



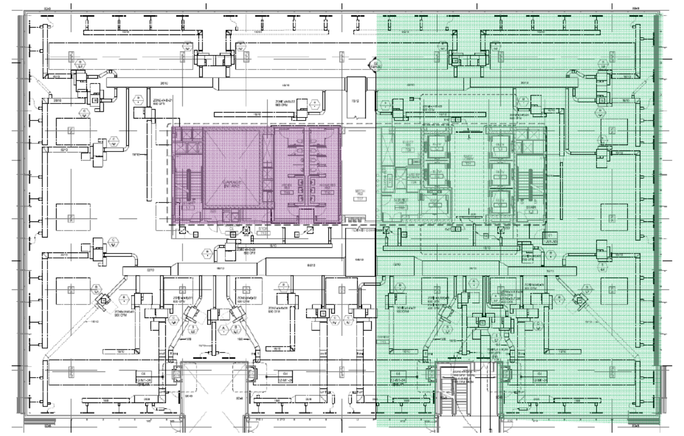
Rough In Duct Mains & Install VAV Boxes **AND** Lavatory Steel

- Install VAV Boxes
- Lavatory Steel
- Rough In Duct Mains



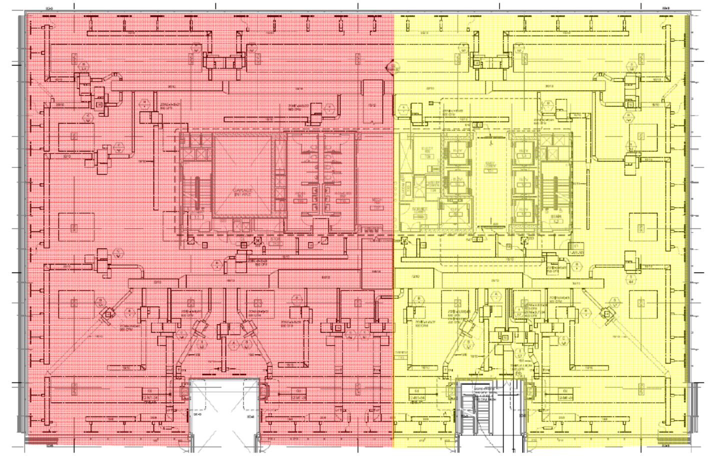
Rough In Duct Mains & Install VAV Boxes **AND** Frame Walls

- Install VAV Boxes
- Frame Walls
- Rough In Duct Mains



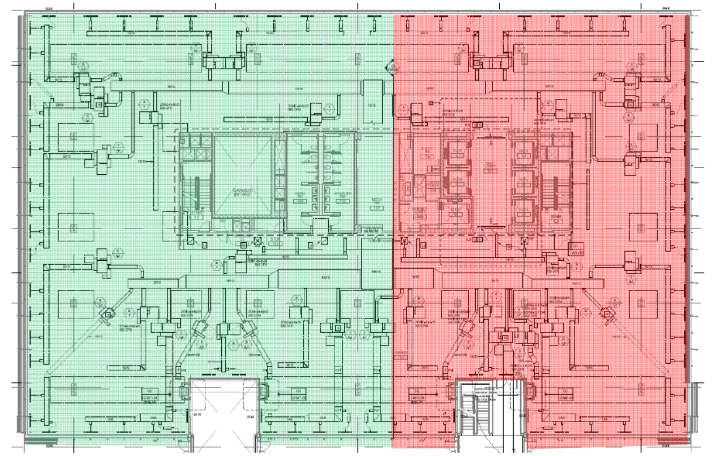
Frame Walls **AND** Mechanical Pipe, Plumbing, Duct Rough In

- Mechanical Pipe, Plumbing, Duct Rough In
- Frame Walls



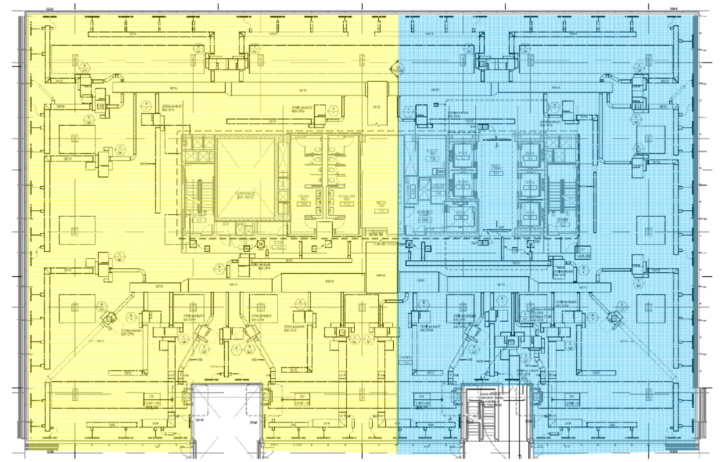
Electrical and Fire Alarm Rough In **AND** Sprinkler Rough In

- Sprinkler Rough In
- Electrical and Fire Alarm Rough In



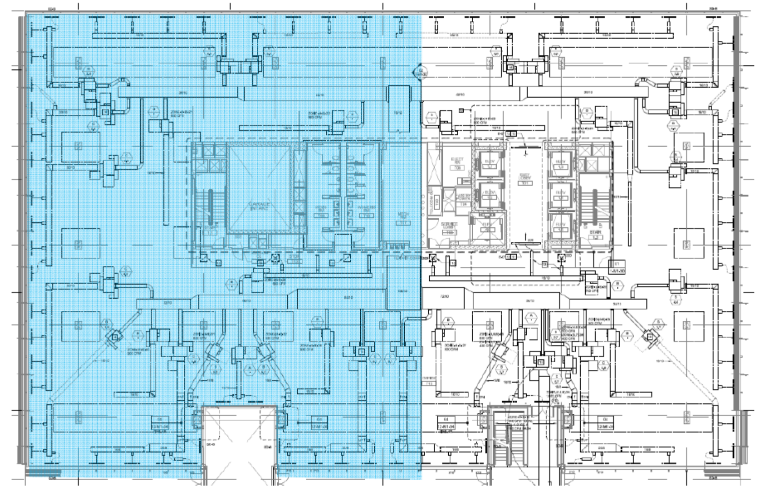
Mechanical Pipe, Plumbing, Duct Rough In **AND** Electrical and Fire Alarm Rough In

- Mechanical Pipe, Plumbing, Duct Rough In
- Electrical and Fire Alarm Rough In



Sprinkler Rough In **AND** Frame Ceilings

- Sprinkler Rough In
- Frame Ceilings



Finish Framing Ceilings

- Frame Ceilings

Table 1. ASHRAE/IES 90.1 lighting power allowances using the Building Area Method.

