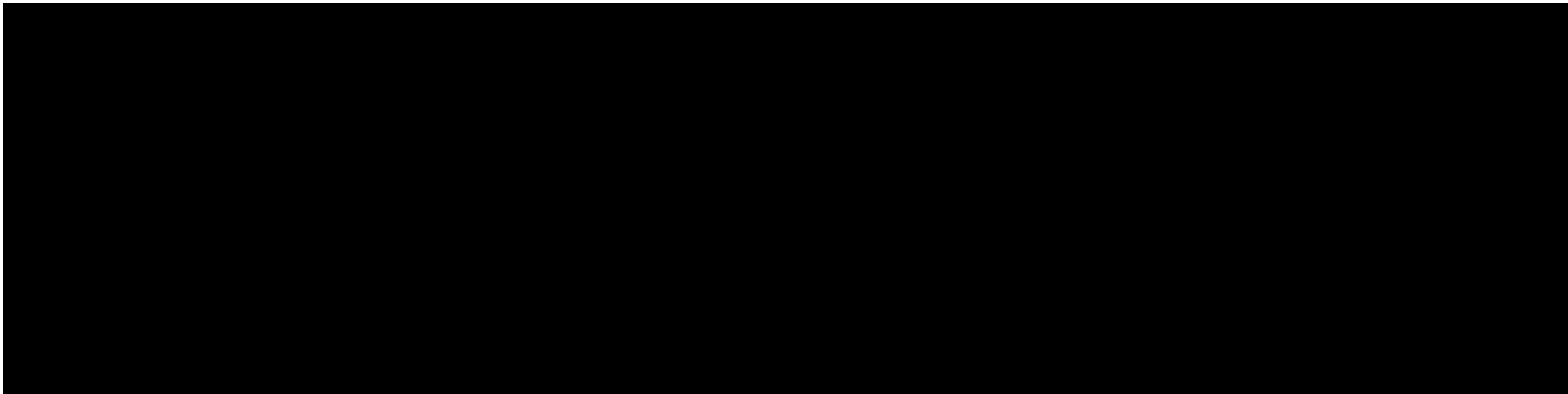


OFFICE BUILDING

NORTHEAST UNITED STATES



PENN STATE AE SENIOR CAPSTONE PROJECT
PATRICK LANINGER - CONSTRUCTION OPTION
ADVISOR: DR. ROBERT LEIGHT



OFFICE BUILDING
NORTHEAST UNITED STATES

ANALYSIS TOPICS

COLUMN RELOCATION
INCREASE DRYWALL PRODUCTIVITY

FAÇADE REDESIGN
INCREASE MASONRY PRODUCTIVITY

BIM IN THE FIELD
PROMOTE RAPID CONFLICT RESOLUTION

DESIGN-BUILD TEAM DYNAMIC
ASSIST IN CONTRACTOR AND OWNER COMMITMENT



BREADTH TOPICS

COLUMN RELOCATION
TWO-WAY CONCRETE SLAB ANALYSIS

FAÇADE REDESIGN
SOLAR GAIN/ENERGY SAVINGS ANALYSIS

PENN STATE AE SENIOR CAPSTONE PROJECT
PATRICK LANINGER - CONSTRUCTION OPTION
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PATRICK LANINGER
CONSTRUCTION MANAGEMENT

PROJECT OVERVIEW

CONFIDENTIAL OFFICE BUILDING
NORTHEAST UNITED STATES

PRESENTATION OUTLINE:

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 - RECOMMENDATIONS
- ACKNOWLEDGEMENTS

PROJECT LOCATION

- NORTHEAST UNITED STATES

BUILDING SIZE

- AREA : 390,000 SF
- STORIES: 3 ABOVE, 2 BELOW GRADE

PROJECT PARAMETERS:

- COST: \$535 MILLION
- TIMELINE: NOV. 2009 - MAY 2013
- DELIVERY METHOD: DESIGN-BUILD



APRIL 2011 PROGRESS PHOTOGRAPH



FEBRUARY 2012 PROGRESS PHOTOGRAPH

PATRICK LANINGER
CONSTRUCTION MANAGEMENT

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McKissack & McKissack

PROJECT PARTICIPANTS

OWNER: CONFIDENTIAL

GENERAL CONTRACTOR: CLARK CONSTRUCTION

OWNER'S REPRESENTATIVE: TISHMAN AECOM

ARCHITECT (HQ BUILDING): WDG ARCHITECTURE

ARCHITECT (GARAGE/CUP): MCKISSACK & MCKISSACK



BUILDING ONE EXTENTS

PROJECT OVERVIEW

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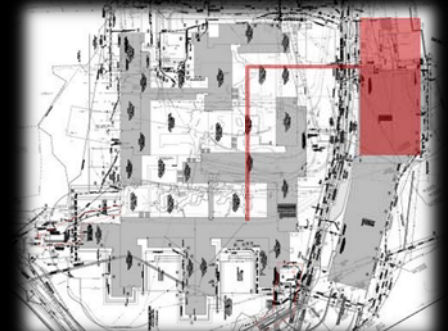
STRUCTURAL/FAÇADE COMPONENTS

