### East Coast, USA

## **Codi Shine**

Construction Option

Advisor: Dr. Chimay Anumba



Analysis 1: Analysis 2: Analysis 3: Façade Study Breadths: Analysis 4: Implementation

Alternative Delivery Method Short Interval Production Schedule (SIPS) Architectural & Mechanical Building Information Modeling (BIM)

## **Statistics**

Size: 72,000 GSF Stories: 2 plus a penthouse **Delivery Method**: Design-Bid-Build **Contract Value:** \$41 million **Construction Dates:** 6/1/11-4/22/13

LEED: Platinum Arch Engi Gen Struc Civil



# **Project Background**

Project 1	eam
hitect/MEP ineer	Ewing Cole
neral Contractor	Hensel Phelps
ctural Engineer	Woods Peacock
il Engineer	Alpha Corporation

Schedule Summary	Start
Notice to Proceed	June 1
Earthwork	Nover
Concrete	Nover
Structural Steel	Februa
HVAC	Octob
Electrical	Decer
Plumbing	Decer
Specialty Trades	Decer
Turnover	

	End
1, 2011	
mber 3, 2011	November 1, 2012
mber 7,2011	November 12, 2012
ary 22, 2012	April 23,2012
oer 31, 2011	November 27, 2012
mber 19, 2011	November 30, 2012
mber 21, 2011	October 24, 2012
mber 21,2011	February 22, 2013
	April 22, 2013

Project Background Analysis 1 – Alternative Delivery Method Background Research/Comparisons Schedule reduction Analysis 2 – SIPS Sequence & crews **Different SIPS Options** Schedule Reduction Analysis 3 – Façade Study Background Materials/Research Architectural Breadth Changes Model Mechanical Breadth R-value & Condensation Production & Cost Recommendations Acknowledgements

#### Analysis Goals

# Reduce the schedule by getting the General Contractor in earlier

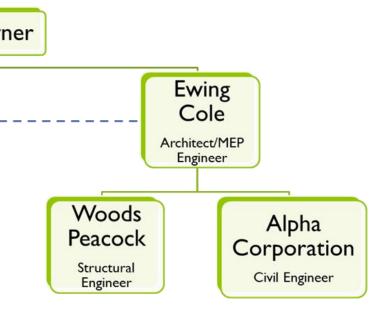
Current: Design-

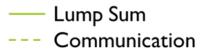
- Phases are Fir relationship
- Lacks chemis<sup>-</sup>
- Owner acts a
- Owner has to
- Owner holds
- Multiple contr

## Background

### Analysis 1 – Alternative Delivery Method

	Dropost	
-Bid-Build	Proposed: Design-Build	Own Hensel Phelps
Finish-Start istry as a mediator o find all parties the liability itracts	<ul> <li>GC can be involved earlier</li> <li>Subcontractors assist with design</li> <li>GC and designer are in a joint venture</li> <li>One point of contact</li> <li>Cost effective</li> <li>Shared risk</li> <li>One contract</li> </ul>	General Contractor Joshua Construction Mechanical/Plumbing Contractor Steel LLC Steel Contractor Steel Contractor







Project Background Analysis 1 – Alternative Delivery Method Background **Research/Comparisons** Schedule reduction Analysis 2 – SIPS Sequence & crews **Different SIPS Options** Schedule Reduction Analysis 3 – Façade Study Background Materials/Research Architectural Breadth Changes Model Mechanical Breadth R-value & Condensation Production & Cost Recommendations Acknowledgements

**Building Nam** 

Environmental Stu

Technical Monitori lub

**Commercial Hang** 

## **Research & Comparisons**

### Analysis 1 – Alternative Delivery Method

- Design assist subcontractors
- Involved owner
- Owner let Hensel Phelps take control
- Start site work early
- Innovation
- Finalize long lead items early

	Square Foot	Cost/Sq Ft	Intensity	Construction Speed	Delivery Duration
dies	72,000	\$491	\$1,756,192	3576	3473
ng	71,336	\$460	\$2,218,444	4820	
er	60,000	\$329	\$1,768,125		3947

# Interviews



Project Background Analysis 1 – Alternative Delivery Method Background Research/Comparisons Schedule reduction Analysis 2 – SIPS Sequence & crews Different SIPS Options Schedule Reduction Analysis 3 – Façade Study Background Materials/Research Architectural Breadth Changes Model Mechanical Breadth R-value & Condensation Production & Cost Recommendations Acknowledgements

ctivity Name	Original	Start	Finish	20	909			2	010
	Duration			Q2	Q3	Q4	Q1	Q2	Q3
ESL:E Environmental Studies Lab: E	1323	23-Mar-09	20-May-14						
📲 ESL:E.2 Pre-Design	75	23-Mar-09	03-Jul-09		7 03-JuH	09, ESL:E.	2 Pre De	sign	
ESL:E.3 Schematic Design	14	29-Jun-09	17-Jul-09	•		109, ESL:1		matic Des	sign
Prepare SD drawings	10	29-Jun-09	10-Jul-09		Prepar	e SD orav	ings		
Fundamental design report	11	29-Jun-09	13-Jul-09		📕 Funda	mental de	sign repo	4	
Issue SD package	0	17-Jul-09			🔶 Issue	SD packa	ge, 17 Ju	609	
ESL:E.4 Design Development 35%	24	10-Aug-09	11-Sep-09			11-Sep-09	, ESL:E.4	Design	Develop
Prepare DD drawings	20	10-Aug-09	04-Sep-09		📥 r	repare D	D drawing	<b>#</b>	
Issue DD package	0	11-Sep-09			•	lssue DD	( I F	1 1 1	
ESL:E.5 Design Development 65%	49	14-Sep-09	20-Nov-09		-	7 20	Nov-09,	ESL:E.F	Design
Advance DD documents to Construction Document lev	20	14-Sep-09	09-Oct-09					cuments i	
Prepare DD drawings	25	12-Oct-09	13-Nov-09			📫 Pre	pare DD	drawings	
Prepare DD specs	25	12-Oct-09	13-Nov-09			📫 Pre	pare DD	specs	
Issue DD package	0	20-Nov-09				Is	sue DD p	ackage, 2	20-Nov-0
ESL:E.6 Construction Documents 95%	40	04-Jan-10	01-Mar-10					01-Mar-10	D ESL:E
Prepare drawings	35	04-Jan-10	19-Feb-10				Pi	repare dr	awings
Prepare specs	35	04-Jan-10	19-Feb-10					repare sp	
Issue 95% CD package	0	01-Mar-10					<b> </b>	ssue 95%	1 1 1
ESL:E.7 Construction Documents 100%	5	12-Apr-10	19-Apr-10					<b>T</b> 19-A	φr-10, E
Prepare drawings	5	12-Apr-10	16-Apr-10					Prep	are drav
Prepare specs	5	12-Apr-10	16-Apr-10					Prep	are spec
Issue 100% CD package		19-Apr-10						🔶 lssu	e 100%
ESL:E.8 Preconstruction	800	04-Apr-11	20-May-14						
Notice of Award	0	04-Apr-11							
<ul> <li>Submittals</li> </ul>		04-Apr-11	20-May-14						
Notice to Proceed	0	01-Jun-11							
Obtain approved permits		01-Jun-11	01-Aug-11						
Prepare & Approve Baseline CPM schedule	75	29-Jun-11	13-Oct-11						

# Schedule Reduction

### Analysis 1 – Alternative Delivery Method

			011	•			12		2013 Q1 Q2			
13 Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2		
opimeint 35%												
n Developmen Istruction Docu												
r-09 :E.6 Cohstiluc s	ton Docur	nents 95%										
oackage 01-M ESLE.7 Cons		ocuments	100%									
awings ie¢s % CDI package	.19-Apr-1	0										
		• Notice	of Award, I	04-Apr-11								
		•	: : :	roceed, 01 ain approv Prepa	ed permits	ve Baselir	e CPN so	hedule				

Environmental Studies Lab: Expansion														
Activity Name	Original Start Duration	Finish	2009	201			2011				012		2013	
ESL:E Environmental Studies Lab: E	1039 23-Mar-09	10-Apr-13	Q2 Q3 Q4	Q1 Q2	Q3 Q4	Q1 Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1 (	Q2 10-
ESL:E.2 Pre-Design	75 23-Mar-09	03-Jul-09	<b>03-)</b> ul 09, E\$	L:E.2 Pre-Design										
ESL:E.3 Schematic Design	14 29-Jun-09	17-Jul-09		SL:E 3 Schematic De	esign		111	111						
Prepare SD drawings	10 29-Jun-09	10-Jul-09	Prepare SD o	irawings			111	111		111	111	111		
Fundamental design report	11 29-Jun-09	13-Jul-09	🗖 Fundamenta	design report										
Issue SD package	0 17-Jul-09		🔶 issue SD pa	ckage, 17-Jul 09										
ESL:E.4 Design Development 35%	24 10-Aug-09	11-Sep-09	🔫 11-Sep	-09, ESL:E.4 Design	Development 35	%								
Prepare DD drawings	20 10-Aug-09	04-Sep-09	Prepare	DD drawings										
🚍 Issue DD package	0 11-Sep-09		🌢 Issue 🕻	D package, 11-Sep-	09		111	111		111				
Notice of Award	0 11-Sep-09		Notice	of Award, 11-Sep 09										
ESL:E.5 Design Development 65%	49 14-Sep-09	20-Nov-09	<b>T</b>	20-Nov-09, ESL:E.5	Design Developr	hent 65%								
Advance DD documents to Construction Document le	20 14-Sep-09	09-Oct-09	Adv	ance DD documents	to Construction D	ocument level								
Prepare DD drawings	25 12-Oct-09	13-Nov-09		repare DD drawings			111	111		111	111	111		
Prepare DD specs	25 12-Oct-09	13-Nov-09		repare DD specs			111	111						
Issue DD package	0 20-Nov-09		•	lssue DD package, 2	20-Nev-09									
ESL:E.6 Construction Documents 95%	835 04-Jan-10	10-Apr-13		++++++						<u> </u>			<del>i i i r</del>	10-
Prepare drawings	35 04-Jan-10	19-Feb-10		Prepare dra										
Prepare specs	35 04-Jan-10	19-Feb-10		Ptepare spe	ic <b>s</b>									
Notice to Proceed	0 19-Feb-10			<ul> <li>Notice to Pro</li> </ul>	oceed, 19-Feb-10	)	111	111		111				
Submittals	800 22-Feb-10	10-Apr-13												Sut
Issue 95% CD package	0 01-Mar-10			🔶 lssue 95%	CD package, 01		111	111		111				
ESL:E.7 Construction Documents 100	115 22-Feb-10	03-Aug-10			💙 03-Aug-10, E	SL:E.7 Constru	iction Deci	uments 10	00%					
Obtain approved permits	43 22-Feb-10	21-Apr-10		Obtain	n approved permi	5	111	111				111		
Prepare drawings	5 12-Apr-10	16-Apr-10		🛿 Prepar	re drawings		111	111						
Prepare specs	5 12-Apr-10	16-Apr-10		Prepar										
Issue 100% CD package	0 19-Apr-10			♦ Issue	100% OD packa	je, 19 Apr-10	111	111						
Prepare & Approve Baseline CPM schedule	75 19-Apr-10	03-Aug-10			Prepare & Ap	prove Baseline	CPM sohe	dule						



Project Background Analysis 1 – Alternative Delivery Method Background Research/Comparisons Schedule reduction Analysis 2 – SIPS Sequence & crews Different SIPS Options Schedule Reduction Analysis 3 – Façade Study Background Materials/Research Architectural Breadth Changes Model Mechanical Breadth R-value & Condensation Production & Cost Recommendations Acknowledgements