Building Type	Maximum Lighting Power Density (W/sq.ft.) Allowed Per Version of the ASHRAE/IES 90.1 Standard			
	1989	1999/2001	2004/2007	2010
Automotive Facility	0.96	1.5	0.9	0.982
Convention Center	2.07	1.4	1.2	1.08
Court House	1.44	1.4	1.2	1.05
Dining: Bar Lounge/Leisure	1.37	1.5	1.3	0.99
Dining: Cafeteria/Fast Food	1.37	1.8	1.4	0.90
Dining: Family	1.37	1.9	1.6	0.89
Dormitory	1.15	1.5	1.0	0.61
Exercise Center	2.07	1.4	1.0	0.88
Gymnasium	2.07	1.7	1.1	1.00
Healthcare Clinic	1.44	1.6	1.0	0.87
Hospital	1.44	1.6	1.2	1.21
Hotel	1.15	1.7	1.0	1.00
Library	1.29	1.5	1.3	1.18
Manufacturing Facility	0.96	2.2	1.3	1.11
Motel	1.15	2.0	1.0	0.88
Motion Picture Theater	2.07	1.6	1.2	0.83
Multi-Family	1.15	1.0	0.7	0.60
Museum	2.07	1.6	1.1	1.06
Office	1.26	1.3	1.0	0.90
Parking Garage	1.03	0.3	0.3	0.25
Penitentiary	1.44	1.2	1.0	0.97
Performing Arts Theatre	2.07	1.5	1.6	1.39
Police/Fire Station	1.44	1.3	1.0	0.96
Post Office	1.44	1.6	1.1	0.87
Religious Building	2.07	2.2	1.3	1.05
Retail	2.25	1.9	1.5	1.40
School/University	1.29	1.5	1.2	0.99
Sports Arena	2.07	1.5	1.1	0.78
Town Hall	1.44	1.4	1.1	0.92
Transportation	2.07	1.2	1.0	0.77
Warehouse	1.03	1.2	0.8	0.66
Workshop	0.96	1.7	1.4	1.20

# of receptacle circuits necessary

$$22436SF \cdot 2.5W / SF = 56090W$$

$$56090W / 180\frac{VA}{rec} = 312rec$$

$$\frac{312rec}{6\frac{rec}{ckt}} = 52ckts$$

For the 3RD Floor, panels L3A1 & L3B1 have XX spare 70 ckts …. OK

For remaining floors, top panels have 67 spare ckts, and bottom panels have 70 spare ckts…. OK

Remaining Typical Floor Layout

Original XFMR anticipated max load of 112.5 kVA from low voltage panels, or 4.8 W/SF.

By reducing receptacle power density to 2.5 W/SF, I propose…

Eliminate XFMRs on floors 4, 6, & 8

The low voltage panels on those floors will be fed by the XFMR on the above floor

So,

Current max kVA for low voltage panels is 112.5kVA, or 4.8 W/SF

Receptacle power density changed to 2.5W/SF

Factor in existing 10kVA load, or .4 W/SF…

$$\frac{112.5kVA}{4.8W / SF} = \frac{X}{2.9W / SF}$$

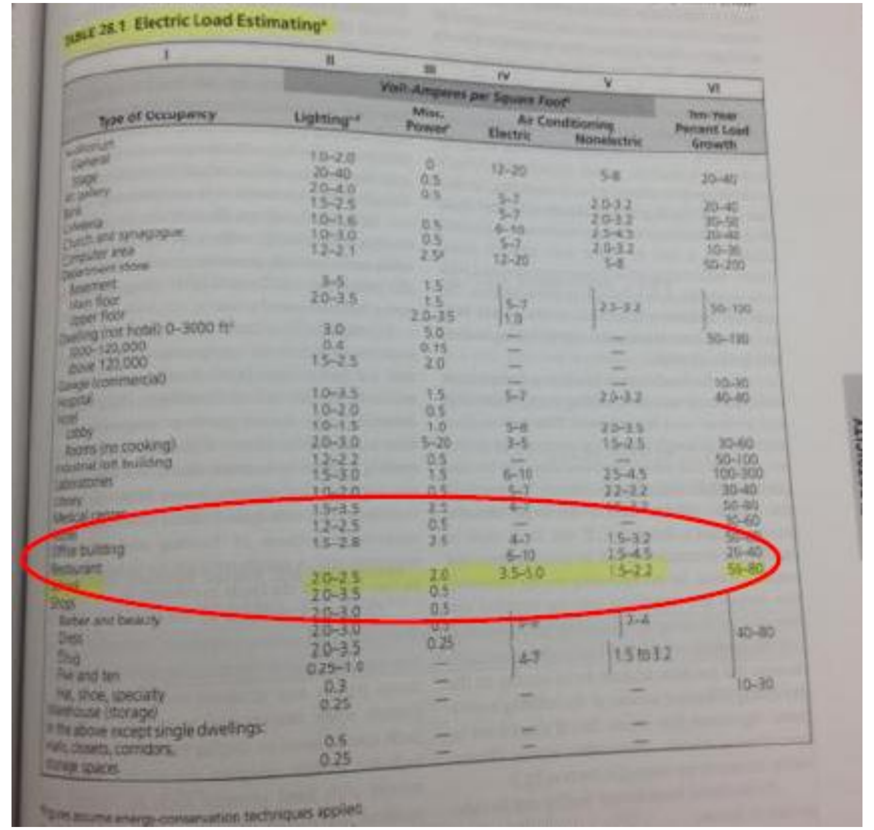
$$X = 68kVA$$

Therefore, a set of panels require 68 kVA

Meaning both sets together will be a total of 136 kVA

Consequently, you will need a 150 kVA XFMR

*Refer to riser diagram for additional wire and breaker sizing


Electric Load Estimating

Appendix

Switchboard MS12A resize

Capacity:

