The Tower

PENN STATE AE SENIOR THESIS PROJECT

SHIVAM PATEL|CONSTRUCTION MANAGEMENT OPTION

ADVISOR: DR GANNON

The Tower

RESEARCH TOPIC
MATERIAL TRACKING TECHNOLOGIES

ANALYSIS # 1
GUIDED FORMWORK TO SELF CLIMBING

ANALYSIS # 2
IMPLEMENTATION OF PHOTOVOLTAIC CURTAIN WALL
*STRUCTURAL BREADTH
*ELECTRICAL BREADTH

ANALYSIS # 3
SIPS

PENN STATE AE SENIOR THESIS PROJECT

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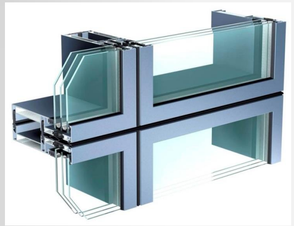
BUILDING PARAMETERS

- **COMMERCIAL HIGH RISE**
- **AREA:** 475, 000 GSF
- **# OF FLOORS:** 32

PROJECT PARAMETERS

- **COST:** $208 M
- **CONTRACT TYPE:** GMP
- **DELIVERY METHOD:** CM AT Risk
- **TIMELINE:** 12/24/12 – 3/3/15 (26 months)

Photo provided of Hines

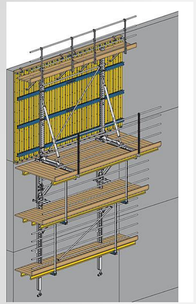


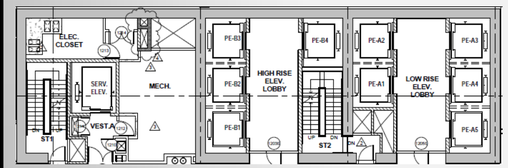
Photos provided by google images

Summary

- Material Tracking can increase productivity and decrease delays
- Complex Coordination
- $6,900 additional cost
- Recommend Implementation

GUIDED FORMWORK TO SELF CLIMBING





Layout provided by Turner

PROBLEM

- One full work day to lift system
- Multiple lifts
- Safety Concerns

Background

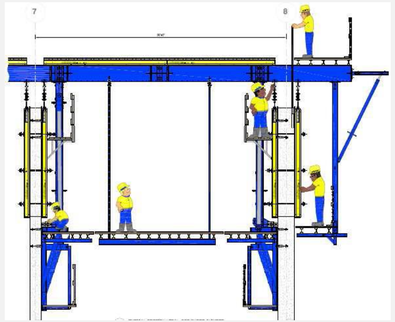
- X Climb 60 manufactured by Doka
- Guiding Shoes and Hydraulic Lifts are used
- 26 lifts

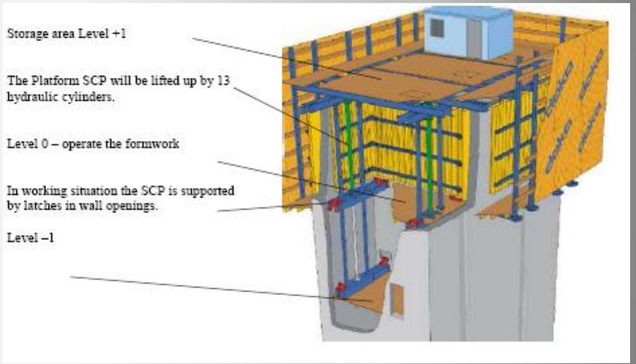
Photos provided by Doka

GUIDED FORMWORK TO SELF CLIMBING

Background

- Super Climber manufactured by Doka
- Interior and exterior formwork raised all at once
- Closed System





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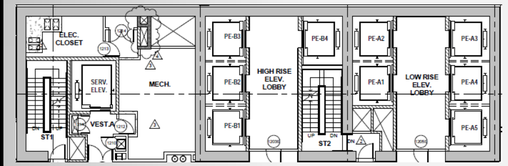
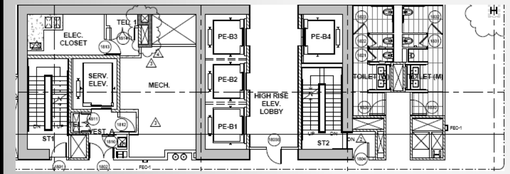
GUIDED FORMWORK TO SELF CLIMBING





Photos provided by Turner

Current Schedule

- Five Day Cycle (Three Bay System)
- Four Day Cycle (Two Bay System)

Proposed Schedule

- Four Day Cycle (Three Bay System)
- Three Day Cycle (Two Bay System)

Results

- Saves 30 working days

Original Concrete Core Schedule		
Lift Formwork from 3rd Floor to 4th Floor	Monday	11/4/2013
Install Rebar and Embeds for 4th Floor	Tuesday	11/5/2013
Install Rebar and Embeds for 4th Floor	Wednesday	11/6/2013
Install Rebar and Embeds for 4th Floor	Thursday	11/7/2013
Install Remaining Rebar and Embeds & Pour 4th Floor Concrete Core Walls	Friday	11/8/2013
New Concrete Core Schedule		
Lift Formwork From 3rd Floor to 4th Floor/ Start Install of Rebar and Embeds for 4th Floor	Tuesday	10/29/2013
Install Rebar and Embeds for 4th Floor	Wednesday	10/30/2013
Install Rebar and Embed for 4th Floor	Thursday	10/31/2013
Install Remaining Rebar and Embeds & Pour 4th Floor Concrete Core Walls	Friday	11/1/2013

GUIDED FORMWORK TO SELF CLIMBING

System Expense

- $174,000 Difference

Labor Savings

- $1.5 Million Saved

Xclimb 60 Formwork System				
Description	Rate	Unit	Quantity	Total
Below 18th Floor	$ 1,820.00	Day	143	$260,260.00
18th Floor & Above	$ 1,104.54	Day	57	$ 62,958.78
Purchase Items - All Lifts	$79,424.00	EA	1	$ 79,424.00
Frieght to & from Jobsite	$28,800.00	EA	1	$ 28,800.00
Total				$431,442.78
Super Climber Formwork System				
Description	Rate	Unit	Quantity	Total
Below 18th Floor	$ 2,691.40	Day	125	$336,425.00
18th Floor & Above	$ 1,975.57	Day	45	$ 88,900.65
Purchase Items - All Lifts	$79,424.00	EA	1	$ 79,424.00
Pre Assembly	$71,952.00	EA	1	$ 71,952.00
Freight to & from Jobsite	$28,800.00	EA	1	$ 28,800.00
Total				$605,501.65