Environmental Studies Lab: Expansion				Environmental Studies Lab: Expansion												
Activity Name	Original Start Finish	2009 2010	2011 2012 2013	Activity Name	Original Start Finish		2009		201	0		2011			2012	2013
	Duration	Q2 Q3 Q4 Q1 Q2 Q3 Q4 Q1	Q2 Q3 Q4 Q1 Q2 Q3 Q4 Q1 Q2		Duration		2 Q3	Q4	Q1 Q2	Q3 Q4	4 Q1	Q2 0	Q3 Q4	Q1 Q2	Q3	Q4 Q1 Q2
늘 ESL:E Environmental Studies Lab: E	1323 23-Mar-09 20-May-14			🖀 ESL:E Environmental Studies Lab: E	1039 23-Mar-09 10-Apr	-13										<b>1</b>
ESL:E.2 Pre-Design	75 23-Mar-09 03-Jul-09	d3-Jui-d9, ES⊈E2 Pre-Deşigh		ESL:E.2 Pre-Design	75 23-Mar-09 03-Jul-	09	<b>y</b> 03-Ju	109, E\$L:E.2	Pre-Design			,				
ESL:E.3 Schematic Design	14 29-Jun-09 17-Jul-09	🕶 17 Jul-00, E\$L:E.3 Schematic Design		ESL:E.3 Schematic Design	14 29-Jun-09 17-Jul-	09	🕶 17-J	ul-09, ESL:E	3 Schematic De	esign		,				
Prepare SD drawings	10 29-Jun-09 10-Jul-09	📋 Prepare SD drawings		Prepare SD drawings	10 29-Jun-09 10-Jul-	09	Prep	are SD draw	ngs							
Fundamental design report	11 29-Jun-09 13-Jul-09	📋 Fundamental design report		Fundamental design report	11 29-Jun-09 13-Jul-	09	Fund	lamental des	gn report			,				
Issue SD package	0 17-Jul-09	◆ Issue SD package, 17 Jul 09		Issue SD package	0 17-Jul-09		🔶 lssu	e SD packa	e, 17-Jul 09			,				
ESL:E.4 Design Development 35%	24 10-Aug-09 11-Sep-09	🕶 🔻 11-Sep-09, ESL:E.4: Désign Devélopment 35%		ESL:E.4 Design Development 35%	24 10-Aug-09 11-Sep	-09		11-Sep-09,	ESL:E:4 Design	Development	ft 35%	,				
Prepare DD drawings	20 10-Aug-09 04-Sep-09	📫 Prepare DD drawings		Prepare DD drawings	20 10-Aug-09 04-Sep	-09		Prepare DD	drawings			,				
Issue DD package	0 11-Sep-09	🔶 İssue DD padkape, 11-Sep-09		Issue DD package	0 11-Sep-09				ackage, 11-Sep-	09		,				
ESL:E.5 Design Development 65%	49 14-Sep-09 20-Nov-09	20-Nov-09, ESLE Diesign Development85%			0 11-Sep-09				ard, 11-\$ep-09							
Advance DD documents to Construction Document lev	20 14-Sep-09 09-Oct-09	Advance DD blocuments to Construction Document lev	el	ESL:E.5 Design Development 65%	49 14-Sep-09 20-Nov	-09			ov-09, ESL:E.5		bpment 65%	,				
Prepare DD drawings	25 12-Oct-09 13-Nov-09	Prepate OD drawings		Advance DD documents to Construction Document le	20 14-Sep-09 09-Oct	.00		Advance	DD documents	to Constructio	an Document	level				
Prepare DD specs	25 12-Oct-09 13-Nov-09	📫 Prépale DD spécs		Prepare DD drawings	25 12-Oct-09 13-Nov	i i i		<b>T</b> : : :	re DD drawings							
Issue DD package	0 20-Nov-09	♦ Issue DD package: 20-Nov-09		Prepare DD specs	25 12-Oct-09 13-Nov			1 - 1 - 1 - 1 - 1	re DD specs							
ESL:E.6 Construction Documents 95%	40 04-Jan-10 01-Mar-10	💭 🗤 Di Mar 10, EŞL:E.6, Cohstiuction Dobu	inhents \$6%	Ssue DD package	0 20-Nov-09			1 1 1 1	e DD package, 2	0-Nov-09						
Prepare drawings	35 04-Jan-10 19-Feb-10	Priepare draiwings		ESL:E.6 Construction Documents 95%	835 04-Jan-10 10-Apr	-13					<u>         </u>			<u> </u>		<u> </u>
Prepare specs	35 04-Jan-10 19-Feb-10	Prepare specs			35 04-Jan-10 19-Feb			IIIL	Prepare dra							
Issue 95% CD package	0 01-Mar-10	♦ Issue 95% CD package, 01-Mar-10		Prepare drawings	35 04-Jan-10 19-Feb 35 04-Jan-10 19-Feb					-						
ESL:E.7 Construction Documents 100%	5 12-Apr-10 19-Apr-10	₩ 19-Apr-10, ESLE.7 Construction	Documents 100%	Prepare specs     Notice to Proceed		-10		· · · •	Ptepare spe							
Prepare drawings	5 12-Apr-10 16-Apr-10	I Prépare drawings		Submittals	0 19-Feb-10 800 22-Feb-10 10-Apr	42			<ul> <li>Notice to Pro</li> </ul>	odeed, 18-Per						
Prepare specs	5 12-Apr-10 16-Apr-10	I Prépare \$pe¢s			0 01-Mar-10	13			traite 05%	CD tookata	1011Max 10.1	<del></del>				
Issue 100% CD package	0 19-Apr-10	♦ Issue 100% CD package, 19 Apt-	10	Issue 95% CD package		10			♦ Issue 95%	1 1 I T			Decuments 100			
ESL:E.8 Preconstruction	800 04-Apr-11 20-May-14			ESL:E.7 Construction Documents 100 <sup>c</sup>	115 22-Feb-10 03-Aug							onstruction	Decuments ruc	1		
Notice of Award	0 04-Apr-11		Notice of Award, 04-Apr-11	Obtain approved permits	43 22-Feb-10 21-Apr				Obtain		etmit					
Submittals	800 04-Apr-11 20-May-14			Prepare drawings	5 12-Apr-10 16-Apr	i i i				e drawings						
Notice to Proceed	0 01-Jun-11		Notice to Proceed, 01-Jun-11	Prepare specs	5 12-Apr-10 16-Apr	10			l Prepar							
Obtain approved permits	43 01-Jun-11 01-Aug-11		Obtain approved permits	Issue 100% CD package	0 19-Apr-10						okage, 19-Ap					
Prepare & Approve Baseline CPM schedule	75 29-Jun-11 13-Oct-11		Prépare & Approve Başeline & PN) schedule	Prepare & Approve Baseline CPM schedule	75 19-Apr-10 03-Aug	-10				Prepare a	& Approve Ba	seline CPM	schedule			

# Schedule Reduction

### Analysis 1 – Alternative Delivery Method



Project Background Analysis 1 – Alternative Delivery Method Background Research/Comparisons Schedule reduction Analysis 2 – SIPS Sequence & crews Different SIPS Options Schedule Reduction Analysis 3 – Façade Study Background Materials/Research Architectural Breadth Changes Model Mechanical Breadth R-value & Condensation Production & Cost Recommendations Acknowledgements

Environmental Studies Lab: Expansion									
Activity Name	Original	Start	Finish	20	909			20	010
	Duration			Q2	Q3	Q4	Q1	Q2	Q
늘 ESL:E Environmental Studies Lab: E	1323	23-Mar-09	20-May-14	1 1 1					: :
ESL:E.2 Pre-Design	75	23-Mar-09	03-Jul-09		🗸 03-Jul-(	19, ESL:E.	2 Pre De	sign	
ESL:E.3 Schematic Design	14	29-Jun-09	17-Jul-09		🔫 17-Ju	-09, ESL:	5.3 Scher	natic Des	ign
Prepare SD drawings	10	29-Jun-09	10-Jul-09		Prepar	e SD drav	ingь		
Fundamental design report	11	29-Jun-09	13-Jul-09		🗆 Funda	me <b>n</b> tal de	sign repor		
Issue SD package	0	17-Jul-09			Issue	SD packa	ge, 17+Ju	-09	
ESL:E.4 Design Development 35%	24	10-Aug-09	11-Sep-09			11-Sep-09	, ESL:E.4	Design [	levelo
Prepare DD drawings	20	10-Aug-09	04-Sep-09			repare D	D drawing	5	
Issue DD package	0	11-Sep-09			۲	lssue DD	padkage,	11-Sep-0	9
ESL:E.5 Design Development 65%	49	14-Sep-09	20-Nov-09		-	20	-Nav-09,	ESL:E.Ð I	Desigr
Advance DD documents to Construction Document lev	20	14-Sep-09	09-Oct-09			Advan	e DD doc	uments t	d Cons
Prepare DD drawings	25	12-Oct-09	13-Nov-09			Pre Pre	pare DD (	drawings	

tivity Name	Original	Start	Finish		2009				2010			2	011			2	012		20	13
	Duration			Q.2	Q	3 Q	4 (	Q1 Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2
늘 ESL:E Environmental Studies Lab: E	1323	23-Mar-09	20-May-14		: :						: :									: :
ESL:E.2 Pre-Design	75	23-Mar-09	03-Jul-09		<b>-</b> d3	-Jul-09, E	SL:E2 P	re-Design												
ESL:E.3 Schematic Design	14	29-Jun-09	17-Jul-09		<b>T</b>	7-Jul-09, I	ESL:E.3	Schematic D	esign											
Prepare SD drawings	10	29-Jun-09	10-Jul-09			repare SD														
Fundamental design report	11	29-Jun-09	13-Jul-09		j je je	undament	al design	report												
Issue SD package	0	17-Jul-09			• Is	ssue SD p	ackage,	17-Jul-09												
ESL:E.4 Design Development 35%	24	10-Aug-09	11-Sep-09			🔫 11-Se	ep-09, E\$	SL:E.4 Desig	1 Developme	eint 35%										
Prepare DD drawings	20	10-Aug-09	04-Sep-09			📫 Prepa	ire DD di	awings												
Issue DD package		11-Sep-09				Issue	1 ( 1	kape, 11-Sep												
ESL:E.5 Design Development 65%	49	14-Sep-09	20-Nov-09				V 20-No	v-09, ESL:E.	Design De	velopment	65%									
Advance DD documents to Construction Document lev	20	14-Sep-09	09-Oct-09			- Ac	dvance D	D blocuments	to Constru	ction Docut	nent level									
Prepare DD drawings	25	12-Oct-09	13-Nov-09			中	Prepar	e DD drawing	5											
Prepare & Approv	e B	aselr	ne CF	M	scł	hed	ule	2				7	5 2	8-J	un-1	1	13-	Oct	-11	
Prepare drawings								Prepare d	rawings											
Prepare specs								Prepare s												
Issue 95% CD package								T I I I	% CD pack	- I I I	1 1									
ESL:E.7 Construction Documents 100%	5							₩ 19	Apr-10, ESL	.E.7 Cpnst	truction D	ocument	100%							
Prepare drawings	5	12-Apr-10	16-Apr-10					I Pre	pare drawin	gs -										
Prepare specs	Lo.	12-Apr-10	16-Apr-10						pare specs											
Issue 100% CD package		19-Apr-10						Iss	ue 100% CC	) package,	19-Apr-1	0								
ESL:E.8 Preconstruction	800	04-Apr-11	20-May-14																	
Notice of Award		04-Apr-11									-	Notice	of Award	, 04-Apr	-11					
Submittals	800	04-Apr 11	20-May-14														1 1 1			
Notice to Proceed	0	01-Jun-11										•	Notice to							
Obtain approved permits			01-Aug-11									F	- 1	1 1 1	roved perm	1 1 1				
Prepare & Approve Baseline CPM schedule	75	29-Jun-11	13-Oct-11											Pre Pre	pare & App	rove Basel	line GPM s	chedule		

# Schedule Reduction

### Analysis 1 – Alternative Delivery Method

ctivity Name Original Start Finish 2009 Q2 Q3 C Q3 C Q2 Q3 C Q3 C Q2 Q3 C	Q4 0	2010 21 Q2 Q
	Q4 0	21 Q2 Q
ESL:E Environmental Studies Lab: E 1039 23-Mar-09 10-Apr-13		
ESL:E.2 Pre-Design 75 23-Mar-09 03-Jul-09	19, E\$L:E.2	Pre-Design
ESL:E.3 Schematic Design 14 29-Jun-09 17-Jul-09	-09, ESL:E3	3 Schematic Desig
Prepare SD drawings 10 29-Jun-09 10-Jul-09	e SD drawin	gs
🕞 Fundamental design report 11 29-Jun-09 13-Jul-09	mental desig	n report
■ Issue SD package 0 17-Jul-09 ♦ Issue	SD package	, 17-Jul-09
ESL:E.4 Design Development 35% 24 10-Aug-09 11-Sep-09	11-Sep-09, E	SL:E:4 Design De
Prepare DD drawings 20 10-Aug-09 04-Sep-09	repare DD d	rawings
📄 Issue DD package 0 11-Sep-09	ssue DD pa	ckage, 11-Sep-09
Notice of Award 0 11-Sep-09	Notice of Awa	ard, 11-\$ep-09
ESL:E.5 Design Development 65% 49 14-Sep-09 20-Nov-09	🗸 20-No	w-09, ESL:E.5 De
C Advance DD documents to Construction Document les 20, 14, Sep 00, 00, Oct 00	Advanced	Di decumente tol