BUILDING SYSTEMS

STRUCTURAL SYSTEM
CAST-IN-PLACE CONCRETE
BRICK, STONE, METAL PANEL AND CURTAIN WALL FAÇADE

MECHANICAL SYSTEM
SEVEN AIR-HANDLING UNITS, VAV SYSTEM
STEAM FED FROM CENTRAL UTILITY PLANT BOILERS

ELECTRICAL SYSTEM
FED FROM CENTRAL UTILITY PLANT
POWER STEP-DOWN IN BASEMENT TRANSFORMER AND SWGR

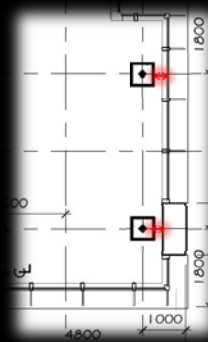


OVERALL SITE - CENTRAL UTILITY PLANT ROUTE

COLUMN RELOCATION

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COLUMN/FAÇADE PROXIMITY

PROBLEM BACKGROUND

VICINITY OF COLUMNS TO EXTERIOR WALL
DECREASES METAL STUD/DRYWALL PRODUCTIVITY

POTENTIAL SOLUTIONS

RELOCATE SLAB-EDGE COLUMNS
UTILIZE THINNER EXTERIOR CMU BLOCKS



COLUMN/FAÇADE PROXIMITY

COLUMN RELOCATION

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RESEARCH

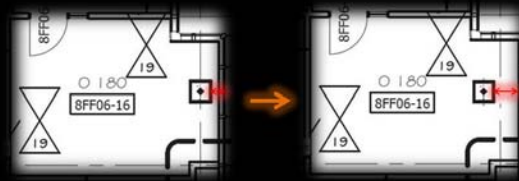
- SLOWS PRODUCTIVITY BY 75%
- REQUIRES SPECIAL TOOLS
- OPTIMUM DISTANCE: 24"-48"
- WILL REQUIRE MORE REBAR
- DOES NOT AFFECT BLAST RATING

MODIFICATIONS

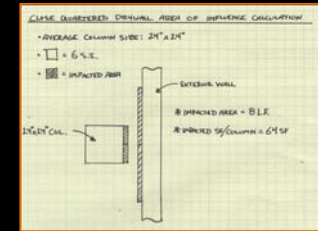
- MOVED COLUMNS TO 24" FROM E.O.S.



RESEARCH, MODIFICATIONS & ANALYSIS



COLUMN LOCATION MODIFICATION



AREA OF INFLUENCE SKETCH

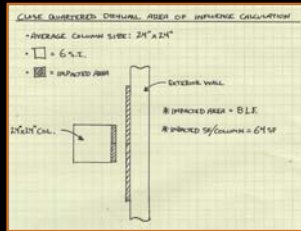
Slab Edge Rebar Sizing and Spacing						
Design	Edge	Rebar Size & Spacing	Rebar Weight (Per LF)	Rebar Length (Per 5 Strips)	Rebar Weight Per 5 Strips (LBS)	Total Rebar Weight (LBS)
Original	6032	#5 @ 12" O.C. Both Ways	1.043	4	4.172	25165.50
Modified	6032	#5 @ 4" O.C. Long Way #5 @ 9" O.C. Short Way	1.043	5	5.215	31456.88
Differential						6291.38

REBAR CHANGES

COLUMN RELOCATION

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AREA OF INFLUENCE SKETCH

BUDGET AND SCHEDULE EFFECTS

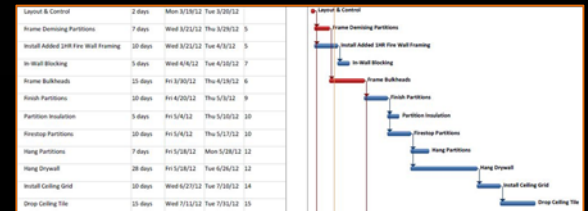
Column Relocation Productivity Analysis		
Item	Units	Quantity
Original Duration	Days	237
Updated Duration	Days	213
Differential		24