Xclimb 60 Formwork System				
Description	Rate	Unit	Quantity	Total
Concrete Crane	$62,500.00	Month	11	$ 687,500.00
Concrete Placing Boom	$27,400.00	Month	11	$ 301,400.00
Tower Crane Operator (1)	$ 125.89	Hour	2100	$ 264,369.00
Maintenance (1)	$ 103.29	Hour	2100	$ 216,909.00
Pump Operator (1)	$ 99.67	Hour	2100	$ 209,307.00
Oiler (2)	$ 90.21	Hour	2100	$ 378,882.00
Laborers (9)	$ 111.45	Hour	2100	$ 2,106,405.00
Carpenters (9)	$ 89.34	Hour	2100	$ 1,688,526.00
Ironworkers (16)	$ 91.41	Hour	2100	$ 3,071,376.00
Lathers (12)	$ 85.36	Hour	2100	$ 2,151,072.00
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Laborers (9)	$ 111.45	Hour	1800	$ 1,805,490.00
Carpenters (9)	$ 89.34	Hour	1800	$ 1,447,308.00
Ironworkers (16)	$ 91.41	Hour	1800	$ 2,632,608.00
Lathers (12)	$ 85.36	Hour	1800	$ 1,843,776.00
Total				$ 9,544,868.00

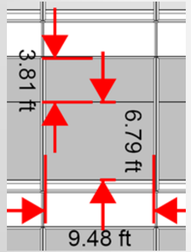
Background

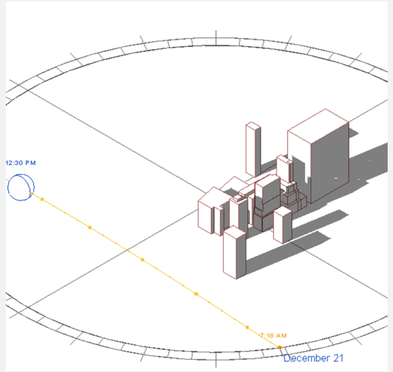
- Photovoltaic Arrays becoming increasingly popular
  - Reduces amount of electricity purchased
  - Federal and State incentives
  - Adds value

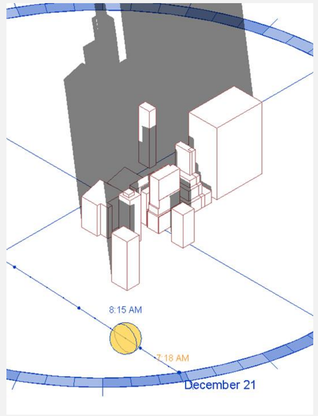
Photos provided by Google Images

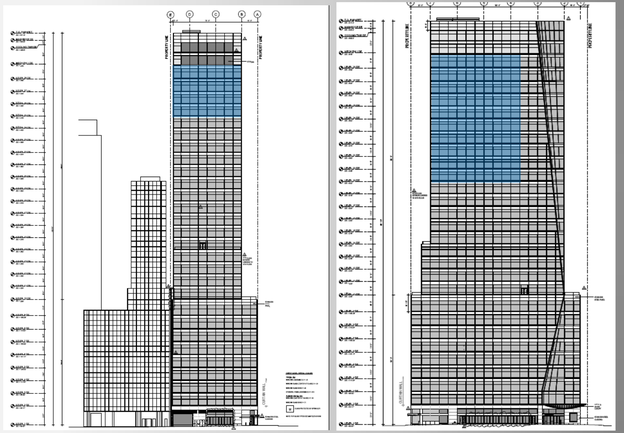
Solar Study

- Determined area of installation
  - Floors 19-28 (East Side)
  - Floors 25-28 (South Side)
    - 264 PV Units
    - 13,500 Square Feet







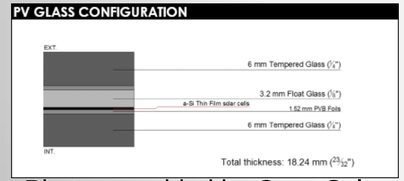


Photos provided by Turner

PHOTOVOLTAIC CURTAIN WALL

Panel Specifications

- 20% Transparency
- Junction Boxes Included



Photos provided by Onyx Solar

9.5 X 3.8 Panel		
Specification	**#**	**Unit**
Nominal Peak Power	133.65	Watts
Open Circuit Voltage	185	Volts
Short Circuit Voltage	1.1	Amps
Voltage at Nominal Power	140	Volts
Current at Nominal Power	0.97	Amps
Weight	285.5	Lbs

9.5 X 6.8 Panel		
Specification	**#**	**Unit**
Nominal Peak Power	237.79	Watts
Open Circuit Voltage	185	Volts
Short Circuit Voltage	1.94	Amps
Voltage at Nominal Power	140	Volts
Current at Nominal Power	1.724	Amps
Weight	507.98	Lbs

PV Generation

- Determined energy generated
- Peak Power 37.14 kW and 11.88 kW

RESULTS

ELECTRICITY GENERATED PER YEAR
30,523 kWh

TOTAL HOURS OF LIGHT GENERATED PER YEAR
1,526,150 hours *

AVOIDED CO_2 EMMISIONS PER YEAR
20,450 Kg CO2

ELECTRIC CAR MILEAGE THANKS TO THE ENERGY GENERATED
226,096 km

* Calculated with energy efficient light bulbs of 20W (light intensity equivalent to a traditional incandescent light bulb of 100W)

Month	E_d	E_m	H_d	H_m
January	68.03	2,109.00	2.04	63.24
February	82.00	2,296.00	2.46	68.88
March	92.61	2,871.00	2.88	89.28
April	93.60	2,868.00	3.02	90.60
May	94.94	2,943.00	3.07	95.17
June	89.67	2,690.00	2.99	89.70
July	89.61	2,778.00	3.03	93.93
August	94.81	2,939.00	3.16	97.96
September	92.03	2,761.00	3.02	90.60
October	83.81	2,598.00	2.69	83.39
November	62.37	1,871.00	2.04	61.20
December	58.03	1,799.00	1.82	56.42
Yearly average	83.63	2,543.58	2.69	81.70
Total for year		30,523.00		980.37