Lighting & Receptacle Capacity: 1902 kVA

$$1902kVA = \frac{kW}{1000 \cdot 0.95} = 1807000W$$

$$\Rightarrow \frac{1807000W}{257500SF} = 7.02W/SF \text{ Capacity}$$

Recommendations:

ASHRAE, Sec. 9, provides maximum lighting power density recommendation for office building (W/SF)

- ASHRAE 2007 = 1.0 W/SF
- ASHRAE 2010 = 0.9 W/SF

**http://lightingcontrolsassociation.org/ashrae-releases-90-1-2010-part-1-design-scope-administrative-requirements/*

Per MEEB, pg. 1265, receptacle (misc. power) power density recommendation is: 2.375 W/SF

Therefore,

$$0.9W/SF + 2.375W/SF = 3.275W/SF \text{ for lighting \& receptacle loads}$$

Switchboard MS12A provides an excess of 3.645 W/SF for these loads

Proposal:

Remove 800kVA from lighting & receptacle loads

From 1902kVA to 1102KVA

$$1102kVA \cdot 1000 \cdot 0.95 = 1046900W$$

$$\Rightarrow \frac{1046900W}{257500SF} = 4.1W/SF \text{ \underline{NEW} lighting \& receptacle capacity}$$

This is still 0.8 W/SF more than design recommendations

Note: A PF of 0.95 was used in all calculations

Effect:

Initial Switchboard total kVA load: 3173 kVA (3982A @ 460V, 3ϕ)

Revised Switchboard total kVA load: 2373 kVA (2978A @ 460V, 3ϕ)

Therefore,

You can go from 4000A switchboard to 3000A switchboard!!

3RD Floor Redesign

XFMR

Square footage of office space (minus core) = 22,436 SF

Panels L3A1 & L3B1 (120/208V) are designated for receptacles + already designated loads

So,

$$2.5W/SF \cdot 22436SF = 56090W$$

$$\frac{56090W}{0.95PF} = 59042kVA \approx 59kVA$$

Add in existing circuit loads $59kVA + 10kVA + 0kVA = 69kVA$

(10kVA from panel L3A1 and 0kVA from panel L3B1)

Therefore, transformer can be reduced from 112.5 kVA to 75 kVA

Which means your primary breaker can be 100A and your secondary breaker can be or 250A

See PAGES XXX FOR PANEL SCHEDULES

H3MA1

Consolidation of panels H3MA1 & H3MB1

See Floors 3-9 480V panel consolidation section

Wiring

Refer to riser diagram

All calculations based off NFPA 70 – NEC 2011

Appendix

PANEL H(3-11)L1

BREAKER INTERUPTING RATING: SERIES RATED | M.L.O. | 3 Ø - 4 WIRE

CONDUIT SIZE	WIRE SIZE	SERVING	KVA AØ	KVA BØ	KVA CØ	CKT BKR	CKT NO	CKT NO	CKT BKR	KVA AØ	KVA BØ	KVA CØ	SERVING
1/2"	2#12	TOILET RM. LTS.	1.34			1P-20	1	2	1P-20	1.00			LTG. RELAY PANEL
1/2"	2#12	CORRIDOR LTS.		0.38		|	3	4	|				SPARE
		SPARE				|	5	6	|				|
		|				|	7	8	|				|
		|				|	9	10	|				|
		|				|	11	12	|				|
		|				|	13	14	|				|
		|				|	15	16	|				|
		V				V	17	18	V				V
		SPACE					19	20					SPACE
		|					21	22					|
		|					23	24					|
		|					25	26					|
		|					27	28					|
		|					29	30					|
		|					31	32					|
		|					33	34					|
		|					35	36					V
		|					37	38	3P-175	1.62			112.5 KVA XFMR
		|					39	40			0.54		(PANEL LXA1)
		V					41	42				0.50	
			1.3	0.4	0.0					2.6	0.5	0.5	

AØ = 4 KVA CØ = 1 KVA
BØ = 1 KVA TOTAL = 5 KVA

PANEL H3MA1

BREAKER INTERUPTING RATING: SERIES RATED | M.L.O. | 3 Ø - 4 WIRE

CONDUIT SIZE	WIRE SIZE	SERVING	KVA AØ	KVA BØ	KVA CØ	CKT BKR	CKT NO	CKT NO	CKT BKR	KVA AØ	KVA BØ	KVA CØ	SERVING
		SPACE					1	2	1P-30	5.82			FPTU (B/5.0)
		|					3	4	|		5.82		FPTU (B/5.0)
		|					5	6	|			5.82	FPTU (B/5.0)
		|					7	8	|	5.82			FPTU (B/5.0)
		|					9	10	|		5.22		FPTU (B/4.4)
		|					11	12	|			5.22	FPTU (B/4.4)
		|					13	14	V	5.22			FPTU (B/4.4)
		|					15	16	1P-25		4.72		FPTU (B/3.9)
		|					17	18	|			4.72	FPTU (B/3.8)
		|					19	20	|	4.42			FPTU (B/3.6)
		|					21	22	V		4.52		FPTU (B/3.7)
		|					23	24	1P-20			3.42	FPTU (B/2.6)
		|					25	26	|	3.42			FPTU (B/2.6)
		V					27	28	|		1.64		FPTU (B/-)
3/4"	2#10	FPTU (B/5.0)			5.82	1P-30	29	30	|			1.64	FPTU (B/-)
|	|	FPTU (B/5.0)	5.82			|	31	32	|	1.64			FPTU (B/-)
|	|	FPTU (B/5.0)		5.82		|	33	34	|		1.64		FPTU (B/-)
|	|	FPTU (B/5.0)			5.82	|	35	36	V			1.64	FPTU (B/-)
|	|	FPTU (C/4.8)	6.22			|	37	38	3P-15	3.00			EWH-1
|	|	FPTU (C/4.8)		6.22		|	39	40			3.00		(9.0 KW)
V	V	FPTU (C/4.8)			6.22	V	41	42				3.00	
			12.0	12.0	17.9	FEED THRU LUGS				29.3	26.6	25.5	

AØ = 41 KVA CØ = 43 KVA
BØ = 39 KVA TOTAL = 123 KVA

NOTE: CONTRACTOR SHALL LABEL ALL FPTU CIRCUITS WITH MECHANICAL ZONE DESIGNATIONS (E.G., "FPTU 2-1"). REFER TO MECHANICAL DRAWINGS FOR ZONE DESIGNATIONS.