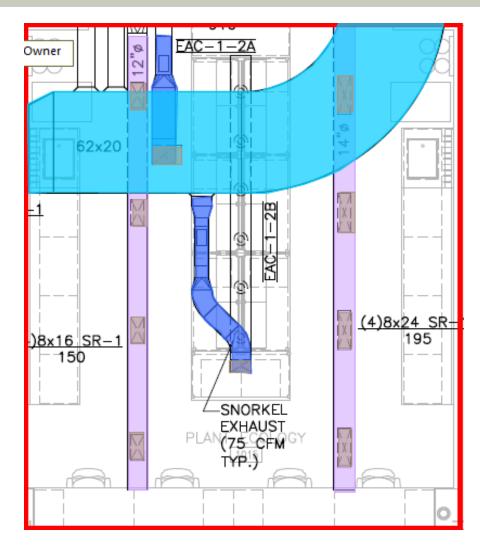
#### Prepare & Approve Baseline CPM schedule

ESL:E.6 Construction Documents 95	%					
Prepare drawings						Prepare drawi
Prepare specs	35		19-Feb-10		110	Ptepare spect
Notice to Proceed	0					<ul> <li>Notice to Proc</li> </ul>
<ul> <li>Submittals</li> </ul>	807	22-Feb-10	10-Apr-13			
Issue 95% CD package	0	01-Mar-10				Issue 95% C
ESL:E.7 Construction Documents 10	0 <sup>c</sup> 115	23-Feb-10	03-Aug-10			<b>N</b>
<ul> <li>Obtain approved permits</li> </ul>	43	22-Neb-10	21-Apr-10			Optain a
Prepare drawings	5	12-Api-10	16-4pr-10			Prepare
Prepare specs	5	12-Apr-10	16-Apr-10			🛛 Prepare
Issue 100% CD package	0	19-Apr-10				
Prepare & Approve Baseline CPM schedule	75	19-Apr-10	03-Aug-10			

0		20	11			20	12		201	13
Q3 Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2
sign										10-
Devielopment 3: 9 Design Develop	rheåt 65%	lavel								
7	5 19	9-A	pr-1	0	03	B-AL	ıg-1	0		10-
vings >\$										, ic
ceed, 19-Feb-1	0									) Sul

Project Background Analysis 1 – Alternative Delivery Method Background Research/Comparisons Schedule reduction Analysis Goals Analysis 2 – SIPS Sequence & crews **Different SIPS Options** Reduce the schedule by Schedule Reduction Analysis 3 – Façade Study construction that will also Background Materials/Research Architectural Breadth Changes Model Mechanical Breadth R-value & Condensation Production & Cost Recommendations Acknowledgements

creating a repetitive manner of improve the quality of the work.



# **Sequencing & Crews**

## **Analysis 2 – Short Interval Production Schedule** (SIPS)

Activity	Crew
Layout	1 Sheet Metal Layout
Install sleeves	1 Sheet Metal Worker
lest all Llangers (an oborg	1 Sheet Metal Worker
Install Hangers/anchors	1 Sheet Metal Apprentice
Layout/Rough-in	1 Sheet Metal Layout
Unload and distribute	2 Sheet Metal Workers
duct sections	
Hang trunk lines	2 Sheet Metal Workers
	1 Sheet Metal Apprentice
Install medium pressure	2 Sheet Metal Workers
branch	1 Sheet Metal Apprentice
	1 Sheet Metal Worker
Install SACs, EACs	1 Sheet Metal Apprentice
Install Low Pressure	2 Sheet Metal Workers
Branch	1 Sheet Metal Apprentice
Hard Duct Taps (Exhaust)	2 Sheet Metal Workers
Hard Duct Taps (Exhaust)	1 Sheet Metal Apprentice
Install RGD	1 Sheet Metal Worker

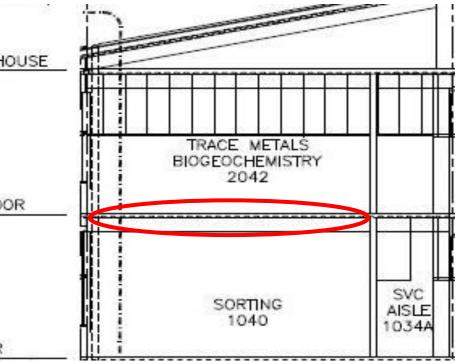
- 8 hour work days

FINISHED MECH PENTHOUSE ELEV 30'-0"

FINISHED SECOND FLOOR ELEV 15'-0"

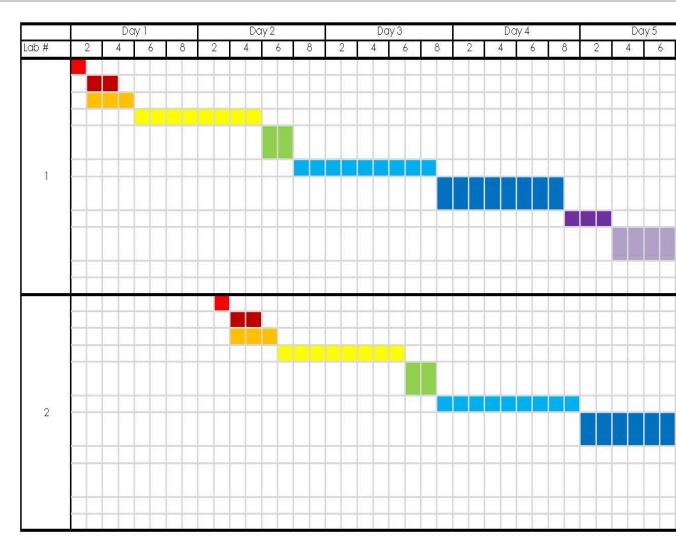
FINISHED FIRST FLOOR

#### Slightly different sequence on first and second floors





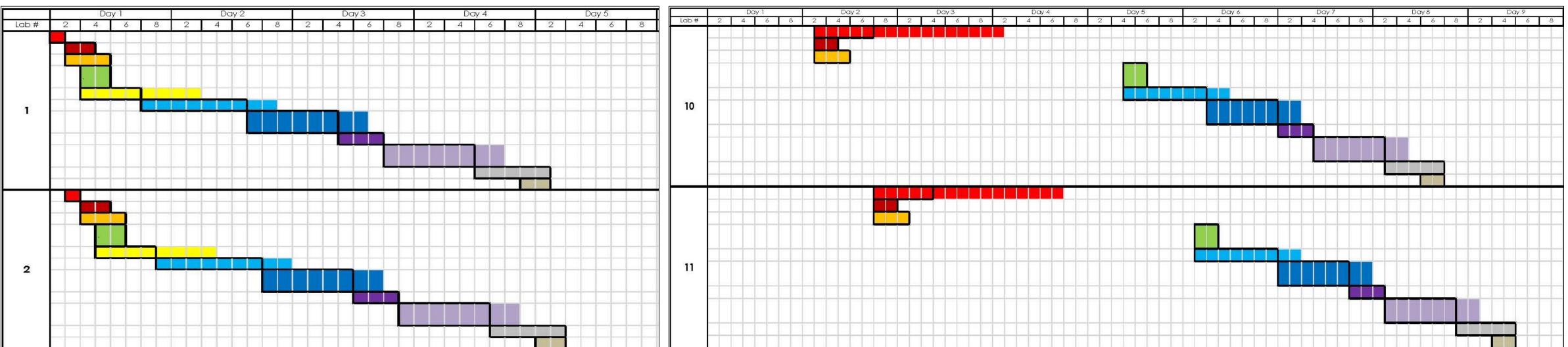
Project Background Analysis 1 – Alternative Delivery Method Background Research/Comparisons Schedule reduction Analysis 2 – SIPS Sequence & crews Different SIPS Options Schedule Reduction Analysis 3 – Façade Study Background Materials/Research Architectural Breadth Changes Model Mechanical Breadth R-value & Condensation Production & Cost Recommendations Acknowledgements



# **Sequencing & Crews**

		Day	6		D	iay 7				Do	ay 8			-			Da	y 10				Day	y 11				Day	12	15		0	 Do	ay 13	21. 			0	Da	y 14					Day	15				Day 1	16				Day 1	7			Do	iy 18	15			D	ay 19	19	
5 8	2	4	6	8 2	4	6	8		2	4	6	8		Lab #		2	4	6	8	2	2	4	6	8	8	2	4	6		8	2	4	(	Ś	8	2		4	6	8	8	2	4	4	6	8	4	2	4	6	8	2	4	4	6	8	2	4	6	8	3	2	4		6	8
																												1		1		1						1																												
								_																																															T											
							-	_		_																	11																																							
								_		-																																																								
		_					-		$\vdash$					10	)																	1						1																												
														1.38																												4																								
							-	-	-																																																									Ε
		_				1		-		-			-						11	1										1						1 1	1																													Г
			n'n 'n		1	11	11	1	Ħ	1	$\square$	ŤŤ																																																						Γ
															1																																																		T	F
		_						_		_				1.100																																																				
		_	_			-		-		-				11	1		1			1									1							1				1.1															11					11						
			_							_																																																								
					in'					-			-																							1																														
																																																										-								
								1	+	-		+																																																						
																																																												11						

Project Background Analysis 1 – Alternative Delivery Method Background Research/Comparisons Schedule reduction Analysis 2 – SIPS Sequence & crews **Different SIPS Options** SIPS 1 Schedule Reduction Analysis 3 – Façade Study Background Materials/Research Architectural Breadth Changes Model Mechanical Breadth R-value & Condensation Production & Cost Recommendations



## **Different SIPS Options** SIPS 1

## Analysis 2 – Short Interval Production Schedule (SIPS)

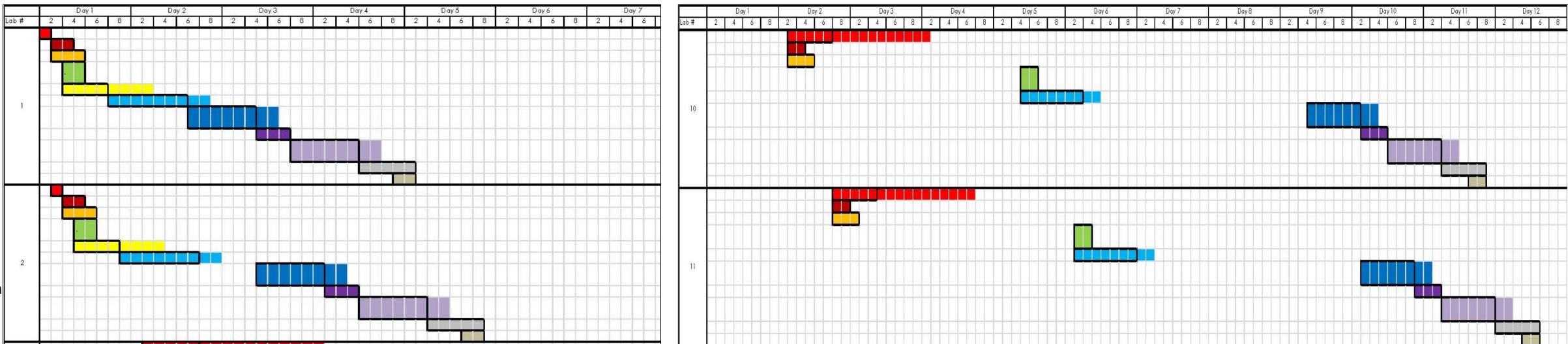
Multiple crews on all activities except for "Layout," "Install sleeves," "Install hangers/anchors."