RESULTS

ELECTRICITY GENERATED PER YEAR
10,544 kWh

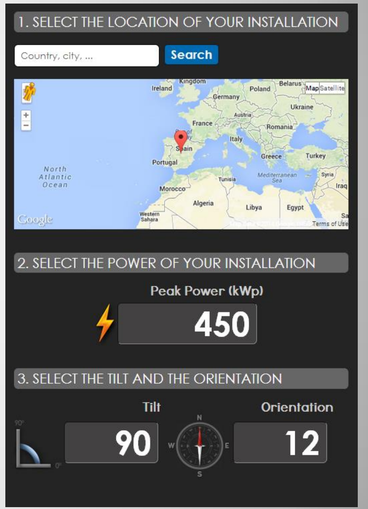
TOTAL HOURS OF LIGHT GENERATED PER YEAR
527,200 hours *

AVOIDED CO_2 EMMISIONS PER YEAR
7,064 Kg CO2

ELECTRIC CAR MILEAGE THANKS TO THE ENERGY GENERATED
78,104 km

* Calculated with energy efficient light bulbs of 20W (light intensity equivalent to a traditional incandescent light bulb of 100W)

Month	E_d	E_m	H_d	H_m
January	30.23	937.00	2.78	86.18
February	32.75	917.00	3.03	84.84
March	34.52	1,070.00	3.38	104.78
April	29.00	870.00	2.99	89.70
May	24.77	768.00	2.72	84.32
June	22.73	682.00	2.60	78.00
July	22.84	708.00	2.62	81.22
August	25.61	794.00	2.84	88.04
September	32.13	964.00	3.38	101.40
October	34.74	1,077.00	3.45	106.95
November	28.47	854.00	2.78	83.40
December	29.13	903.00	2.73	84.63
Yearly average	28.91	878.67	2.94	89.46
Total for year		10,544.00		1,073.46



Costs Analysis

- Reduces tenants electric bill
- Federal and State Incentives
- IRS Private Letter Ruling 2009
- Energy property is depreciated
- 30% Investment Tax Credit
  - Year 1: ($27,109)
  - Year 2: $112,846

Cost Comparison of Glass			
	Cost Per Square Foot	Square Footage	System Cost
Originial Glass	$ 20.00	$ 13,200.00	$ 264,000.00
Photovoltaic Glass	$ 34.60	$ 13,200.00	$ 456,720.00
			$ (192,720.00)

Original Module Vs Photovoltaic Module				
	Module Cost	Installation Cost	Number of Modules	System Cost
Original Module	$ 2,500.00	$ 750.00	$ 264.00	$ 858,000.00
Photovoltaic Module	$ 3,985.00	$ 1,595.00	$ 264.00	$ 1,473,120.00
				$ (615,120.00)

$2500 – ($20 $\frac{\$}{SF}$ x 101.65 SF) = Cost of Remaining materials = $470

Month	# days per month	Solar Energy (Daily) South Side	Solar Energy (Monthly) South Side	Solar Energy (Daily) East Side	Solar Energy (Monthly) East Side	Total Solar Energy	Con Ed Rate ($/kWh)	Monthly Total
January	31	30.23	937.13	68.03	2108.93	3046.06	$ 0.03	$ 76.15
February	28	32.75	917	82	2296	3213	$ 0.03	$ 80.33
March	31	34.52	1070.12	92.61	2870.91	3941.03	$ 0.03	$ 98.53
April	30	29	870	95.6	2868	3738	$ 0.03	$ 93.45
May	31	24.77	767.87	94.94	2943.14	3711.01	$ 0.03	$ 92.78
June	30	22.73	681.9	89.67	2690.1	3372	$ 0.03	$ 84.30
July	31	22.84	708.04	89.61	2777.91	3485.95	$ 0.03	$ 87.15
August	31	25.61	793.91	94.81	2939.11	3733.02	$ 0.03	$ 93.33
September	30	32.13	963.9	92.03	2760.9	3724.8	$ 0.03	$ 93.12
October	31	34.74	1076.94	83.81	2598.11	3675.05	$ 0.03	$ 91.88
November	30	28.47	854.1	62.37	1871.1	2725.2	$ 0.03	$ 68.13
December	31	29.13	903.03	58.03	1798.93	2701.96	$ 0.03	$ 67.55
			10543.94		30523.14	41067.08		$ 1,026.68

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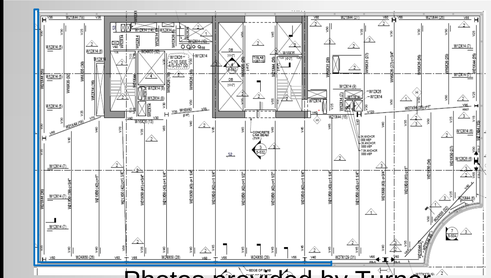
PHOTOVOLTAIC CURTAIN WALL

Turner Construction Company

Hines

- PROJECT BACKGROUND
- RESEARCH TOPIC: MATERIAL TRACKING
- ANALYSIS #1: GUIDED FORMWORK TO SELF-CLIMBING
- ANALYSIS #2: PHOTVOLTAIC CURTAINWALL
- STRUCTURAL BREADTH
- ANALYSIS #3: SIPS
- CONCLUSIONS
- ACKNOWLEGEMENTS



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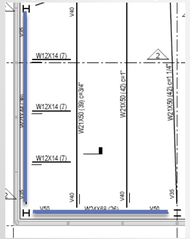
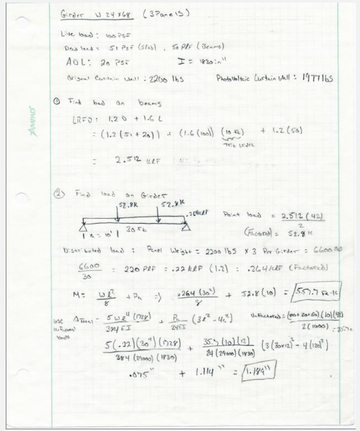
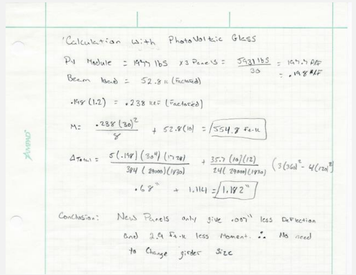
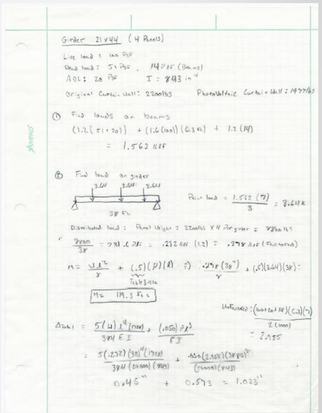