PANEL H(3-9)MB1

BREAKER INTERUPTING RATING: SERIES RATED | M.L.O. | 3 Ø - 4 WIRE

CONDUIT SIZE	WIRE SIZE	SERVING	KVA AØ	KVA BØ	KVA CØ	CKT BKR	CKT NO	CKT NO	CKT BKR	KVA AØ	KVA BØ	KVA CØ	SERVING
3/4"	4#12	FPTU (C/5.8)	2.51			3P-15	1	2					SPACE
				2.51			3	4					|
					2.51		5	6					|
3/4"	4#12	FPTU (C/5.9)	2.51			3P-15	7	8					|
				2.51			9	10					|
					2.51		11	12					|
3/4"	4#12	FPTU (C/6.6)	2.74			3P-15	13	14					|
				2.74			15	16					|
					2.74		17	18					|
3/4"	4#12	FPTU (C/6.6)	2.74			3P-15	19	20					|
				2.74			21	22					|
					2.74		23	24					|
3/4"	4#12	FPTU (C/5.7)	2.44			3P-15	25	26					|
		(FL. 4, 6, & 8 ONLY)		2.44			27	28					|
					2.44		29	30					|
		SPACE					31	32					|
		|					33	34					|
		|					35	36					|
		|					37	38					|
		|					39	40					|
		V					41	42					V
			12.9	12.9	12.9					0.0	0.0	0.0	

AØ = 13 KVA CØ = 13 KVA
BØ = 13 KVA TOTAL = 39 KVA

NOTE; CONTRACTOR SHALL LABEL ALL FPTU CIRCUITS WITH MECHANICAL ZONE DESIGNATIONS (E.G., "FPTU 2-1"). REFER TO MECHANICAL DRAWINGS FOR ZONE DESIGNATIONS.

PANEL L(3-11)A1

BREAKER INTERUPTING RATING: 10,000 A.I.C. | 3P-400A M.C.B. (200% NEUTRAL) | 3 Ø - 4 WIRE

CONDUIT SIZE	WIRE SIZE	SERVING	KVA AØ	KVA BØ	KVA CØ	CKT BKR	CKT NO	CKT NO	CKT BKR	KVA AØ	KVA BØ	KVA CØ	SERVING
1/2"	2#12	CORE RECEP.	1.44			1P-20	1	2	1P-20	0.18			SEC. PNL. (5 & 10)
|	|	TOILET RM. RECEP.		0.54		|	3	4	|		1.80		W.SLOT TRK. (5)
|	|	ILCP-1 (3&7 ONLY)			0.50	|	5	6	|			1.08	W.SLOT LED (5 & 9)
|	|	FLUSH VALVE	0.50			|	7	8	|	1.00			E.SLOT (3-9,11)
|	|	SMOKE DAMPERS		0.50		|	9	10	|		1.46		E.SLOT LED (10,11)
V	V	SMOKE DAMPERS			0.50	|	11	12	|				SPARE
		SPARE				|	13	14	|				|
		|				|	15	16	|				|
		|				|	17	18	|				|
		|				|	19	20	|				|
		|				|	21	22	|				|
		|				|	23	24	|				|
		|				|	25	26	|				|
		|				|	27	28	|				|
		V				V	29	30	V				V
		SPACE					31	32					SPACE
		|					33	34					|
		|					35	36					|
		|					37	38					|
		|					39	40					|
		V					41	42					V
			1.9	1.0	1.0	FEED THRU LUGS				1.2	3.3	1.1	

AØ = 3 KVA CØ = 2 KVA
BØ = 4 KVA TOTAL = 10 KVA

PANEL L(2-11)B1

BREAKER INTERUPTING RATING: 10,000 A.I.C. | M.L.O. (200% NEUTRAL) | 3 Ø - 4 WIRE

CONDUIT SIZE	WIRE SIZE	SERVING	KVA AØ	KVA BØ	KVA CØ	CKT BKR	CKT NO	CKT NO	CKT BKR	KVA AØ	KVA BØ	KVA CØ	SERVING
		SPARE				1P-20	1	2	1P-20				SPARE
		|				|	3	4	|				|
		|				|	5	6	|				|
		|				|	7	8	|				|
		|				|	9	10	|				|
		|				|	11	12	|				|
		|				|	13	14	|				|
		|				|	15	16	|				|
		|				|	17	18	|				|
		|				|	19	20	|				|
		|				|	21	22	|				|
		|				|	23	24	|				|
		|				|	25	26	|				|
		|				|	27	28	|				|
		V				V	29	30	V				V
		SPACE					31	32					SPACE
		|					33	34					|
		|					35	36					|
		|					37	38					|
		|					39	40					|
		V					41	42					V
			0.0	0.0	0.0	FEED THRU LUGS				0.0	0.0	0.0	

AØ = 0 KVA CØ = 0 KVA
BØ = 0 KVA TOTAL = 0 KVA

Appendix

TYPE[1]	CAPACITY[2]	MAX. NUMBER OF STRANDS	KEY DATA FOR VSL LIFTING UNITS CABLE DIAMETER	OVERALL DIMENSIONS		WEIGHT[3]
	kN		D(mm)	HxW(mm)		kg
SLU-10	104	1	16	970	200	60
SLU-30	312	3	54	1130	250	120
SLU-40	416	4	67	1275	250	200
SLU-70	728	7	82	1122	400	230
SLU-120	1248	12	116	1400	400	430
SLU-220	2288	22	167	2100	520	1520
SLU-330	3224	31	190	2140	600	1820
SLU-440	4368	42	228	2050	610	2220
SLU-580	5720	55	254	1780	790	3250