Project Background Analysis 1 – Alternative Delivery Method Background Research/Comparisons Schedule reduction Analysis 2 – SIPS Sequence & crews **Different SIPS Options** 

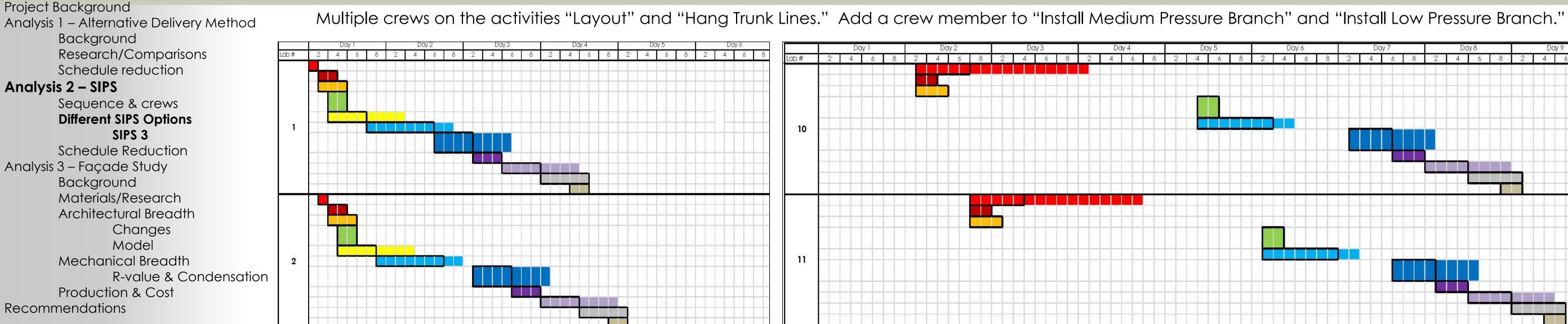
SIPS 2

Schedule Reduction Analysis 3 – Façade Study Background Materials/Research Architectural Breadth Changes Model Mechanical Breadth **R-value & Condensation** Production & Cost Recommendations



## **Different SIPS Options** SIPS 2

Multiple crews on the activities "Layout" and "Hang Trunk Lines"



## **Different SIPS Options** SIPS 3

	Da	ıy 7			Da	y 8			Day	19	
2	4	6	8	2	4	6	8	2	4	6	8
$\square$											
						_					_
										11	
-											-
-											
											_
		-									
-											
-			-			-				_	-
-				_	_			_			
	_						_		_		



Project Background		_				
Analysis 1 – Alternative Delivery Method	Schedule 1st	Crew/Lab	Hourly Rate	Hours/lab	Total Cost/lab	Total cost
Background	Original	22	\$39.93	50.22	44,116	\$397,046
Research/Comparisons	SIPS 1	48	\$39.93	40.00	76,666	\$689,990
Schedule reduction	SIPS 2	32	\$39.93	40.00	51,110	\$459,994
Analysis 2 – SIPS	SIPS 3	34	\$39.93	37.60	51,047	\$459,419
Sequence & crews	511 5 5		407.70	57.00	51,047	φ <del>4</del> 57,417
Different SIPS Options	Schedule 2nd	Crew/Lab	Hourly Rate	Hours/lab	Total Cost/lab	Total cost
Schedule Reduction	Original	21	\$39.93	57.33	48,073	\$432,656
Analysis 3 – Façade Study	SIPS 1	44	\$39.93	40.44	71,050	\$639,449
Background	SIPS 2	32	\$39.93	40.44	51,673	\$465,054
Materials/Research	SIPS 3	32	\$39.93	38.04	48,612	\$437,505
Architectural Breadth	TOTAL	02	<i>\\</i>		10/012	Total cost
Changes		_	_			
Model	Original					\$829,703
Mechanical Breadth	SIPS 1					\$1,329,439
R-value & Condensation	SIPS 2					\$925,047
Production & Cost	SIPS 3					\$896,924
Recommendations						
Acknowledgements						

# **Schedule Reduction**

Schedule	Duration	Days Saved
Original	33	-
SIPS 1	12	21
SIPS 2	17	16
SIPS 3	13	20



_	_				_
Schedule 1st	Crew/Lab	Hourly Rate	Hours/lab	Total Cost/lab	Total cost
Original	22	\$39.93	50.22	44 116	\$397,046
					\$689,990
					\$459,994
					\$459,419
315 3 3		φ07.70	57.00	51,047	\$437,417
Schedule 2nd	Crew/Lab	Hourly Rate	Hours/lab	Total Cost/lab	Total cost
Original	21	\$39.93	57.33	48,073	\$432,656
SIPS 1	44		40.44		\$639,449
SIPS 2	32		40.44		\$465,054
					\$437,505
	02	φσ7.7 σ	00.01	10,012	Total cost
	_	_		_	
	-				\$829,703
SIPS 1					\$1,329,439
SIPS 2					\$925,047
SIPS 3					\$896,924
	Original SIPS 1 SIPS 2 SIPS 3 Schedule 2nd Original SIPS 1 SIPS 2 SIPS 3 TOTAL Original SIPS 1 SIPS 1 SIPS 1	Original22SIPS 148SIPS 232SIPS 334Schedule 2ndCrew/LabOriginal21SIPS 144SIPS 232SIPS 332TOTALJane 1OriginalSIPS 1SIPS 1SIPS 2	Original         22         \$39.93           SIPS 1         48         \$39.93           SIPS 2         32         \$39.93           SIPS 3         34         \$39.93           SIPS 3         34         \$39.93           Schedule 2nd         Crew/Lab         Hourly Rate           Original         21         \$39.93           SIPS 1         44         \$39.93           SIPS 2         32         \$39.93           SIPS 3         32         \$39.93           TOTAL         Joriginal         Joriginal           SIPS 1         Joriginal         Joriginal           SIPS 2         Joriginal         Joriginal           SIPS 2         Joriginal         Joriginal           SIPS 2         Joriginal         Joriginal	Original         22         \$39.93         50.22           SIPS 1         48         \$39.93         40.00           SIPS 2         32         \$39.93         40.00           SIPS 3         34         \$39.93         40.00           SIPS 3         34         \$39.93         40.00           SIPS 3         34         \$39.93         37.60           Schedule 2nd         Crew/Lab         Houriy Rate         Hours/lab           Original         21         \$39.93         57.33           SIPS 1         44         \$39.93         40.44           SIPS 2         32         \$39.93         40.44           SIPS 3         32         \$39.93         38.04           TOTAL	Original         22         \$39.93         50.22         44,116           SIPS 1         48         \$39.93         40.00         76,666           SIPS 2         32         \$39.93         40.00         51,110           SIPS 3         34         \$39.93         40.00         51,047           Schedule 2nd         Crew/Lab         Hourly Rate         Hours/lab         Total Cost/lab           Original         21         \$39.93         57.33         48,073           SIPS 1         44         \$39.93         40.44         71,050           SIPS 2         32         \$39.93         40.44         51,673           SIPS 3         32         \$39.93         40.44         51,673           SIPS 1         44         \$39.93         38.04         48,612           SIPS 3         32         \$39.93         38.04         48,612           TOTAL         TOTAL         TOTAL         Total Cost/lab         Total Cost/lab           SIPS 1         51         51         51         51           SIPS 2         32         \$39.93         38.04         48,612

# **Schedule Reduction**

## Analysis 2 – Short Interval Production Schedule (SIPS)

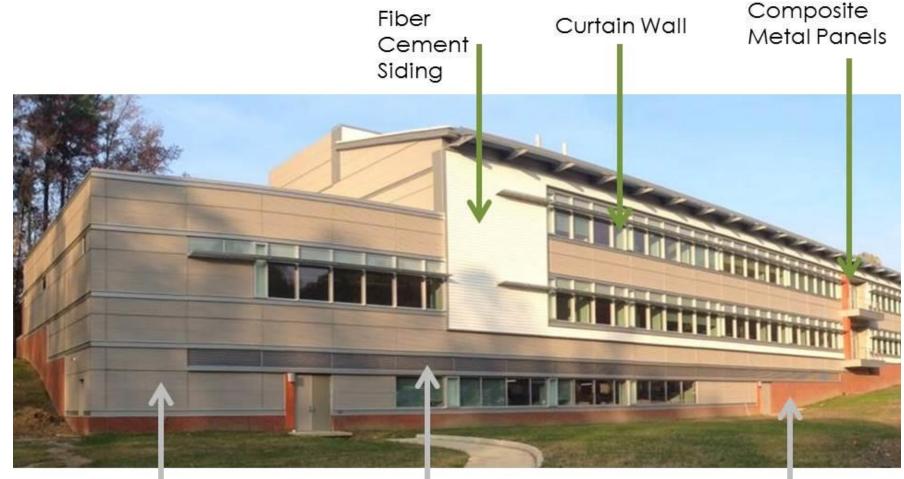
Schedule	Duration	Days Saved
Original	33	-
SIPS 1	12	21
SIPS 2	17	16
SIPS 3	13	20

## SIPS 3 saves 20 days and only \$67,000 more for labor

Project Background Analysis 1 – Alternative Delivery Method Background Research/Comparisons Schedule reduction Analysis Goals Analysis 2 – SIPS Sequence & crews Elevation **Different SIPS Options** Reduce the schedule by Analysis 3 – Façade Study reducing the complexity of the North Background façade materials. Materials/Research Architectural Breadth Changes West Model Mechanical Breadth Total **R-value & Condensation** Production & Cost Recommendations Acknowledgements

# Background

## Analysis 3 – Façade Study



Corrugated Metal Panels

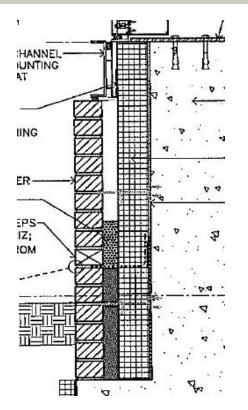
Louvers

		Expansion			
gated	Composite (orange)	Fiber Cement Siding	Louvers	Brick Veneer	Total Square Footage
2,307	0	992	0	818	4,117
14,769	2,412	8,146	1,833	5,737	32,897
490	0	0	0	0	490
3,846	0	0	0	959	4,805
19,105	2,412	9,138	1,833	7,514	40,002

Brick Veneer



Project Background Analysis 1 – Alternative Delivery Method Background Research/Comparisons Schedule reduction Analysis 2 – SIPS Sequence & crews **Different SIPS Options** Analysis 3 – Façade Study Background Materials/Research Architectural Breadth Changes Model Mechanical Breadth R-value & Condensation Production & Cost Recommendations Acknowledgements



#### **Brick Veneer**



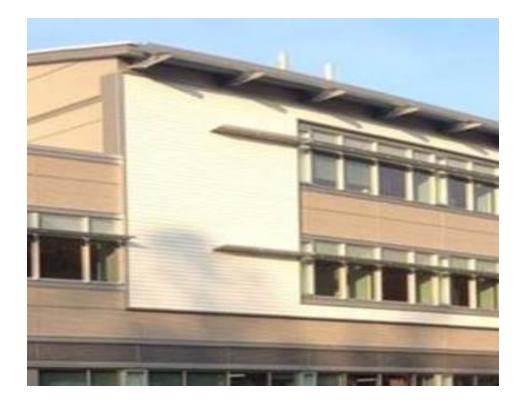
Composite Metal Panels

## Materials & Research

## Analysis 3 – Façade Study







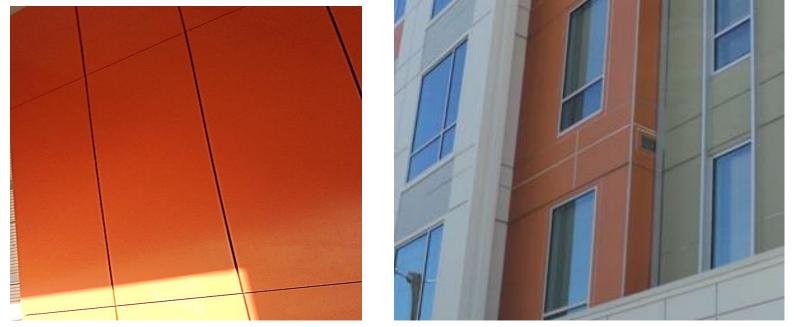


Louvers



#### Fiber Cement Siding

Project Background Analysis 1 – Alternative Delivery Method Background Research/Comparisons Schedule reduction Analysis 2 – SIPS Sequence & crews **Different SIPS Options** Analysis 3 – Façade Study Background Materials/Research Architectural Breadth Changes Model Mechanical Breadth R-value & Condensation Production & Cost Recommendations Acknowledgements



#### Change 1: Composite Metal Panels to Fiber Cement Siding

- Same Manufacturer
- Vertical Panels are 4'x10'
- Not fabricated metal look

## Architectural Breadth

## Analysis 3 – Façade Study

• Difficult installation on metal Z-clips



#### **Change 2: Corrugated Metal Panels to Fiber Cement Siding** • Stainless-steel fasteners over hat channels

- Same Manufacturer
- 4" Minimum exposure
- Not fabricated metal look



Project Background Analysis 1 – Alternative Delivery Method Background Research/Comparisons Schedule reduction Analysis 2 – SIPS Sequence & crews **Different SIPS Options** Analysis 3 – Façade Study Background Materials/Research Architectural Breadth Changes Model Mechanical Breadth R-value & Condensation Production & Cost Recommendations Acknowledgements



#### Change 3: Louvers to Fiber Cement Siding

- Stainless-steel screws
- Same exposure •
- Consistent look

## Architectural Breadth

### Analysis 3 – Façade Study



## 4" BRICK VENEER MORTAR NET-FULL JOINT WEEPS HOLD BACK FROM

#### Change 4: Brick Veneer to Concrete

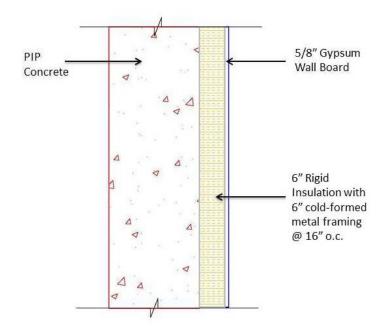
- Dovetail connection to concrete
- Ties into the site