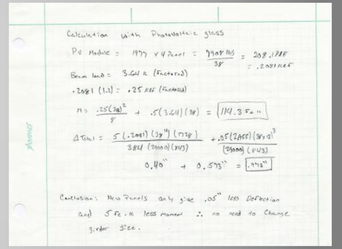




Results

- 0.007″ less Deflection
- 2.9 ft-k less moment





Results

- 0.05″ less Deflection
- 5 ft-k less moment

PROBLEM

- Greater need for coordination
- Core is first activity for each floor

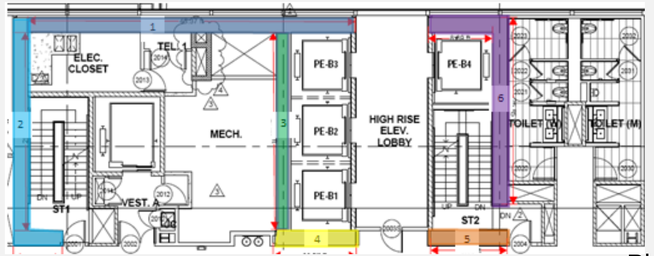
Background

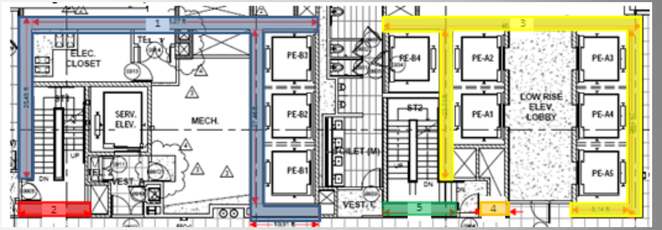
- SIPS breaks down project sequence
- Used on highly repetitive projects
- Project split into construction zones
- Benefit for subcontractor and project team

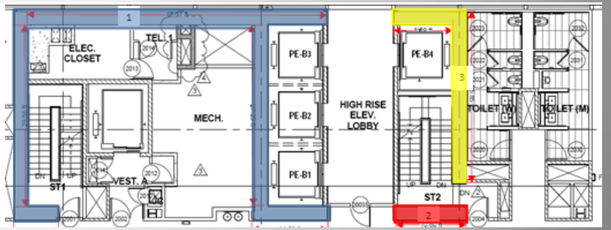
Original Concrete Core Schedule		
Lift Formwork from 3rd Floor to 4th Floor	Monday	11/4/2013
Install Rebar and Embeds for 4th Floor	Tuesday	11/5/2013
Install Rebar and Embeds for 4th Floor	Wednesday	11/6/2013
Install Rebar and Embeds for 4th Floor	Thursday	11/7/2013
Install Remaining Rebar and Embeds & Pour 4th Floor Concrete Core Walls	Friday	11/8/2013
New Concrete Core Schedule		
Lift Formwork From 3rd Floor to 4th Floor/ Start Install of Rebar and Embeds for 4th Floor	Tuesday	10/29/2013
Install Rebar and Embeds for 4th Floor	Wednesday	10/30/2013
Install Rebar and Embed for 4th Floor	Thursday	10/31/2013
Install Remaining Rebar and Embeds & Pour 4th Floor Concrete Core Walls	Friday	11/1/2013

Durations

- 44 and 30 Tons of rebar
- 246 and 172 Cubic Yards
- 10 hour workdays
- 1.26 and 1.2 tons/hour
- Crew increase from 16 to 32 men
- 2.52 and 2.4 tons/hour
- 49.2 and 34.4 cubic yards/hour



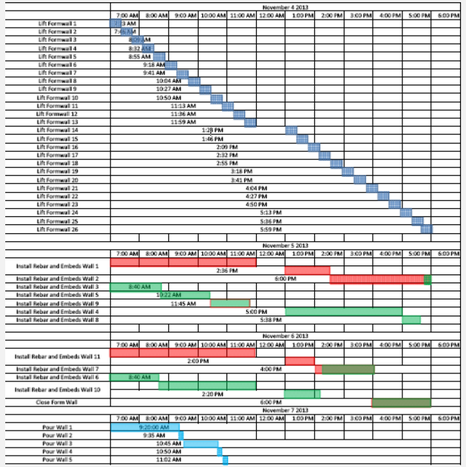




Photos provided by Turner

Schedule Impact

- Decreases 1 ½ days per week
  - Saves 30 working days
- 180 days for Xclimb (3/17/14)
- 150 days for Super Climber(2/19/14)



Cost Impact

- Xclimb 60: $1 Million increase
- Super Climber: $570,000 Increase
- Activities that follow core have potential to start sooner

Xclimb 60 Formwork System with out SIPS

Description	Rate	Unit	Quantity	Total
Concrete Crane	$62,500.00	Month	11	$ 687,500.00
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Tower Crane Operator (1)	$ 125.89	Hour	2100	$ 264,369.00
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Pump Operator (1)	$ 99.67	Hour	1575	$ 156,980.25
Oiler (2)	$ 90.21	Hour	1575	$ 284,161.50
Laborers (9)	$ 111.45	Hour	1800	$ 1,805,490.00
Carpenters (9)	$ 89.34	Hour	1800	$ 1,447,308.00
Ironworkers (32)	$ 91.41	Hour	1800	$ 5,265,216.00
Lathers (12)	$ 85.36	Hour	1800	$ 1,843,776.00
Total				$12,114,455.75

Super Climber without SIPS

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Pump Operator (1)	$ 99.67	Hour	1800	$ 179,406.00
Oiler (2)	$ 90.21	Hour	1800	$ 324,756.00
Laborers (9)	$ 111.45	Hour	1800	$ 1,805,490.00
Carpenters (9)	$ 89.34	Hour	1800	$ 1,447,308.00
Ironworkers (16)	$ 91.41	Hour	1800	$ 2,632,608.00
Lathers (12)	$ 85.36	Hour	1800	$ 1,843,776.00
Total				$ 9,544,868.00

Super Climber with SIPS

Description	Rate	Unit	Quantity	Total
Concrete Crane	$62,500.00	Month	8	$ 500,000.00
Concrete Placing Boom	$27,400.00	Month	8	$ 219,200.00
Tower Crane Operator (1)	$ 125.89	Hour	1500	$ 188,835.00
Maintenance (1)	$ 103.29	Hour	1500	$ 154,935.00
Pump Operator (1)	$ 99.67	Hour	1500	$ 149,505.00
Oiler (2)	$ 90.21	Hour	1500	$ 270,630.00
Laborers (9)	$ 111.45	Hour	1500	$ 1,504,575.00
Carpenters (9)	$ 89.34	Hour	1500	$ 1,206,090.00
Ironworkers (32)	$ 91.41	Hour	1500	$ 4,387,680.00
Lathers (12)	$ 85.36	Hour	1500	$ 1,536,480.00
Total				$10,117,930.00