Package 1 - Original

Description	Length	Count	Mat. $	Equip. $	Total Mat. $	Lbr Hr.	Lbr. $	Total Lbr. $	Total $
4000A MS12A DISTRIBUTION SWITCHBOARD		1		$ 67,200.00	$ 67,200.00	80.5	$ 45.00	$ 3,622.50	$ 70,822.50
225A HXMA1 PANELBOARD		7		$ 7,600.00	$ 7,600.00	119	$ 45.00	$ 5,355.00	$ 12,955.00
225A HXMB1 PANELBOARD		7		$ 4,900.00	$ 4,900.00	70	$ 45.00	$ 3,150.00	$ 8,050.00
225A HXL1 PANELBOARD		7		$ 5,400.00	$ 5,400.00	206.5	$ 45.00	$ 9,292.50	$ 14,692.50
400A LXA1 PANELBOARD		7		$ 10,250.00	$ 10,250.00	227.5	$ 45.00	$ 10,237.50	$ 20,487.50
400A LXB1 PANELBOARD		7		$ 5,400.00	$ 5,400.00	175	$ 45.00	$ 7,875.00	$ 13,275.00
112.5 KVA 3PH 480V STEEL FLEX WITH GROUND		7	$ 5,364.33	$ 35,450.00	$ 40,814.33	292.88	$ 45.00	$ 13,179.60	$ 53,993.93
225A CU BUS DUCT	1	14		$ 18,450.00	$ 18,450.00	84.2	$ 45.00	$ 3,789.00	$ 22,239.00
BUS PLUG -> PNL HXMA1 - 2 1/2" EMT [4] 3/0, [1] 6GRD CONC T-ROD	35*7	1	$ 6,566.98		$ 6,566.98	19.94	$ 45.00	$ 897.30	$ 7,464.28
BUS PLUG -> PNL HXL1 - 2 1/2" EMT [40 3/0, [1] 6GRD CONC T-ROD	28*7	1	$ 5,017.60		$ 5,017.60	16.08	$ 45.00	$ 723.60	$ 5,741.20
4000A CU LZ DUCT	390	1	$ 245,700.00		$ 245,700.00	719.9	$ 45.00	$ 32,395.50	$ 278,095.50
Total					$ 417,298.91	2,011.50		$ 90,517.50	**$ 507,816.41**

Package 2 - New

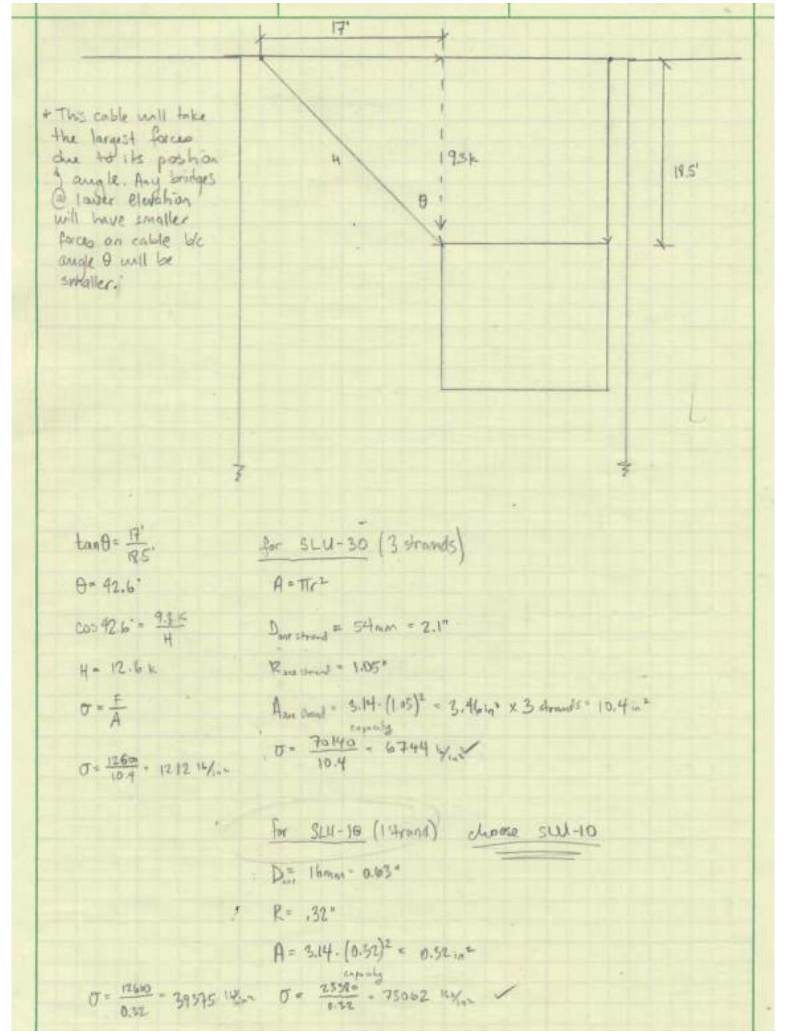
Description	Length	Count	Mat. $	Equip. $	Total Mat. $	Lbr Hr.	Lbr. $	Total Lbr. $	Total $
3000A MS12A DISTRIBUTION SWITCHBOARD		1		$ 40,700.00	$ 40,700.00	80.5	$ 45.00	$ 3,622.50	$ 44,322.50
225A HXMA1 PANELBOARD		7		$ 10,500.00	$ 10,500.00	175	$ 45.00	$ 7,875.00	$ 18,375.00
225A H3L1 PANELBOARD		1		$ 1,500.00	$ 1,500.00	28	$ 45.00	$ 1,260.00	$ 2,760.00
225A H4L1 PANELBOARD		3		$ 4,510.00	$ 4,510.00	75	$ 45.00	$ 3,375.00	$ 7,885.00
225A H5L1 PANELBOARD		3		$ 5,800.00	$ 5,800.00	88.5	$ 45.00	$ 3,982.50	$ 9,782.50
400A L3A1 PANELBOARD		1		$ 1,170.00	$ 1,170.00	25	$ 45.00	$ 1,125.00	$ 2,295.00
400A L3B1 PANELBOARD		7		$ 4,900.00	$ 4,900.00	175	$ 45.00	$ 7,875.00	$ 12,775.00
600A LXA1 PANELBOARD		3		$ 6,500.00	$ 6,500.00	102	$ 45.00	$ 4,590.00	$ 11,090.00
600A LXB1 PANELBOARD		3		$ 3,190.00	$ 3,190.00	88.5	$ 45.00	$ 3,982.50	$ 7,172.50
75 KVA 3PH 480V STEEL FLEX WITH GROUND		1	$ 558.27	$ 4,200.00	$ 4,758.27	28.81	$ 45.00	$ 1,296.45	$ 6,054.72
150 KVA 3PH 480V STEEL FLEX WITH GROUND		3	$ 3,612.46	$ 19,800.00	$ 23,412.46	145.2	$ 45.00	$ 6,534.00	$ 29,946.46
250A CU BUS DUCT	1	3		$ 7,180.00	$ 7,180.00	18.2	$ 45.00	$ 819.00	$ 7,999.00
200A CU BUS DUCT	1	8		$ 16,000.00	$ 16,000.00	48.2	$ 45.00	$ 2,169.00	$ 18,169.00
100A CU BUS DUCT	1	3		$ 4,800.00	$ 4,800.00	12.2	$ 45.00	$ 549.00	$ 5,349.00
BUS PLUG -> PNL H3MA1 - 2 1/2" EMT [4] 3/0, [1] 6GRD CONC T-ROD	35	1	$ 865.17		$ 865.17	19.42	$ 45.00	$ 873.90	$ 1,739.07
BUS PLUG -> PNL H3L1 - 2 1/2" EMT [4] 3/0, [1] 6GRD CONC T-ROD	28	1	$ 716.80		$ 716.80	16.08	$ 45.00	$ 723.60	$ 1,440.40
BUS PLUG -> PNL H4MA1 - 2 1/2" EMT [4] 3/0, [1] 6GRD CONC T-ROD	35	1	$ 840.92		$ 840.92	18.02	$ 45.00	$ 810.90	$ 1,651.82
BUS PLUG -> PNL H4L1 - 1 1/4" EMT [4] 3, [1] 8GRD CONC T-ROD	28	1	$ 243.02		$ 243.02	10.93	$ 45.00	$ 491.85	$ 734.87
BUS PLUG -> PNL H5MA1 - 2 1/2" EMT [4] 3/0, [1] 6GRD CONC T-ROD	35	1	$ 840.92		$ 840.92	18.02	$ 45.00	$ 810.90	$ 1,651.82
BUS PLUG -> PNL H5L1 - 2 1/2" EMT [4] 250, [1] 4 CONC T-ROD	28	1	$ 1,019.43		$ 1,019.43	19.27	$ 45.00	$ 867.15	$ 1,886.58
PNL LXB1 -> PNL LXA1 - 2 1/2" EMT [4] 3/0, [1] 6GRD CONC T-ROD	10*3	1	$ 1,291.08		$ 1,291.08	11.88	$ 45.00	$ 534.60	$ 1,825.68
3000A CU LZ DUCT	390	1	$ 163,800.00		$ 163,800.00	626	$ 45.00	$ 28,170.00	$ 191,970.00
Total					$ 304,538.07	1,829.73		$ 82,337.85	**$ 386,875.92**