Drywall General Conditions Calculation				
Base Bid	% G.C.	General Conditions	Contract Duration (Days)	G.C. (Per Day)
\$11,475,000.00	5	\$573,750.00	780	\$735.58
Total				\$735.58

Note: General Conditions assumed to be 5% of Drywall Contract
Note: Drywall Contract Approximately (3 Years * 52 Weeks * 5 Days) = 780 Days Long

Column Relocation Cost Reduction Analysis				
Item	Units	Quantity	Unit Cost	Total Cost
Drywall Labor	Hours	-192	\$26.11	(\$5,013.12)
Rebar Material	Pounds	6292	\$0.69	\$4,316.82
Rebar Labor	Pounds	6292	\$0.47	\$2,977.88
General Conditions	Days	-24	\$735.58	(\$17,653.85)
Total				(\$15,972.27)

Note: Drywall Labor Rate Taken From Davis Bacon Act Prevailing Wages
Note: All Unit Costs Were Obtained From R.S. Means Assemblies 2012 and have been adjusted for the project's location.



EFFECT ON SCHEDULE LOGIC

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BUILDING ACCESS INTERFERENCE

PROBLEM BACKGROUND

MULTIPLE RECESSES AFFECT MASONRY PRODUCTIVITY

RECESSES ALSO AFFECT SCAFFOLD SAFETY

POTENTIAL SOLUTIONS

REMOVE RECESSES AND REPLACE WITH BRICK SECTIONS



FAÇADE RECESIONS

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INDUSTRY SURVEY/RESEARCH RESULTS

RESEARCH

- SLOWS PRODUCTIVITY BY 50%
- CORNER POLES UNAPPLICABLE
- DOES NOT AFFECT QUALITY
- DOES NOT AFFECT WATER SEAL

MODIFICATIONS

- REMOVE BRICK/GLASS RECESSES
- REPLACE WITH BRICK SECTIONS
- MAINTAIN ARCHITECTURE

Brick Size	Units/Sf	Linear Construction		Corner Construction		Avg. % Reduction
		# Units/Mason/Day	SF/Mason/Day	# Units/Mason/Day	SF/Mason/Day	
Modular	6.75	550	81	275-500	41-74	29
Oversize	5.8	525	91	262-475	45-82	30
Closure	4.5	460	102	230-410	51-91	30
2-1/4" Norman	4.4	430	98	215-380	49-86	31
Utility	3	360	120	180-310	60-103	32
2-1/4" Emperor	3.375	395	117	198-345	59-102	31
4" Emperor	2.25	330	147	165-280	73-124	33
					Avg.	31

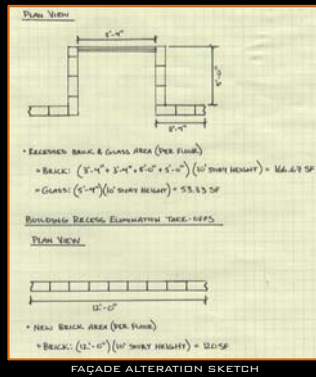
BRICK PRODUCTIVITY RATES



MASONRY CORNER POLE RESTRICTIONS

PRESENTATION OUTLINE:

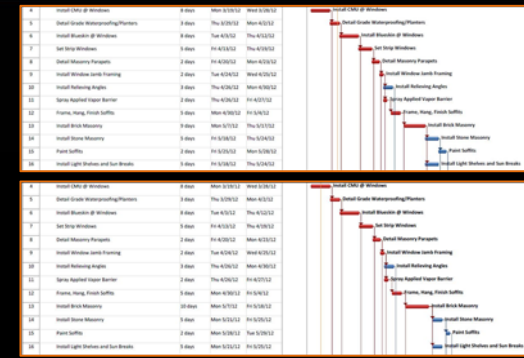
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MASONRY SCHEDULE ACCELERATION

As Designed Façade Productivity Analysis					
Item	Units	Quantity (SF)	Fraction of Brick Façade	Total Duration (Days)	Individual Duration
Linear Brick Façade (As Designed)	SF	40414	0.81	140	113.35
Recessed Brick Façade (As Designed)	SF	9502	0.19		26.65
Totals		49916	1	140	140