BRACKETS & HAT CHANNELS

MEMBRANE LAP OVER SS FLASHING

AVB TRANSITION

- Hensel Phelps will self-perform
- Fewer wall materials



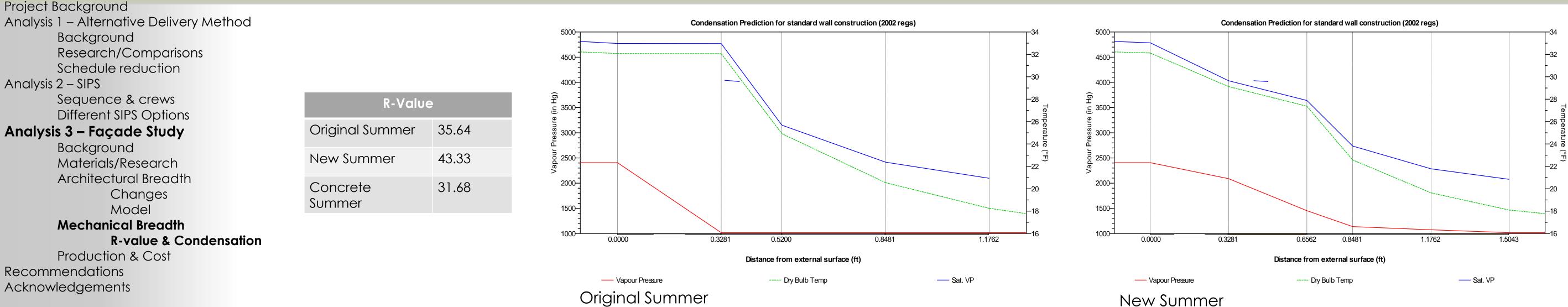


Project Background Analysis 1 – Alternative Delivery Method Background Research/Comparisons Schedule reduction Analysis 2 – SIPS Sequence & crews **Different SIPS Options** Analysis 3 – Façade Study Background Materials/Research Architectural Breadth Changes Model Mechanical Breadth R-value & Condensation Production & Cost Recommendations Acknowledgements

## Architectural Breadth

### Analysis 3 – Façade Study





Production & Cost Recommendations

Project Background

Analysis 2 – SIPS

Acknowledgements

**Original Summer** 

## **Mechanical Breadth**

#### Analysis 3 – Façade Study

Project Background Analysis 1 – Alternative Delivery Method Background Research/Comparisons Material Schedule reduction Analysis 2 – SIPS Corrugated Sequence & crews Composite Different SIPS Options iber Cement Analysis 3 – Façade Study Siding Background Louvers Materials/Research Brick Architectural Breadth Total Changes Model Mechanical Breadth R-value & Condensation **Production & Cost** Recommendations Acknowledgements

# **Production & Cost**

Analysis 3	3 – F
------------	-------

	Original Pro	oduction and Cost			
uare Footage	Duration (Days)	Production Rate (SF/Day)	Cost/Sqft	Cost/Day	Total Cost
19,105	21	940	\$15.00	\$14,100.00	\$296,100
2,412	15	161	\$40.00	\$6,440.00	\$96,600
9,138	10	979	\$13.09	\$12,815.11	\$128,151
1,833	5	367	\$41.50	\$15,230.50	\$76,153
7,514	19	395	\$23.00	\$9,095.89	\$172,822
40,002	70	2,842		\$57,681.50	\$769,826

			New Prod	uction and Cost			
Material	Quantity	Units	Duration (Days)	Production Rate (Unit/Day)	Cost/Unit	Cost/Day	Total Cost
Fiber Cement Siding	32,488	SF	33	979	\$13.09	\$12,815.11	\$425,268
Concrete	509	CY	14	37	\$100.00	\$3,700.00	\$50,928
Total			47	1,016		\$16,515.11	\$476,196

### Façade Study

Project Background Analysis 1 – Alternative Delivery Method Background Research/Comparisons Material Schedule reduction Analysis 2 – SIPS Corrugated Sequence & crews Composite **Different SIPS Options** iber Cement Analysis 3 – Façade Study Siding Background Louvers Materials/Research Brick Architectural Breadth Total Changes Model Mechanical Breadth R-value & Condensation **Production & Cost** Recommendations Acknowledgements

# **Production & Cost**

Analysis	3	—	F
----------	---	---	---

	Original Pro	oduction and Cost			
are Footage	Duration (Days)	Production Rate (SF/Day)	Cost/Sqft	Cost/Day	Total Cost
19,105	21	940	\$15.00	\$14,100.00	\$296,100
2,412	15	161	\$40.00	\$6,440.00	\$96,600
9,138	10	979	\$13.09	\$12,815.11	\$128,151
1,833	5	367	\$41.50	\$15,230.50	\$76,153
7,514	19	395	\$23.00	\$9,095.89	\$172,822
40,002	70	2,842		\$57,681.50	\$769,826

	New Production and Cost														
Material	Quantity	Units	Duration (Days)	Production Rate (Unit/Day)	Cost/Unit	Cost/Day	Total Cost								
Fiber Cement Siding	32,488	SF	33	979	\$13.09	\$12,815.11	\$425,268								
Concrete	509	СҮ	14	37	\$100.00	\$3,700.00	\$50,928								
Total			47	1,016		\$16,515.11	\$476,196								

Façade changes

### Façade Study

# saves 23 days and \$293,630

Drain at Dalkara und	
Project Background	
Analysis 1 – Alternative Delivery Method	And
Background	
Research/Comparisons	Saves 315
Schedule reduction	
Analysis 2 – SIPS	
Sequence & crews	
Different SIPS Options	Analysis 2
Analysis 3 – Façade Study	Saves
Background	54763
Materials/Research	
Architectural Breadth	
Changes	
Model	Savos
Mechanical Breadth	Saves 2
R-value & Condensation	
Production & Cost	
Recommendations	
Acknowledgements	

## Recommendations

nalysis 1: Alternative Delivery Method **5 days with construction starting August 3, 2010**  Recommend

2: Short Interval Production Schedule (SIPS) es 21 days with a slight labor cost increase

Analysis 3: Façade Study **23 days with about a \$300,000 cost savings**  Recommend

Recommend

Project Background Analysis 1 – Alternative Delivery Method Background Research/Comparisons Schedule reduction Analysis 2 – SIPS Sequence & crews **Different SIPS Options** Analysis 3 – Façade Study Background Materials/Research Architectural Breadth Changes Model Mechanical Breadth R-value & Condensation Production & Cost **Recommendations** Acknowledgements

ivity Name	Original	Start	Finish	2	009			2010				2011				20	12		2	2013
	Duration			Q2	Q3	Q4	Q1 (	Q2 Q3	Q4	Q	1 (	22 (	Q3	Q4	Q1	Q2	Q3	Q4	Q1	
ESL:E Environmental Studies Lab: E	1039	23-Mar-09	10-Apr-13	111										L L						
ESL:E.2 Pre-Design	75	23-Mar-09	03-Jul-09		🛉 03-Ju	1-09, ESL:	E.2 Pre-Des	ign												
ESL:E.3 Schematic Design	14	29-Jun-09	17-Ju⊢09		😽 17-J	uF09, ESL	:E3 Schem	atic Design												
Prepare SD drawings	10	29-Jun-09	10-Jul-09		Prep	are SD dra	wings													Million -
🥃 Fundamental design report	11	29-Jun-09	13-Jul-09		🗖 Fund	lamental d	esign report													
🥃 Issue SD package	0	17-Jul-09			🔷 lssu	e SD pack	age, 17-Jul-	09												
ESL:E.4 Design Development 35%	24	10-Aug-09	11-Sep-09			11-Sep-0	9, ESL:E.4	Design Dev	elopment3	35%										
🥃 Prepare DD drawings	20	10-Aug-09	04-Sep-09			Prepare [	D drawings													
🥃 Issue DD package	0	11-Sep-09				Issue DD	package, 1	1-Sep-09												1000
Notice of Award	0	11-Sep-09			•	Notice of	Award, 11-S	ep-09												- Aller
ESL:E.5 Design Development 65%	49	14-Sep-09	20-Nov-09			20	-Nov-09, ES	LE5 Desi	gn Develoj	pment	65%									
Advance DD documents to Construction Document level	20	14-Sep-09	09-Oct-09			📥 Advar	ce DD docu	nents to Co	nstruction	Docu	ment lev	rel								
🥃 Prepare DD drawings	25	12-Oct-09	13-Nov-09			🔲 Pr	pare DD dr	wings												
Prepare DD specs	25	12-Oct-09	13-Nov-09			🔲 Pr	pare DD sp	ecs												1010
🥃 Issue DD package	0	20-Nov-09				Is 🔷	sue DD paci	age, 20-No	v-09											Ditter
ESL:E.6 Construction Documents 95%	835	04-Jan-10	10-Apr-13																	
🥃 Prepare drawings	35	04-Jan-10	19-Feb-10				Prepa	re drawing												
🥃 Prepare specs	35	04-Jan-10	19-Feb-10				Prepa	re specs												Mare -
Notice to Proceed	0	19-Feb-10					Notic	to Procee	l, 19-Feb-	10										
🥃 Submittals	800	22-Feb-10	10-Apr-13								; ; ; 1 1 1							<u> </u>	<u></u>	
💼 Issue 95% CD package	0	01-Mar-10					🔷 İssu	e 95% CD p	ackage, 0	1-Mar-	10									
ESL:E.7 Construction Documents 100%	115	22-Feb-10	03-Aug-10					<b></b>	3-Aug-10,	ËSL:E	7 Con	struction	Docu	mėnts 1	00%					
🥃 Obtain approved permits	43	22-Feb-10	21-Apr-10					Obtain app	oved perr	nits										APARA -
Prepare drawings	5	12-Apr-10	16-Apr-10				0	Prepare dra	wings											
Prepare specs	5	12-Apr-10	16-Apr-10					Prepare spi	cs											
💼 Issue 100% CD package	0	19-Apr-10					٠	lssue 100%	CD pack	age, 1	9-Apr-1	ווס								
🥃 Prepare & Approve Baseline CPM schedule	75	19-Apr-10	03-Aug-10			1111	- i i i 🖻	F	repare &/	Approv	e Basel	inė CPM	scheid	dule						1

## Recommendations

tivity Name	Original Start	Finish	2009	I		201	5		2011		2012	201
	Duration		Q2 Q3	Q4	Q1	Q2	Q3	Q4	Q1 Q2	Q3 Q4	Q1 Q2 Q3 Q4	Q1
ESL:E.8 Construction	330 03-Aug-10	16-Nov-11					Y			V	16-Nov-11, ESL E.8 Construction	
ESL:E.9 Earthwork	255 03-Aug-10	02-Aug-11					-			💙 02-Aug-1	I, ESL:E.9 Earthwork	
ESL:E.10 Concrete	260 09-Aug-10	15-Aug-11								15-Aug-	11, ESLE.10 Concrete	
ESL:E.11 Structural Steel	44 17-Nov-10	20-Jan-11						-	🔽 20- Jan-11, ESI	E.11 Structu	Iral Steel	
ESL:E.12 HVAC	254 29-Jul-10	27-Jul-11								1 1 1 1 1	ESL:E.12 HVAC	
									Site HVAC			
	126 29-Jul-10	26-Jan-11						1 1				
Basement HVAC	187 16-Sep-10									asement HVA		
Penthouse HVAC		27-Jul-11					1			Pentriouse		
Eab 1		13-Apr-11							I Lab 1			
Eab 2	4 08-Apr-11	13-Apr-11						1 1	Lab 2	$\begin{array}{cccccccccccccccccccccccccccccccccccc$		
😑 Lab 3		13-Apr-11							∥ Lab3			
Eab 4	5 08-Apr-11	14-Apr-11							□ Labi4			
👝 Lab 5	5 08-Apr-11	14-Apr-11							[]Lab 5			
💼 Lab 6	6 08-Apr-11	15-Apr-11							[]Labi6			
😑 Lab 7	6 11-Apr-11	18-Apr-11							🛛 Lab 7			
🚘 Lab 8	6 11-Apr-11	18-Apr-11		111	111				]]Lab 8			<u>     </u>
🖨 Lab 9	6 11-Apr-11	18-Apr-11							🛛 Lab 9			
Lab 10	7 11-Apr-11	19-Apr-11							🛛 Lab 10			
🚘 Lab 11	7 12-Apr-11	20-Apr-11							Lab 11			
🚘 Lab 12	6 12-Apr-11	19-Apr-11							Lab 12			
🚘 Lab 13	6 13-Apr-11	20-Apr-11							[] Lab 13			
🚘 Lab 14	6 13-Apr-11	20-Apr-11			111		111		Lab 14			
🚘 Lab 15	6 18-Apr-11	25-Apr-11							🛛 Lab 15			
🚘 Lab 16	6 18-Apr-11	25-Apr-11							🛛 Lab 16			
🚘 Lab 17	6 18-Apr-11	25-Apr-11							🛛 Lab 17			
🚘 Lab 18	6 20-Apr-11	27-Apr-11							🖪 Lab 18			
ESL:E.13 Electrical	244 15-Sep-10	29-Aug-11						3 1 1	133331	29-Aug-1	11, ESL:E.13 Electrical	
ESL:E.14 Fire Protection	100 23-Dec-10	13-May-11						V	13+M	ay-11, ESL.E.	14 Fire Protection	
ESL:E.15 Plumbing	216 20-Sep-10	25-Ju⊦11								25-Jul-11, E	SL:E.15 Plumbing	
ESL:E.16 Facade	43 24-Jan-11	23-Mar-11							23-Mar-11	E\$L:E.16 Fa	acade	
FRP Concrete	14 24-Jan-11	10-Feb-11							FRP Concrete			
👝 Install Fiber Cement Siding	33 07-Feb-11	23-Mar-11			111		111		Install Fibe	r Cement Sidi	ing	
ESL:E.17 Closeout	0 15-Nov-11	15-Nov-11			111					▼ 1	5-Nøv-11, ESL:E.17 Closeout	
Turnover	0	15-Nov-11		111	111	1 1 1	111	111			Furnover,	