Research Topic: Material Tracking Technologies

- Cost $6,900 To Implement System
- One Time Cost
- Alleviates Potential Risks

Analysis #1: Guided Formwork To Self Climbing

- Accelerated Schedule by 30 days
- Increase Cost of $174,058.87
- Saves $1,530,878 off General Conditions
- Safer Working Conditions

Analysis #2: Photovoltaic Curtain Wall

- Saves $1000 Off Electrical Bill
- Increase in $615,120
- Owner Sees Payback Within Two Years through Tax Incentives

Analysis #3: SIPS

- Accelerated Schedule by 30 days
- Increased Cost of $1 M and $570,000
- Activities Potentially Can Start Sooner

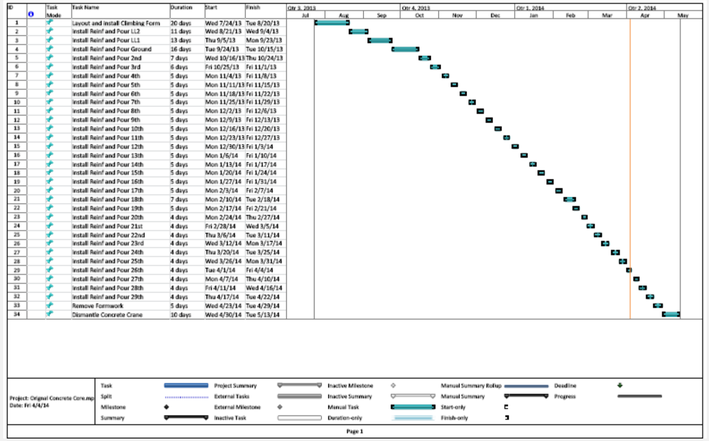
ACKNOWLEDGMENTS

Turner Construction Company
Hines
Dr Ed Gannon: Thesis Advisor
Penn State AE Faculty
Family
Fellow AE Students

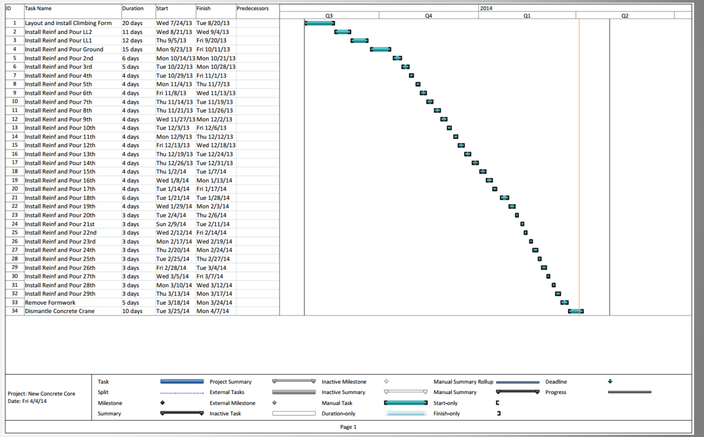
Photos provided by Hines

QUESTIONS?

APPENDICES



ID	Task Mode	Task Name	Duration	Start	Finish
1		Layout and Install Climbing Form	20 days	Wed 7/24/13	Tue 8/20/13
2		Install Reinf and Pour LL2	11 days	Wed 8/21/13	Wed 9/4/13
3		Install Reinf and Pour LL1	13 days	Thu 9/5/13	Mon 9/23/13
4		Install Reinf and Pour Ground	16 days	Tue 9/24/13	Tue 10/15/13
5		Install Reinf and Pour 2nd	7 days	Wed 10/16/13	Thu 10/24/13
6		Install Reinf and Pour 3rd	6 days	Fri 10/25/13	Fri 11/1/13
7		Install Reinf and Pour 4th	5 days	Mon 11/4/13	Fri 11/8/13
8		Install Reinf and Pour 5th	5 days	Mon 11/11/13	Fri 11/15/13
9		Install Reinf and Pour 6th	5 days	Mon 11/18/13	Fri 11/22/13
10		Install Reinf and Pour 7th	5 days	Mon 11/25/13	Fri 11/29/13
11		Install Reinf and Pour 8th	5 days	Mon 12/2/13	Fri 12/6/13
12		Install Reinf and Pour 9th	5 days	Mon 12/9/13	Fri 12/13/13
13		Install Reinf and Pour 10th	5 days	Mon 12/16/13	Fri 12/20/13
14		Install Reinf and Pour 11th	5 days	Mon 12/23/13	Fri 12/27/13
15		Install Reinf and Pour 12th	5 days	Mon 12/30/13	Fri 1/3/14
16		Install Reinf and Pour 13th	5 days	Mon 1/6/14	Fri 1/10/14
17		Install Reinf and Pour 14th	5 days	Mon 1/13/14	Fri 1/17/14
18		Install Reinf and Pour 15th	5 days	Mon 1/20/14	Fri 1/24/14
19		Install Reinf and Pour 16th	5 days	Mon 1/27/14	Fri 1/31/14
20		Install Reinf and Pour 17th	5 days	Mon 2/3/14	Fri 2/7/14
21		Install Reinf and Pour 18th	7 days	Mon 2/10/14	Tue 2/18/14
22		Install Reinf and Pour 19th	5 days	Mon 2/17/14	Fri 2/21/14
23		Install Reinf and Pour 20th	4 days	Mon 2/24/14	Thu 2/27/14
24		Install Reinf and Pour 21st	4 days	Fri 2/28/14	Wed 3/5/14
25		Install Reinf and Pour 22nd	4 days	Thu 3/6/14	Tue 3/11/14
26		Install Reinf and Pour 23rd	4 days	Wed 3/12/14	Mon 3/17/14
27		Install Reinf and Pour 24th	4 days	Thu 3/20/14	Tue 3/25/14
28		Install Reinf and Pour 25th	4 days	Wed 3/26/14	Mon 3/31/14
29		Install Reinf and Pour 26th	4 days	Tue 4/1/14	Fri 4/4/14
30		Install Reinf and Pour 27th	4 days	Mon 4/7/14	Thu 4/10/14
31		Install Reinf and Pour 28th	4 days	Fri 4/11/14	Wed 4/16/14
32		Install Reinf and Pour 29th	4 days	Thu 4/17/14	Tue 4/22/14
33		Remove Formwork	5 days	Wed 4/23/14	Tue 4/29/14
34		Dismantle Concrete Crane	10 days	Wed 4/30/14	Tue 5/13/14