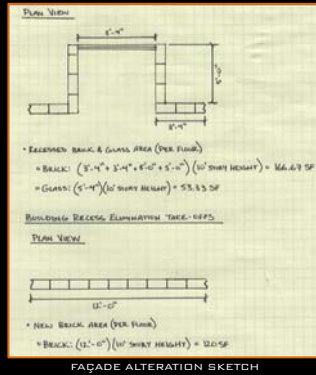
Altered Façade Productivity Analysis						
Item	Units	Quantity (SF)	Original Duration (Days)	% of Design	Productivity Factor	New Duration (Days)
Recessed Brick Façade (As Designed)	SF	9502	27	100	1	27
Replacement Linear Brick Façade	SF	6840	27	72	1.31	15
					Differential	12



AS-DESIGNED AND UPDATED FAÇADE SCHEDULES

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FAÇADE COST ANALYSIS

Location	Total Façade Area (SF)	Total Brick Area (SF)	Brick/Glass Façade Takeoff				
			Total Glass Façade (SF)	Total Recesses	Recessed Brick (SF)	Recessed Glass (SF)	Replacement Brick (SF)
B1 - L19 - South Finger	3850	2344.50	1105.50	4	666.80	213.32	480
B1 - L19 - Middle Finger	5020	3363.40	1656.60	11	1833.70	586.63	1320
B1 - L19 - North Finger	2920	2626.40	1293.60	8	1333.60	426.64	960
B1 - L19 - Child Care	2720	1822.40	897.60	4	666.80	213.32	480
B1 - L18 - Spine	30000	6700.00	3300.00	6	1000.20	319.88	720
B1 - L18 - South Finger	3350	2244.50	1105.50	5	833.50	266.65	600
B1 - L18 - Middle Finger	5020	3363.40	1656.60	11	1833.70	586.63	1320
B1 - L18 - North Finger	3920	2626.40	1293.60	8	1333.60	426.64	960
B1 - L18 - Child Care	2720	1822.40	897.60	4	666.80	213.32	480
B1 - L18 - Spine	30000	6700.00	3300.00	6	1000.20	319.88	720
B1 - L17 - South Finger	3850	2344.50	1105.50	8	1333.60	426.64	960
B1 - L17 - Middle Finger	4360	2921.20	1460.60	3	500.10	159.99	360
B1 - L17 - North Finger	3750	2521.50	1257.50	2	333.40	106.66	240
B1 - L17 - Spine	10000	6700.00	3300.00	3	500.10	159.99	360
B1 - L16 - South Finger	2760	1893.20	910.80	3	500.10	159.99	360
B1 - L16 - Middle Finger	4360	2921.20	1460.60	4	666.80	213.32	480
B1 - L16 - North Finger	5690	3410.30	1679.70	0	0.00	0	0
B1 - L15 - South Finger	1640	1098.80	549.20	0	0.00	0	0
Total	49320	40614	20308	57	8920	3040	6840

Note: Glass Quantities Obtained By Applying 33% Factor to Total Façade Area (Typical Glass Ratio for Entire Building)

Masonry General Conditions Calculation				
Base Bid	% G.C.	General Conditions	Contract Duration (Days)	G.C. (Per Day)
\$4,541,000.00	5	\$227,050.00	650	\$349.31
Total				\$349.31

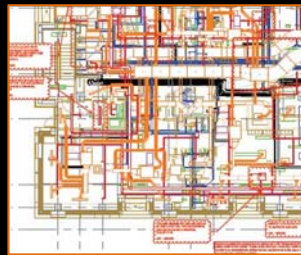
Note: General Conditions assumed to be 5% of Drywall Contract
Note: Drywall Contract Approximately (2.5 Years*52 Weeks*5 Days) = 650 Days Long

Façade Alteration Cost Reduction Analysis							
Item	Units	Quantity	Material Unit Cost	Labor Unit Cost	Total Material Cost	Total Labor Cost	Total Cost
Window Reduction (Inside Recess)	SF	3040	\$17.11	\$25.98	(\$52,609.02)	(\$78,991.36)	(\$131,600.38)
Brick Reduction (Inside Recess)	SF	9502	\$4.93	\$12.99	(\$46,801.53)	(\$123,449.88)	(\$170,251.51)
Brick Addition (Recess Replacement)	SF	6840	\$4.93	\$12.99	\$33,690.01	\$88,865.28	\$122,555.29
General Conditions	Days	12	-	\$349.31	-	(\$4,191.72)	(\$4,191.72)
Totals					(\$65,720.53)	(\$113,576.06)	(\$183,488.33)

Note: All Unit Costs Were Obtained From R.S. Means Assemblies 2012 and have been adjusted for the project's location.