#### Industry:

- Hensel Phelps
- Ewing Cole
- Centria

# Acknowledgments

#### Academic:

- Dr. Chimay Anumba
- Dr. Robert Leicht
- Dr. Craig Dubler
- Dr. David Riley
- Professor Parfitt
- Dr. Cox
- Penn State Architectural

Engineering Facility

#### Special Thanks to:

- The Project team
- The Owner and Owner's Representative
- Pace Industry Members
- My Family and Friends
- Jessica Weber







#### **Project Outcome Metrics**

Metric	Equation
Unit cost (\$/SF)	Actual project cost / Gross square-footage
Cost growth (%)	[(Actual project cost – Initial project cost) / Initial project cost] x 100
Intensity (\$/SF/Month)	Unit cost / (Actual project duration in days / 30)
Schedule growth (%)	[(Actual project duration in days – Initial project duration in days) / Initial project duration in days] x 100
Delivery speed (SF/Month)	Gross square-footage / (Actual project duration in days / 30)
Construction speed (SF/Month)	Gross square-footage / (Actual construction duration in days / 30)
Turnover quality (Sum ratings)	Start-up difficulty + Call back frequency + O&M costs
System quality (Sum ratings)	Structure & envelope expectations met + Interior expectations met + Environmental system expectations met
Design quality (Sum ratings)	Aesthetic expectations met + Functional expectations met
Sustainability	LEED certification level

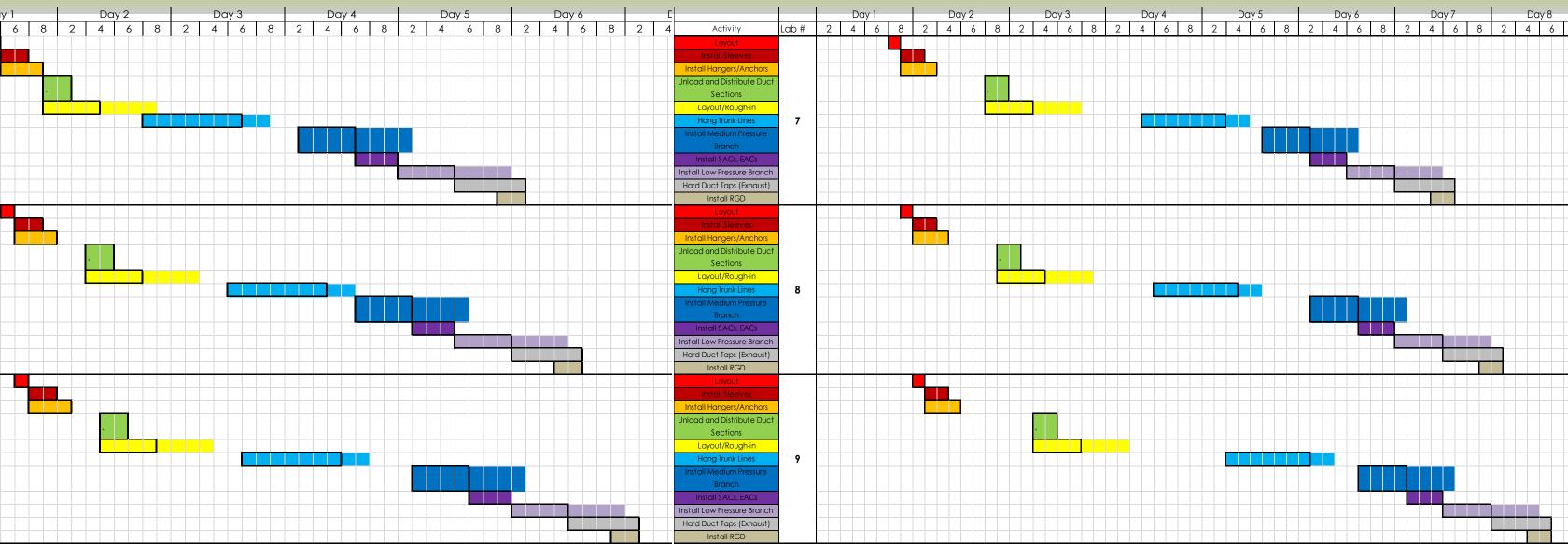
**Building Name** Environmenta 

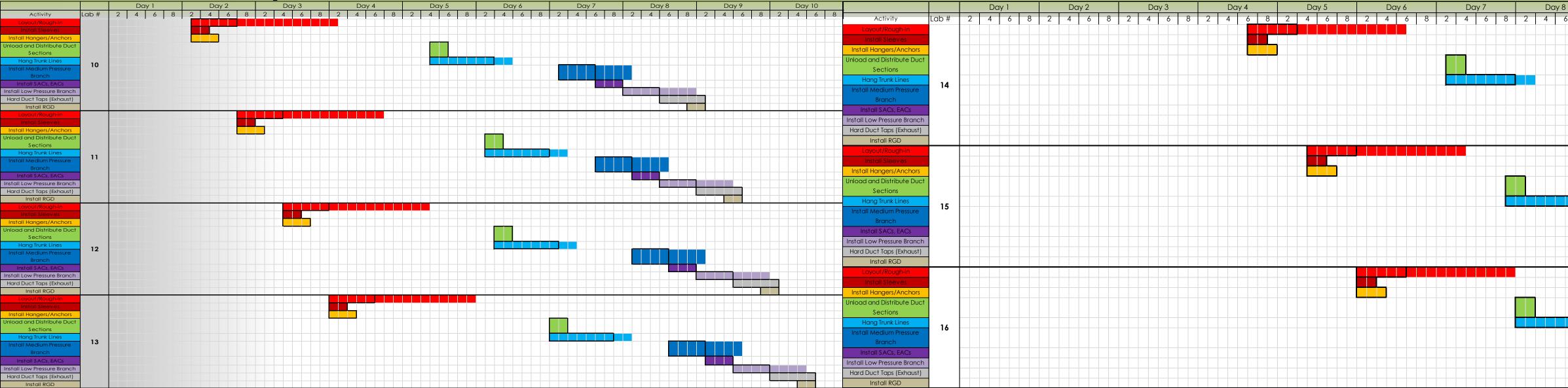
									Finish		Initial	Final				
		Delivery				Project	Start	Finish Plan	Actual	Construction	Construction	Construction			Construction	Delivery
ame	Building Type	Method	Square Foot	NTP	Project End	Duration	Actual Date	date	date	Duration	Cost	Cost	Cost/Sq Ft	Intensity	Speed	Duration
ntal Studies	Lab	DBB	72,000	06/01/11	10/17/13	622	6/15/11	04/22/13	10/07/13	604	33,981,000	35,358,000	\$49 <mark>1</mark>	\$1,756,192	3576	3473
	Naval Base	DB	99,460	04/30/09	05/12/11	531	10/22/09	05/15/11	05/12/11	406	53,787,000	54,518,970	\$548	\$4,028,495	7349	5619
	Health Care	IPD	4,350,100	04/14/08	09/12/12	1153	5/28/09	08/31/12	02/09/12	706	352,852,000	272,892,000	\$63	\$11,595,977	184848	113186
	Municipal building	DB	520,000	12/23/10	08/17/12	432	2/28/11	06/29/12	07/22/12	366	49,177,044	53,396,376	\$103	\$4,376,752	42623	36111
			0_0,000				_/ _0/		•//==/==				+	<u> </u>		
	Transportation	DB	71,336	06/02/11	04/22/13	493	8/10/11	08/01/13	04/22/13	444	25,900,000	32,832,966	\$460	\$2,218,444	4820	4341
	Office/Training/															
	Warehouse	DB	41,155	03/14/12	04/24/13	291	5/21/12	05/31/13	04/24/13	243	8,256,000	10,309,714	\$251	\$1,272,804	5081	4243
	Transportation	DB	2,656,300	10/17/06	06/30/10	967	7/1/07	06/30/10	06/30/10	784	512,771,000	669,456,000	\$252	\$25,616,939	101644	82408
			2,030,300	10/17/00	00/30/10	307	//1/0/	00/30/10	00/30/10	784	512,771,000	009,430,000		ŞZJ,010,939	101044	02400
	Office	DB	250,000	08/01/07	08/01/09	525	8/1/07	06/01/09	06/01/09	479	92,860,000	92,727,765	\$371	\$5,807,584	15658	14286
									On							
		DB	449,000	06/03/11	On Schedule	NA	1/3/12	12/16/15	Schedule	NA	141,231,044	TBD	NA	NA	NA	NA
	Museum	DB	47,000	12/07/09	11/10/12	766	8/7/10	08/23/11	11/09/12	591	11,400,000	12,562,509	\$267	\$637,691	2386	1841
	Hanger-Commercial	DB	60,000	11/03/11	08/01/13	456	3/13/12	06/24/13	06/24/13	335	19,498,000	19,744,063	\$329	\$1,768,125	5373	3947

First Floor														
Activity	Days/Floor	Crew Members	Hours/floor	Hours/lab	Hours/Worker	SIPS 1 & 2 Crew Members	Adjusted Hours/lab	SIPS 3Crew Members	Adjusted Hours/lab					
Layout	1	1	8	0.89	0.89	1	0.89	1	0.89					
Install Sleeves	2	1	16	1.78	1.78	1	1.78	1	1.78					
Install Hangers/Anchors	3	2	24	2.67	1.33	2	2.67	2	2.67					
Unload and Distribute	0			1 70	0.00		1.70	0	1.70					
Duct Sections	2	2	16	1.78			1.78	2	1.78					
Layout/Rough-in	9	•	72	8.00			4.00	2	4.00					
Hang Trunk Lines	10	3	80	8.89	2.96	4	6.67	4	6.67					
Install Medium Pressure	0		70	0.00	0.47		( 00	-	4.00					
Branch	9	3	72	8.00			6.00		4.80					
Install SACs, EACs	3.5	2	28	3.11	1.56	2	3.11	2	3.11					
Install Low Pressure Branch	9	3	72	8.00	2.67	4	6.00	5	4.80					
Hard Duct Taps (Exhaust)	6	3	48	5.33	1.78	3	5.33	3	5.33					
Install RGD	2	1	16	1.78	1.78	1	1.78	1	1.78					
Total		22.00	452	50.22		26	40.00	34	37.60					

				Second Flo	or				
						SIPS 1 Crew	Adjusted	SIPS 3Crew	Adjusted
Activity	Days/Floor	Crew Members	Hours/day	Hours/lab	Hours/Worker	Members	Hours/lab	Members	Hours/lab
Layout/Rough-in	18	1	144	16.00	16.00	3	5.33	3	5.33
Install Sleeves	2	1	16	1.78	1.78	1	1.78	1	1.78
Install Hangers/Anchors	3	2	24	2.67	1.33	2	2.67	2	2.67
Unload and Distribute									
Duct Sections	2	2	16	1.78	0.89	2	1.78	2	1.78
Hang Trunk Lines	10	3	80	8.89	2.96	4	6.67	4	6.67
Install Medium Pressure									
Branch	9	3	72	8.00	2.67	4	6.00	5	4.80
Install SACs, EACs	3.5	2	28	3.11	1.56	2	3.11	2	3.11
Install Low Pressure Branch	9	3	72	8.00	2.67	4	6.00	5	4.80
Hard Duct Taps (Exhaust)	6	3	48	5.33	1.78	3	5.33	3	5.33
Install RGD	2	1	16	1.78	1.78	1	1.78	1	1.78
Total		21.00	516	57.33		26	40.44	32	38.04