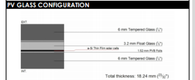


ID	Task Name	Duration	Start	Finish	Predecessors
1	Layout and install Climbing Form	20 days	Wed 7/24/13	Tue 8/20/13	
2	Install Reinf and Pour LL2	11 days	Wed 8/21/13	Wed 9/4/13	
3	Install Reinf and Pour LL1	12 days	Thu 9/5/13	Fri 9/20/13	
4	Install Reinf and Pour Ground	15 days	Mon 9/23/13	Fri 10/11/13	
5	Install Reinf and Pour 2nd	6 days	Mon 10/14/13	Mon 10/21/13	
6	Install Reinf and Pour 3rd	5 days	Tue 10/22/13	Mon 10/28/13	
7	Install Reinf and Pour 4th	4 days	Tue 10/29/13	Fri 11/1/13	
8	Install Reinf and Pour 5th	4 days	Mon 11/4/13	Thu 11/7/13	
9	Install Reinf and Pour 6th	4 days	Fri 11/8/13	Wed 11/13/13	
10	Install Reinf and Pour 7th	4 days	Thu 11/14/13	Tue 11/19/13	
11	Install Reinf and Pour 8th	4 days	Thu 11/21/13	Tue 11/26/13	
12	Install Reinf and Pour 9th	4 days	Wed 11/27/13	Mon 12/2/13	
13	Install Reinf and Pour 10th	4 days	Tue 12/3/13	Fri 12/6/13	
14	Install Reinf and Pour 11th	4 days	Mon 12/9/13	Thu 12/12/13	
15	Install Reinf and Pour 12th	4 days	Fri 12/13/13	Wed 12/18/13	
16	Install Reinf and Pour 13th	4 days	Thu 12/19/13	Tue 12/24/13	
17	Install Reinf and Pour 14th	4 days	Thu 12/26/13	Tue 12/31/13	
18	Install Reinf and Pour 15th	4 days	Thu 1/2/14	Tue 1/7/14	
19	Install Reinf and Pour 16th	4 days	Wed 1/8/14	Mon 1/13/14	
20	Install Reinf and Pour 17th	4 days	Tue 1/14/14	Fri 1/17/14	
21	Install Reinf and Pour 18th	6 days	Tue 1/21/14	Tue 1/28/14	
22	Install Reinf and Pour 19th	4 days	Wed 1/29/14	Mon 2/3/14	
23	Install Reinf and Pour 20th	3 days	Tue 2/4/14	Thu 2/6/14	
24	Install Reinf and Pour 21st	3 days	Sun 2/9/14	Tue 2/11/14	
25	Install Reinf and Pour 22nd	3 days	Wed 2/12/14	Fri 2/14/14	
26	Install Reinf and Pour 23rd	3 days	Mon 2/17/14	Wed 2/19/14	
27	Install Reinf and Pour 24th	3 days	Thu 2/20/14	Mon 2/24/14	
28	Install Reinf and Pour 25th	3 days	Tue 2/25/14	Thu 2/27/14	
29	Install Reinf and Pour 26th	3 days	Fri 2/28/14	Tue 3/4/14	
30	Install Reinf and Pour 27th	3 days	Wed 3/5/14	Fri 3/7/14	
31	Install Reinf and Pour 28th	3 days	Mon 3/10/14	Wed 3/12/14	
32	Install Reinf and Pour 29th	3 days	Thu 3/13/14	Mon 3/17/14	
33	Remove Formwork	5 days	Tue 3/18/14	Mon 3/24/14	
34	Dismantle Concrete Crane	10 days	Tue 3/25/14	Mon 4/7/14	

PHOTOVOLTAIC GLASS	1245 x 2456 mm	
63689-12452456-20	M	Clear-20%
Electrical data test conditions (STC)		
Nominal peak power	120.00	P_{max} (W-p)
Open-circuit voltage	185.00	V_{oc} (V)
Short-circuit current	0.98	I_{sc} (A)
Voltage at nominal power	140.00	V_{mpp} (V)
Current at nominal power	0.87	I_{mpp} (A)
Power tolerance not to exceed	±5	%
STC: 1000 w/m², AM 1.5 and a cell temperature of 25°C, standard module data.		
Mechanical description		
Length	1245	mm
Width	2456	mm
Thickness	18.24	mm
Surface area	3.06	m²
Weight	116.28	Kg
Cell type	a-Si	thin Film
Transparency degree	M	Clear-20%
First layer	3 mm	Tempered Glass
Second layer	3.2 mm	Float Glass
Third layer	6 mm	Tempered Glass
Thickness encapsulation	3.04 mm	PVB Foils
Junction Box		
Protection	IP65	
Wiring Section	2.5 mm² or 4.0 mm²	
Limits		
Maximum system voltage	1000	V_{sys} (V)
Operating module temperature	-40...+85	°C
Temperature Coefficients		
Temperature Coefficient of P_{max}	-0.19	%/°C
Temperature Coefficient of V_{oc}	-0.28	%/°C
Temperature Coefficient of I_{sc}	+0.09	%/°C

PV GLASS DIMENSIONS

PV GLASS CONFIGURATION



NOTES

* For optical and further mechanical properties, please go to: Annex 01 - Other Properties.
* Optional: Insulating Glass Unit: U-value (W/sqm.K), please go to: Annex 02 - Insulating Glass Unit.
* Junction box type and configuration could be adapted for clients request or project needs.