Savings **$ 120,940.49**

H(3-9)MA1

V:	480Y/277	Rm # Elec. Rm	10000 AIC	3P - 4W	Fdr:	(4) 3/0 & #6 G.	2-1/2"C	155 kVA		MLO

Designations		VA/Phase			Bkr/Pole/Wire			Designations		VA/Phase			Bkr/Pole/Wire		
Ckt	Description	A	B	C	Bkr	# P	W	Ckt	Description	A	B	C	Bkr	# P	W
1	FPTU (C/5.9)	2510			20	3	#12	2	FPTU (B/5.0)	5820			30	1	#10
3	-		2510		-	-	-	4	FPTU (B/5.0)		5820		30	1	#10
5	-			2510	-	-	-	6	FPTU (B/5.0)			5820	30	1	#10
7	FPTU (C/5.9)	2510			20	3	#12	8	FPTU (B/5.0)	5820			30	1	#10
9	-		2510		-	-	-	10	FPTU (B/4.4)		5220		30	1	#12
11	-			2510	-	-	-	12	FPTU (B/4.4)			5220	30	1	#12
13	FPTU (C/6.6)	2740			20	3	#12	14	FPTU (B/4.4)	5220			30	1	#12
15	-		2740		-	-	-	16	FPTU (B/3.9)		4720		25	1	#12
17	-			2740	-	-	-	18	FPTU (B/3.8)			4720	25	1	#12
19	FPTU (C/6.6)	2740			20	3	#12	20	FPTU (B/3.6)	4420			25	1	#12
21	-		2740		-	-	-	22	FPTU (B/3.7)		4520		25	1	#12
23	-			2740	-	-	-	24	FPTU (B/2.6)			3420	20	1	#12
25	Space	0			0	0	#####	26	FPTU (B/2.6)	3420			20	1	#12
27	Space		0		0	0	#####	28	FPTU (B/-)		1640		20	1	#12
29	FPTU (B/5.0)			5820	30	1	#10	30	FPTU (B/-)			1640	20	1	#12
31	FPTU (B/5.0)	5820			30	1	#10	32	FPTU (B/-)	1640			20	1	#12
33	FPTU (B/5.0)		5820		30	1	#10	34	FPTU (B/-)		1640		20	1	#12
35	FPTU (B/5.0)			5820	30	1	#10	36	FPTU (B/-)			1640	20	1	#12
37	FPTU (B/4.6)	6220			30	1	#10	38	EWH-1	3000			20	3	#12
39	FPTU (B/4.6)		6220		30	1	#10	40	-		3000		-	-	-
41	FPTU (B/4.6)			6220	30	1	#10	42	-			3000	-	-	-



* This cable will take the largest forces due to its position & angle. Any bridges @ lower elevation will have smaller forces on cable b/c angle θ will be smaller.