			Da	y 1			Da	iy 2				Day	/ 3			C	Day -	4			Do	ay 5					Day
Activity	Lab #	2	4	6	8	2	4	6	8	2	4	4	6	8	2	4		6	8	2	4	6	8	Activity	Lab #	2	4
Layout																								Layout			
Install Sleeves																								Install Sleeves			
Install Hangers/Anchors																								Install Hangers/Anchors			
Unload and Distribute Duct																								Unload and Distribute Duct			
Sections			•																					Sections			
Layout/Rough-in																								Layout/Rough-in			
Hang Trunk Lines	1																							Hang Trunk Lines	4		
Install Medium Pressure																								Install Medium Pressure			
Branch																								Branch			
Install SACs, EACs																								Install SACs, EACs			
Install Low Pressure Branch																								Install Low Pressure Branch			
Hard Duct Taps (Exhaust)																								Hard Duct Taps (Exhaust)			
Install RGD																								Install RGD			
Layout																								Layout			
Install Sleeves																								Install Sleeves			
Install Hangers/Anchors																								Install Hangers/Anchors			
Unload and Distribute Duct																								Unload and Distribute Duct			
Sections			<b>`</b>																					Sections			
Layout/Rough-in																								Layout/Rough-in			
Hang Trunk Lines	2																							Hang Trunk Lines	5		
Install Medium Pressure																								Install Medium Pressure			
Branch																								Branch			
Install SACs, EACs																								Install SACs, EACs			
Install Low Pressure Branch																				_				Install Low Pressure Branch			
Hard Duct Taps (Exhaust)	_																							Hard Duct Taps (Exhaust)			
Install RGD																								Install RGD			
Layout																								Layout			
Install Sleeves																								Install Sleeves			
Install Hangers/Anchors																								Install Hangers/Anchors			
Unload and Distribute Duct																								Unload and Distribute Duct			
Sections					`																			Sections			
Layout/Rough-in																								Layout/Rough-in			
Hang Trunk Lines	3																							Hang Trunk Lines	6		$\square$
Install Medium Pressure																								Install Medium Pressure			
Branch																								Branch			
Install SACs, EACs																								Install SACs, EACs			
Install Low Pressure Branch																								Install Low Pressure Branch	-		
Hard Duct Taps (Exhaust)																								Hard Duct Taps (Exhaust)			
Install RGD																								Install RGD			

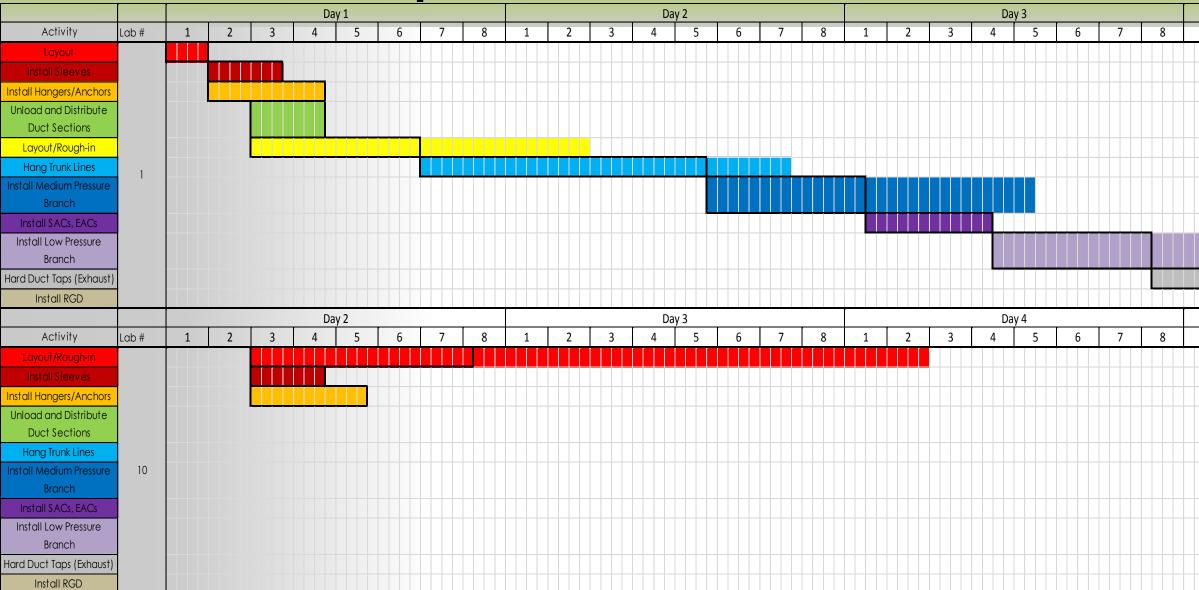




		Day 9												_			_											_			10
	_				_	Da	iy 9		_						/ 10	)							/ 11						0	)ay	<mark>12</mark> /
	8	3	1	2	4	4		5	8	3	1	2	4	4	(	5	8	3	4	2	4	1	ć	5	ξ	3	2	2	4	F	6
																														_	
																														_	
																														_	
																														_	
																														_	
_																														_	
																														_	
																													_	_	
														_								_							_		
																				_		_								_	_
																				_			_						_	_	_
			_	_	_	_		_	_	_	_	_	_	_			_		_	_	_			_	_	_	_	_	_	-	_
_					-																	_	_	_	_	_		_	_	-	
																													_	-	
																													_	_	
																														-	
																						_	_	_	_			_			
																														-	

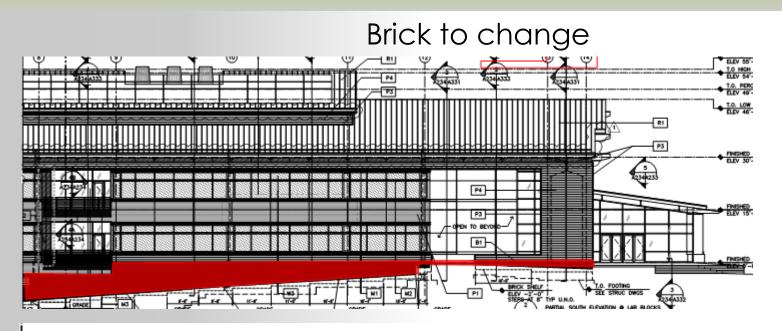
		Day 1		Day 2	2	<b>_</b> Day	3		Day 4		Day (			Day 6		r	Day 7		D	iy 8		Day	)		Day 10			Day 11			Day 12	)	·	Day 13	3
A plivity	l ab #									0 0			0		0			0			0 0			0		0	0			0		- / 0	0		
	Lab #	2 4	δ	2 4	0 8 Z	2 4	0 δ	<u> </u>	6	ŏ 2	4	6 ð	2	4 6	ŏ	2 4	4 6	ŏ	2 4	6 8	ö 2	4	6 ð	2	4 6	o d	2	4 6	o d	2	4 6	ð V	2	4 6	6 ð
Layout/Rough-in Install Sleeves Install Hangers/Anchors Unload and Distribute Duct																																			
Install Sleeves																																			
Install Hangers/Anchors																																			
Unload and Distribute Duct																																			
Sections																																			
Sections Hang Trunk Lines	17																																		
Install Medium Pressure	1/																																		
Install Medium Pressure Branch Install SACs, EACs																																			
Install SACs, EACs																																			
Install Low Pressure Branch																																			
Hard Duct Taps (Exhaust)	1																																		
Install RGD																																			
Install Sleeves																																			
Layout /Rough-in Install Sleeves Install Hangers/Anchors Unload and Distribute Duct																																			
Unload and Distribute Duct																																			
Sections																																			
Sections Hang Trunk Lines																																			
Hang Trunk Lines Install Medium Pressure	18																																		
Propoh																																			
Branch Install SACs, EACs																																			
Install Low Pressure Branch																																			
Hard Duct Taps (Exhaust)																																			
Install RGD																																			

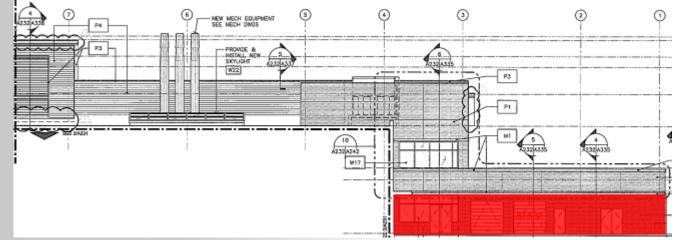


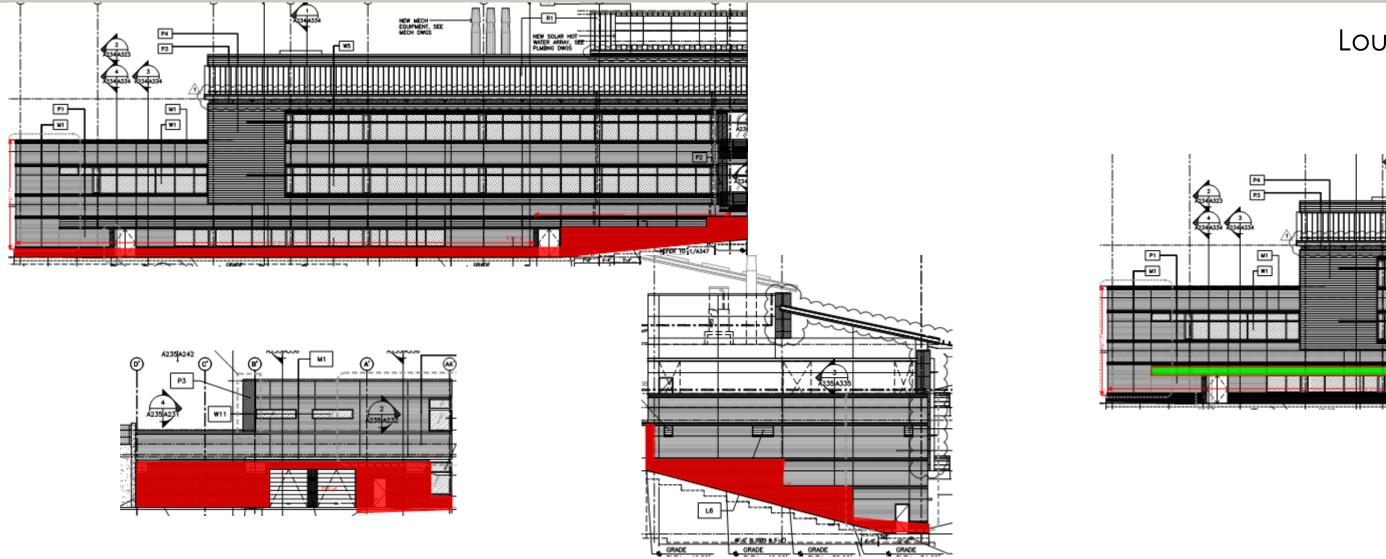


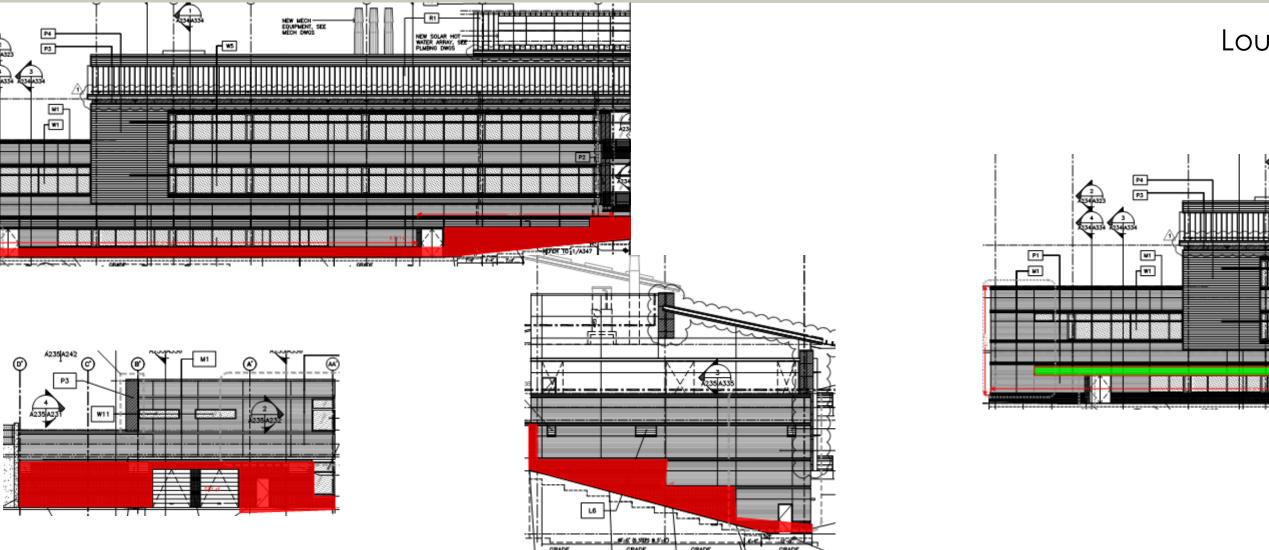


	Day 4 Day 5															D	av 6										Day	7									Day	8										
1	2	3	3	4	5	6		7	8	1	2	3	4		5	6	7		8	1	2	3	D 4	5	5	6	7	8	3	1	2	3			5	6	7	8		1	2	3		4	5	6	7	8
				Day	5	r		r			 r			Day 6				- <u>r</u>			<u>,                                     </u>	 		ay 7		1						1	-	Day			<u> </u>					1		Day	9			<del></del>
1	2	3	3	4	5	6		7	8	1	2	3	4		5	6	7		8	1	2	3	4	5	5	6	7	8		1	2	3		4	5	6	7	8	_	1	2	3	4	4	5	6	7	8
																																																+
																																																++++