Physical Assumptions	
Area of South PV Curtain Wall in SF	3,253
Area of East PV Curtain wall in SF	10,165
Number of Unitized PV Curtain Wall Modules	264
Average SF/module	102

Energy Assumptions	
PV Glass - DC watts/SF Rating	5.00
TOTAL DC Watts	**67,089**
PV Base Year Output - South Wall kWh	10,544
PV Base Year Output - East Wall	30,523
TOTAL System kWh	**41,067**
Base Year Utility Rate	$0.025
Annual Energy Savings Escalation	3.50%

Investment/Return Assumptions	
Maint/Repairs/Insurance ($/watt)	$0.015
Operating Exp Annual Escalation	2.0%
Solar Investment Tax Credit	30%
Individual Tax Rate (incl. state)	41.0%

Capital Cost	
15th Year Inverter Replacement Cost/watt	$0.31
Balance of System (BOS) & install Cost/watt	$1.50
PV Glass Cost/SF	$34.60
Non-PV Glass Cost/SF	$20.00
Installed PV Glass Cost Premium/SF	**$14.60**
Module Cost w/o PV Glass	$2,500
Unitized Curtain Wall Cost in PV area	$858,000
PV Glass Cost Premium	$456,720
BOS & Install Cost for PV Glass	$67,098

Standard Unitized Curtain Wall 39.5 Year Depreciation Schedule	YEAR 0	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7
	($858,000)	($22,000)	($22,000)	($22,000)	($22,000)	($22,000)	($22,000)	($22,000)

PV Curtain Wall INVESTMENT/RETURN ANALYSIS	YEAR 0	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7
PV Degradation Factor		0.00	0.995	0.990	0.985	0.980	0.975	0.970
kWh Generated		41,067	40,862	40,656	40,451	40,246	40,040	39,835
Avg. Annual Utility Rate		0.025	0.026	0.027	0.028	0.029	0.030	0.031
Energy Savings		**$1,027**	**$1,057**	**$1,089**	**$1,121**	**$1,155**	**$1,189**	**$1,224**
Value/SREC		$25.00	$25.00	$25.00	$25.00	$25.00	$25.00	$25.00
SREC's		41.07	40.86	40.66	40.45	40.25	40.04	39.83
SREC Income		**$1,027**	**$1,022**	**$1,016**	**$1,011**	**$1,006**	**$1,001**	**$996**
Maint/Repairs/Insurance		($1,006)	($1,026)	($1,047)	($1,068)	($1,089)	($1,111)	($1,133)
Inverter Replacement								
Operating Expenses		**($1,006)**	**($1,026)**	**($1,047)**	**($1,068)**	**($1,089)**	**($1,111)**	**($1,133)**
Net Operating Income		**$1,047**	**$1,052**	**$1,058**	**$1,065**	**$1,071**	**$1,079**	**$1,087**
Net Present Value @ 7%	$5,028.85							
LESS: PV@6% of 39.5 yr Curtain Wall Deprec.		$36,016	$36,016	$36,016	$36,016	$36,016	$36,016	
PV Glass & BOS/Install MACRS Depreciation		($89,049)	($142,478)	($85,487)	($51,292)	($51,292)	($25,646)	
Unitized Curtain Wall Depreciation		($145,860)	($233,376)	($140,026)	($84,015)	($84,015)	($42,008)	
Inverter Replacement Depreciation								
Net Gain/Loss		**($197,846)**	**($338,786)**	**($188,438)**	**($98,227)**	**($98,220)**	**($30,559)**	
Net Present Value @ 7% (Value of present)	$327,984.61							
Value of Losses to Offset Other Income Tax		**$81,117**	**$138,902**	**$77,260**	**$40,273**	**$40,270**	**$12,529**	
PV Glass & BOS/Install ITC		$157,145						
Unitized Curtain Wall Investment Tax Credit		$257,400						
Total Investment Tax Credit		**$414,545**						
NET AFTER TAX CASH FLOW		**$496,709**	**$139,955**	**$78,318**	**$41,338**	**$41,342**	**$13,608**	**$641**
SOLAR Investment/Return	**($523,818)**	**$496,709**	**$139,955**	**$78,318**	**$41,338**	**$41,342**	**$13,608**	**$641**
Cumulative Return	**($523,818)**	**($27,109)**	**$112,846**	**$191,164**	**$232,501**	**$273,843**	**$287,451**	**$288,092**

With PV curtain wall, some or all of the glass is substituted with PV panes, and typically comes in one of two solar configurations (Silicon and Thin Film) and one of two glass configurations (Vision and Spandrel). Both solar configurations and both glass configurations may be utilized on the PV curtain wall. Current and developing PV technology creates a "tinted" glass that one can see through while it is still generating electricity. Developing PV technology enables virtually 100% of the surface area of the side of a building to generate electricity without impairing the occupants' view outside or the basic configuration of the building for space planning purposes.

It provides for both vertical and horizontal wiring to accommodate various building techniques and solar requirements.

PV curtain wall is shipped to the jobsite for installation.

Ruling Requested

The elements of the purchase price of the PV curtain wall, as described above, constitute energy property under § 48 of the Internal Revenue Code (the Code).

Law and Analysis

Section 48(a) of the Code provides for an energy credit equal to 30 percent of the cost basis of qualifying energy property placed in service before January 1, 2017.

Section 48(a)(3)(A)(i) of the Code provides that energy property includes equipment which uses solar energy to generate electricity, to heat or cool (or provide hot water for use in) a structure, or to provide solar process heat, excepting property used to generate energy for the purposes of heating a swimming pool.

Treasury Reg. § 1.48-9(a)(2) provides that in order to qualify as "energy property" under § 48 of the Code, property must be depreciable property with an estimated useful life when placed in service of at least three years and constructed after certain dates.

Treasury Reg. § 1.48-9(d)(1) provides as follows:

(d) Solar energy property--(1) In general. Energy property includes solar energy property. The term "solar energy property" includes equipment and materials (and parts related to the functioning of such equipment) that use

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electricity through the use of solar energy.

PV curtain wall is sold as one complete product that uses solar energy to generate electricity.

iMac

Although structural components of buildings are generally excluded from the definition of "section 38 property" for purposes of the investment tax credit, the PV curtain wall has been specifically designed and engineered for the taxpayer's commercial building. PV curtain wall in and of itself is machinery or equipment used to produce solar energy. It is only when these are connected to each other and to other structural components of the building that the character or nature of the is potentially transformed. Thus, PV curtain wall in essence, serves a dual purpose: (1) to generate electricity through the use of solar energy; and (2) to enclose the building or structure. Moreover, the regulations specifically address the fact that structural components may qualify as energy property.

Accordingly, we conclude that the elements of the purchase price of the PV curtain wall, as described above, constitute energy property under § 48 of the Code.

Except as expressly provided herein, no opinion is expressed or implied concerning the tax consequences of any aspect of any transaction or item discussed or referenced in this letter. Specifically, no opinion is expressed whether Taxpayer qualifies for the investment credit under § 46 of the Code, or whether the energy property otherwise qualifies under § 48 of the Code.

This ruling is directed only to the taxpayer who requested it. Section 6110(k)(3) of the Code provides that it may not be used or cited as precedent.

In accordance with the Power of Attorney on file in this office, a copy of this letter will be sent to your authorized representatives.