17'

H

9.3k

θ

18.5'

$\tan\theta = \frac{17'}{18.5'}$

$\theta = 42.6°$

$\cos 42.6° = \frac{9.3k}{H}$

$H = 12.6k$

$\sigma = \frac{F}{A}$

$\sigma = \frac{12600}{10.4} = 1212$ lb/in²

for SLU-30 (3 strands)

$A = \pi r^2$

$D_{one\ strand} = 54mm = 2.1"$

$R_{one\ strand} = 1.05"$

$A_{one\ strand} = 3.14 \cdot (1.05)^2 = 3.46 in^2 \times 3$ strands $= 10.4 in^2$

$\sigma = \frac{\overset{capacity}{70140}}{10.4} = 6744$ lb/in² ✓

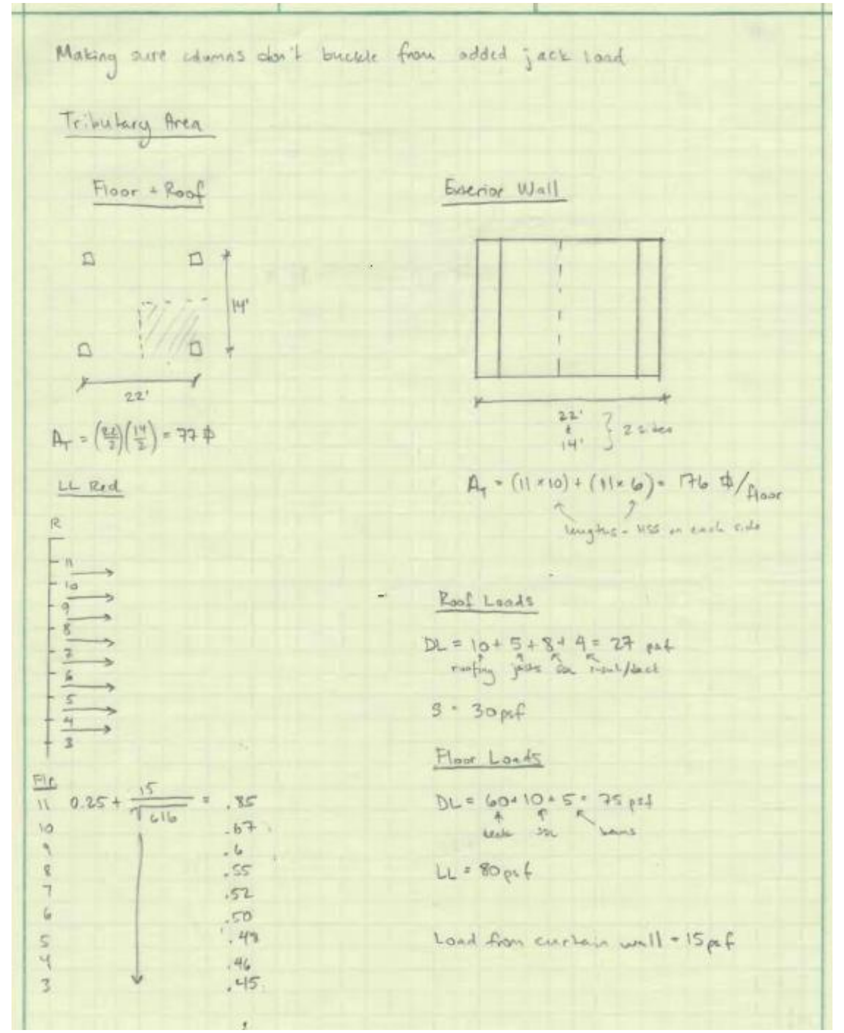
for SLU-10 (1 strand) choose SLU-10

$D_{one} = 16mm = 0.63"$

$R = .32"$

$A = 3.14 \cdot (0.32)^2 = 0.32 in^2$

$\sigma = \frac{12600}{0.32} = 39375$ lb/in² $\sigma = \frac{\overset{capacity}{23380}}{0.32} = 73062$ lb/in² ✓



Making sure columns don't buckle from added jack load

Tributary Area

Floor + Roof

14'

22'

$A_T = \left(\frac{22}{2}\right)\left(\frac{14}{2}\right) = 77$ ft²

LL Red

R, 11, 10, 9, 8, 7, 6, 5, 4, 3

Flr		
11	$0.25 + \frac{15}{\sqrt{616}} =$	.85
10		.67
9		.6
8		.55
7		.52
6		.50
5		.48
4		.46
3		.45

Exterior Wall

22' & 14' } 2 sides

$A_T = (11 \times 10) + (11 \times 6) = 176$ ft²/floor

lengths - HSS on each side

Roof Loads

$DL = \underset{roofing}{10} + \underset{joists}{5} + \underset{conc}{8} + \underset{insul/deck}{4} = 27$ psf