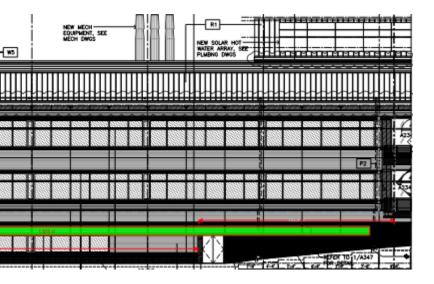




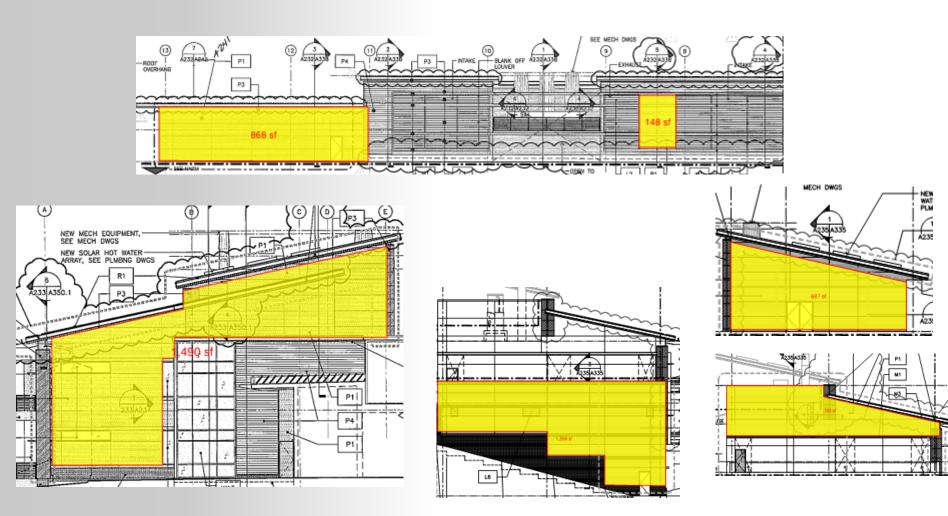
## Appendix

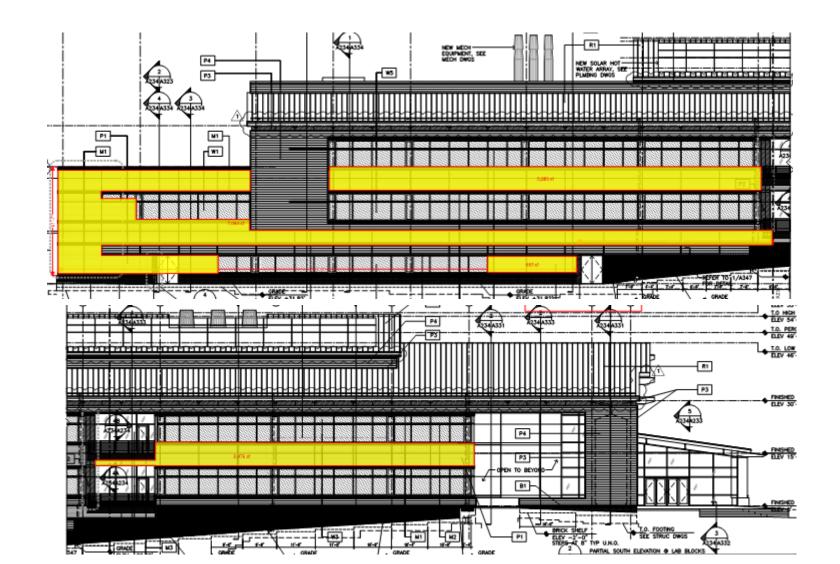
~ ~

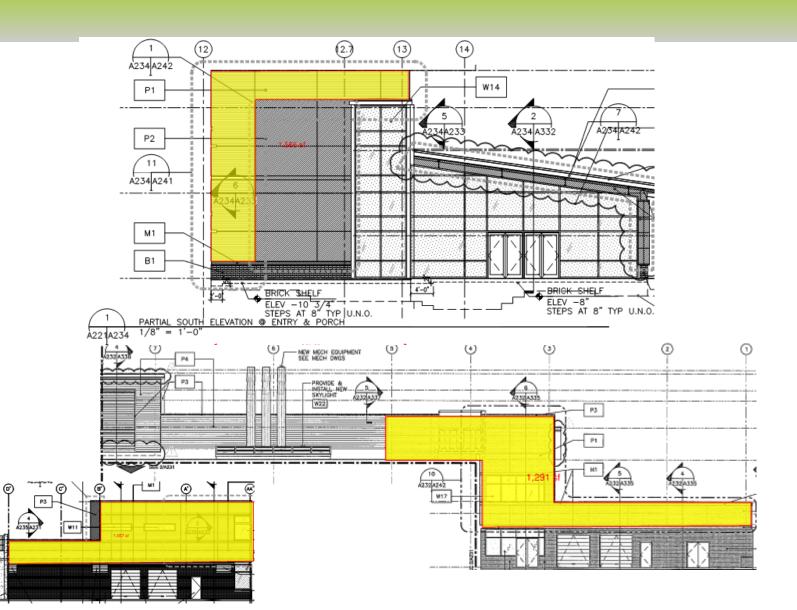
#### Louvers to change



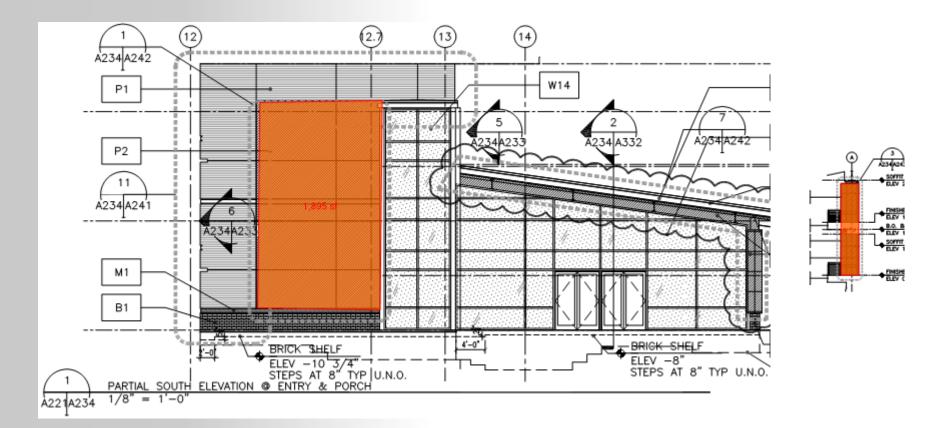
#### Corrugated to change

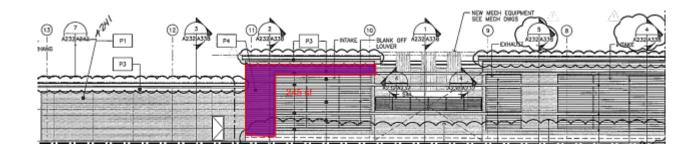






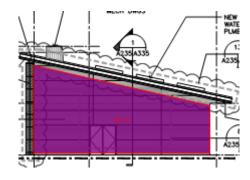
Composite to change

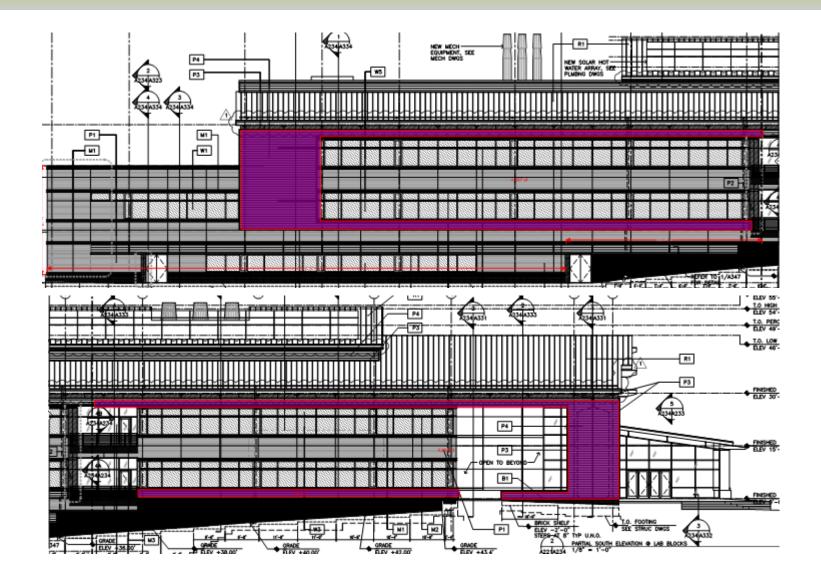




Appendix

#### Current Fiber Cement Siding





		Whole	e Building (Phase	1 & 2)		
Elevation	Corrugated	Composite (orange)	Fiber Cement Siding	Louvers	Brick Veneer	Total Square Footage
North	2,307	0	5,908	0	818	9,033
South	14,769	2,412	8,146	1,833	5,737	32,897
East	1,788	0	638	0	0	2,426
West	9,333	0	0	0	3,768	13,101
Total	28,197	2,412	14,692	1,833	10,323	57,457

		E	Expansion			
Elevation	Corrugated	Composite (orange)	Fiber Cement Siding	Louvers	Brick Veneer	Total Square Footage
North	2,307	0	992	0	818	4,117
South	14,769	2,412	8,146	1,833	5,737	32,897
East	490	0	0	0	0	490
West	3,846	0	0	0	959	4,805
Total	19,105	2,412	9,138	1,833	7,514	40,002



Material Composite Corrugated Louvers Fiber Cement Siding Total

		Originc	I Production and	Cost		
Martarial		Duration	Production Rate	Coat /S aft	Cost/Day	Tatal Cast
Material	Square Footage	(Days)	(SF/Day)	Cost/Sqft	Cost/Day	Total Cost
Corrugated	19,105	21	940	\$15.00	\$14,100.00	\$296,100
Composite	2,412	15	161	\$40.00	\$6,440.00	\$96,60
Fiber Cement						
Siding	9,138	10	979	\$13.09	\$12,815.11	\$128,15
Louvers	1,833	5	367	\$41.50	\$15,230.50	\$76,15
Brick	7,514	19	395	\$23.00	\$9,095.89	\$172,82
Total	40,002	70	2,842		\$57,681.50	\$769,82

		Fib	er Cement Sidi	ng		
1	Square	Duration	Production	Cost /S off	Cost (Dov	Total Cost
	Footage	(Days)	Rate (SF/Day)	Cost/Sqft	Cost/Day	Total Cost
	2,412	2	979	\$13.09	\$12,815.11	\$31,573
	19,105	20	979	\$13.09	\$12,815.11	\$250,084
	1,833	2	979	\$13.09	\$12,815.11	\$23,994
nt						
	9,138	10	979	\$13.09	\$12,815.11	\$128,151
	32,488	34	3,916		\$51,260.44	\$433,803

			New Productio	n and Cost			
Material	Quantity	Units	Duration (Days)	Production Rate (Unit/Day)	Cost/Unit	Cost/Day	Total Cost
Siding	32,488	SF	33	979	\$13.09	\$12,815.11	\$425,268
Concrete	509	CY	14	37	\$100.00	\$3,700.00	\$50,928
Total			47	1,016		\$16,515.11	\$476,196