Sincerely yours,

Peter C. Friedman
Senior Technician Reviewer
(Passthroughs & Special Industries)
Office of the Associate Chief Counsel

Formwork Duration (Strip, Curtain Shear Lift) (LL2-17)

26 Climbing Forms — 10 hour work days

$\frac{480\ min}{26\ Climbing\ Forms} = 23\ min\ /\ Form$

Formwork (18 - Roof)

18 Climbing Forms

$\frac{6\ Cranes}{18\ Climbing} = 33\ m\ /\ Form\ Cycle$

Rebar Duration

(LL2-17)

44 Tons / Floor

3.5 days / Floor

$\frac{44\ Tons}{3.5\ days} = 12.6\ \frac{Tons}{Day}$

$12.6\ \frac{Tons}{Day}\left(\frac{1\ day}{10\ hrs}\right) = 1.26\ \frac{Tons}{hr}$ (16 man crew)

$= .08\ Ton/man$

* Increase Crew Size to 32 man Crew

$.08\ Ton/man \times 32\ men = 2.52\ Tons/hr.$

(18 - Roof)

30 Tons / Floor

2.5 days / Floor

$\frac{30\ Tons}{2.5\ days} = 12\ \frac{Tons}{Day}$

$12\ \frac{Tons}{Day}\left(\frac{1\ day}{10\ hrs}\right) = 1.2\ \frac{Tons}{hr}$ (Roof Crew)

$= .075\ Ton/man$

$.075 \times 32\ men = 2.4\ Tons/hr.$

(LL2-17)

Duration by Wall (240 ft Total) $\frac{44\ Tons}{240\ ft} = .183\ \frac{Tons}{ft}$

Wall 1: $45.2\ ft\ (.183\ \frac{Tons}{ft}) = \frac{8.28\ Tons}{1.26} = 6.6$ hours

Wall 2: $25.5\ ft\ (.183\ \frac{Tons}{ft}) = \frac{4.67\ Tons}{1.26} = 3.71$ hours

Wall 3: $11.4\ ft\ (.183\ \frac{Tons}{ft}) = \frac{2.1\ Tons}{1.26} = 1.67$ hours

Wall 4: $27.5\ ft\ (.183\ \frac{Tons}{ft}) = \frac{5.03\ Tons}{1.26} = 4$ hours

Wall 5: $13.4\ ft\ (.183\ \frac{Tons}{ft}) = \frac{2\ Tons}{1.26} = 1.6$ hours

Wall 6: $11.5\ ft\ (.183\ \frac{Tons}{ft}) = \frac{2.14\ Tons}{1.26} = 1.7$ hours

Wall 7: $23.4\ ft\ (.183\ \frac{Tons}{ft}) = \frac{4.34\ Tons}{1.26} = 3.444$ hours

Wall 8: $4.3\ ft\ (.183\ \frac{Tons}{ft}) = \frac{.794\ Tons}{1.26} = .63$ hours ≈ 38 min

Wall 9: $9.4\ ft\ (.183\ \frac{Tons}{ft}) = \frac{1.67\ Tons}{1.26} = 1.33$ hours

Wall 10: $29.6\ ft\ (.183\ \frac{Tons}{ft}) = \frac{5.412\ Tons}{1.26} = 4.3$ hours

Wall 11: $40.9\ ft\ (.183\ \frac{Tons}{ft}) = \frac{7.5\ Tons}{1.26} = 5.945$ hours

59.99 hours

Duration by Wall (T - Roof) (125 Total Ft)

$\frac{30\ Tons}{125\ ft} = .183\ \frac{Tons}{ft}$

Wall 1 = $45.2\ ft\ (.183\ \frac{Tons}{ft}) = \frac{8.28\ Tons}{1.2} = 6.9$ hours

Wall 2: $36.5\ ft\ (.183\ \frac{Tons}{ft}) = \frac{6.6\ Tons}{1.2} = 5.5$ hours

Wall 3 = $27.5\ ft\ (.183\ \frac{Tons}{ft}) = \frac{5.03\ Tons}{1.2} = 4.2$ hours

Wall 4 = $11.5\ ft\ (.183\ \frac{Tons}{ft}) = \frac{2.1}{1.2} = 1.75$ hours

Wall 5 = $10.6\ ft\ (.183\ \frac{Tons}{ft}) = \frac{1.94}{1.2} = 1.62$ hours

Wall 6 = $35\ ft\ (.183\ \frac{Tons}{ft}) = \frac{6.4}{1.2} = \frac{5.33\ hours}{25.3\ hours}$

Concrete Pour Duration

(LL2 - T)

$= \frac{246\ Cubic\ yards}{5\ hrs} = \frac{49.2\ Cubic\ yards}{hr}$

(T - Roof)

$= \frac{172\ Cubic\ yards}{5} = \frac{34.4\ Cubic\ yards}{hr}$

Duration by Wall (See attached Drawings) (LL2-17)

Wall 1: $\frac{113\ Cubic\ yards}{49.2\ \frac{Cubic\ yards}{hr}} = 2.3$ hrs

Wall 2: $\frac{11.2\ Cubic\ yards}{49.2\ \frac{Cubic\ yards}{hr}} = .24$ hrs ≈ 14 min

Wall 3: $\frac{107\ Cubic\ yards}{49.2\ \frac{Cubic\ yards}{hr}} = 2.17$ hrs

Wall 4: $\frac{4.4\ Cubic\ yards}{49.2} = .09$ hrs ≈ 5.4 min

Wall 5: $\frac{12.1\ Cubic\ yards}{49.2} = .201 \approx 12$ min

5 hours

Duration by Wall (17 - Roof)

Wall 1: $\frac{97.2\ Cubic\ yards}{34.4\ \frac{Cubic\ yards}{hr}} = 2.82$ hours

Wall 2: $\frac{35.7\ Cubic\ yards}{34.4\ \frac{Cubic\ yards}{hr}} = 1.04$ hours

Wall 3: $\frac{11\ Cubic\ yards}{34.4\ \frac{Cubic\ yards}{hr}} = .32$ hours ≈ 19 min

4.18 hours

Proposed Formwork Duration (Strip, Lift) (LL2-17)

4 Stripping Carpets strip entire form (3.5 hours)

$\frac{3.5\ hours}{4\ Carpets} = .875\ \frac{hour}{Carpet} \approx 53$ min

(17, Roof)

$\frac{2.5\ hours}{4\ Carpets} = .625\ \frac{hour}{Carpet} = 38$ min

1 hour to lift.