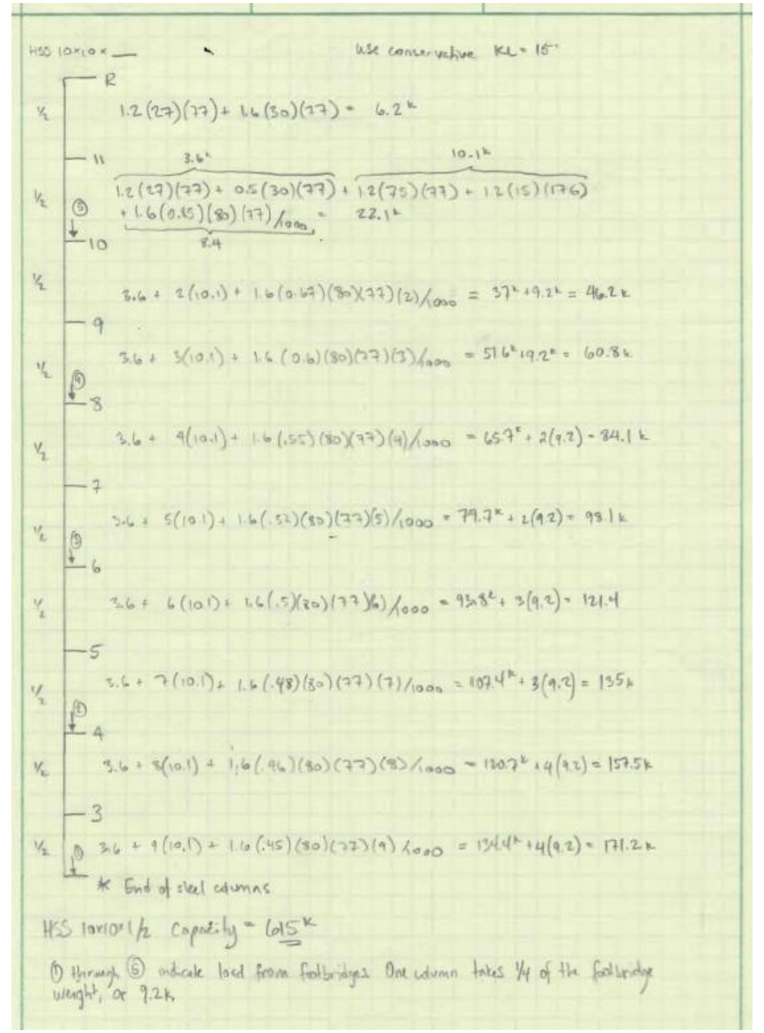
$S = 30$ psf

Floor Loads

$DL = \underset{slab}{60} + \underset{SDL}{10} + \underset{beams}{5} = 75$ psf

$LL = 80$ psf

Load from curtain wall = 15 psf



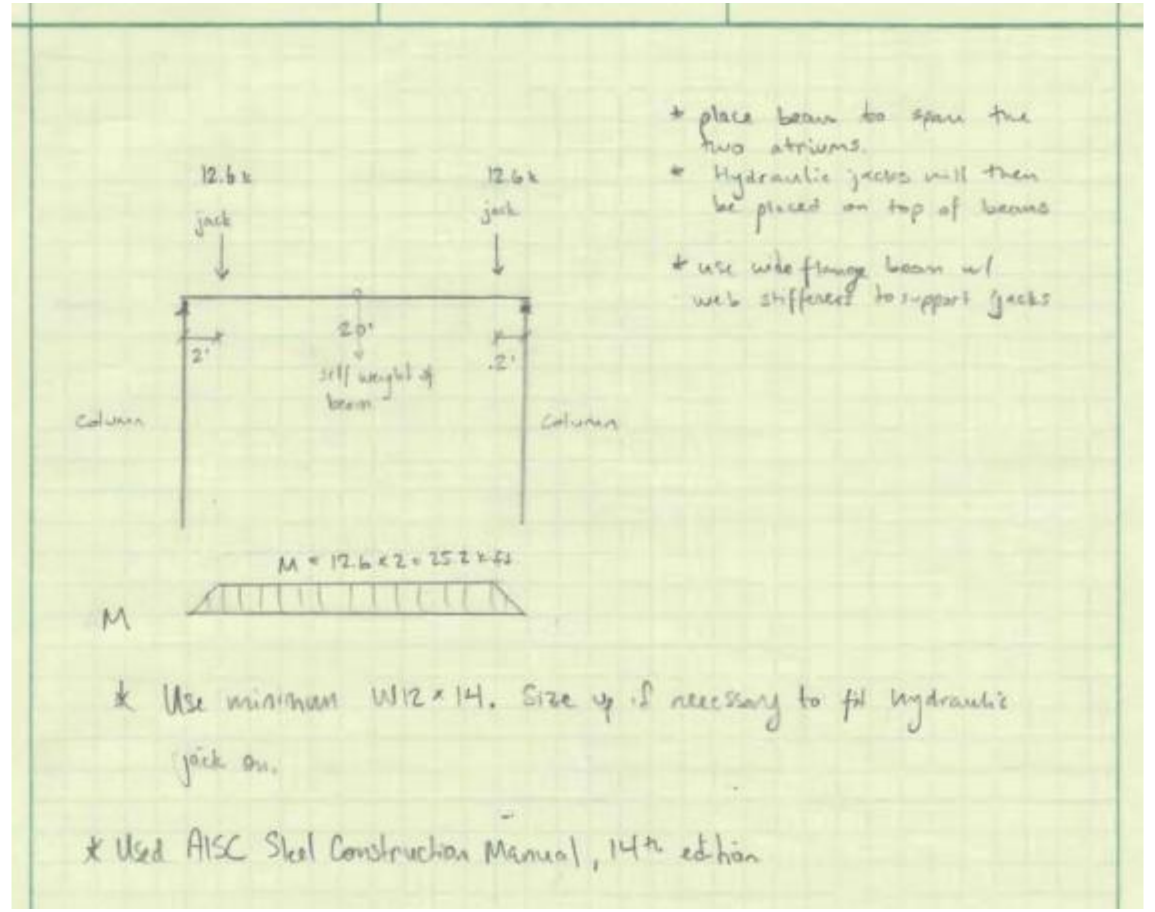
HSS 10x10x ___ use conservative KL = 15'

R		
1/2		$1.2(27)(77) + 1.6(30)(77) = 6.2^k$
11		
1/2	⑤	$\overbrace{1.2(27)(77) + 0.5(30)(77)}^{3.6^k} + \overbrace{1.2(75)(77) + 1.2(15)(176)}^{10.1^k}$ $\underbrace{+ 1.6(0.85)(80)(77)/1000}_{8.4} = 22.1^k$
10		
1/2		$3.6 + 2(10.1) + 1.6(0.67)(80)(77)(2)/1000 = 37^k + 9.2^k = 46.2k$
9		
1/2	④	$3.6 + 3(10.1) + 1.6(0.6)(80)(77)(3)/1000 = 51.6^k + 9.2^k = 60.8k$
8		
1/2		$3.6 + 4(10.1) + 1.6(.55)(80)(77)(4)/1000 = 65.7^k + 2(9.2) = 84.1k$
7		
1/2	③	$3.6 + 5(10.1) + 1.6(.52)(80)(77)(5)/1000 = 79.7^k + 2(9.2) = 98.1k$
6		
1/2		$3.6 + 6(10.1) + 1.6(.5)(80)(77)(6)/1000 = 93.8^k + 3(9.2) = 121.4$
5		
1/2	②	$3.6 + 7(10.1) + 1.6(.48)(80)(77)(7)/1000 = 107.4^k + 3(9.2) = 135k$
4		
1/2		$3.6 + 8(10.1) + 1.6(.46)(80)(77)(8)/1000 = 120.7^k + 4(9.2) = 157.5k$
3		
1/2	①	$3.6 + 9(10.1) + 1.6(.45)(80)(77)(9)/1000 = 134.4^k + 4(9.2) = 171.2k$

* End of steel columns

HSS 10x10x1/2 Capacity = 615^k

① through ⑤ indicate load from footbridges. One column takes 1/4 of the footbridge weight, or 9.2k.



* place beam to span the two atriums
* Hydraulic jacks will then be placed on top of beams
* use wide flange beam w/ web stiffeners to support jacks

12.6k jack   12.6k jack

2'   20'   2'

self weight of beam

column   column

M = 12.6k × 2 = 25.2 k-ft

M

* Use minimum W12×14. Size up if necessary to fit hydraulic jack on.

* Used AISC Steel Construction Manual, 14th edition