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2D COORDINATION DRAWING

PROBLEM BACKGROUND

3D COORDINATED MODELS HIGHLY UNDERUTILIZED
EXCESSIVE MANHOURS SPENT ADDRESSING CONFLICTS

POTENTIAL SOLUTIONS

UTILIZE IN-FIELD BIM KIOSK TECHNOLOGY
LINK FIELD COMPUTERS TO CLOUD SERVER



BIM KIOSK

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RESEARCH

- REDUCES COORDINATION DURATION
- PROMOTES TEAM ATMOSPHERE
- ADDS PRODUCTIVITY "VALUE"

MODIFICATIONS

- ADDED 3 BIM KIOSKS TO PROJECT
- EACH OF THE EIGHT FOREMEN REDUCES TIME COMMITMENT BY 45 MINUTES EACH DAY
- ALSO AFFECTS PROJECT MANAGER AND DESIGN PROFESSIONAL

BIM KIOSK IMPLEMENTATION

BIM Kiosk Implementation Time and Budget Savings						
Personnel	Hourly Wage (w/ Fringe)	Time Savings (Hours Per Conflict)	Conflicts (Per Week)	Job Duration (Weeks)	Time Saved (Hours)	Total Savings
Foreman	\$125.00	0.75	40	156	4680	\$585,000.00
Project Manager	\$165.00	0.75	40	156	4680	\$772,200.00
Design Professionals	\$165.00	0.75	10	156	1170	\$193,050.00
Totals					10530	\$1,550,250.00

BIM Kiosk Implementation Costs						
Personnel	Hourly Cost	Time (Hours)	Quantity	Material Costs	Labor Costs	Total Cost
Foreman Training	\$125.00	2	8	\$400.00	\$2,000.00	\$2,400.00
Project Manager Training	\$165.00	2	12	\$600.00	\$3,960.00	\$4,560.00
Instructor	\$150.00	6	1	-	\$900.00	\$900.00
BIM Kiosk Costs	-	-	3	\$9,000.00	\$1,500.00	\$31,500.00
Network Allowance	-	-	-	\$10,000.00	\$25,000.00	\$35,000.00
Drawing Updates Allowance	-	-	-	\$2,500.00	\$35,000.00	\$37,500.00
Totals				\$22,500.00	\$61,500.00	\$111,860.00

BIM Kiosk Implementation Savings and Costs Comparison

Item	Labor Cost	Material Cost	Labor Hours	Total Cost
Foreman Time Savings	(\$585,000.00)	-	(4680.00)	(\$585,000.00)
PM Time Savings	(\$772,200.00)	-	(4680.00)	(\$772,200.00)
DP Time Savings	(\$193,050.00)	-	(1170.00)	(\$193,050.00)
Foreman Training Costs	\$2,400.00	\$400.00	16.00	\$2,400.00
PM Training Costs	\$3,960.00	\$600.00	24.00	\$4,560.00
Instructor Fees	\$900.00	-	6.00	\$900.00
BIM Kiosk Costs	\$1,500.00	\$9,000.00		\$10,500.00
Networking Costs	\$25,000.00	\$10,000.00		\$35,000.00
Drawing Updates Costs	\$35,000.00	\$2,500.00		\$37,500.00
Totals	(\$1,481,890.00)	\$22,500.00	(10484.00)	(\$1,459,390.00)

PATRICK LANINGER
CONSTRUCTION MANAGEMENT

D/B TEAM DYNAMIC

CONFIDENTIAL OFFICE BUILDING
NORTHEAST UNITED STATES

PRESENTATION OUTLINE:

- PROJECT OVERVIEW
 - GENERAL INFORMATION
 - PROJECT TEAM
 - BUILDING SYSTEMS
- ANALYSIS #1: COLUMN RELOCATION
 - PROBLEM BACKGROUND/SOLUTIONS
 - RESEARCH/MODIFICATION/ANALYSIS
 - EFFECTS ON COST/SCHEDULE
- ANALYSIS #2: FAÇADE REDESIGN
 - PROBLEM BACKGROUND/SOLUTIONS
 - RESEARCH
 - ENERGY ANALYSIS
 - EFFECTS ON COST/SCHEDULE
- ANALYSIS #3: BIM IN THE FIELD
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McKissack & McKissack

PROBLEM BACKGROUND

DESIGN-BUILD ADJUSTMENT ISSUES
VARYING LEVELS OF TEAM COMMITMENT

POTENTIAL SOLUTIONS

RESEARCH D/B KEYS TO SUCCESS

DETERMINE MANNER IN WHICH TO EVALUATE TEAM MEMBERS



DESIGN-BUILD PROJECT SCHEDULE

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INDUSTRY SURVEY/RESEARCH RESULTS

RESEARCH

- SURVEYED INDUSTRY MEMBERS WITH DESIGN-BUILD EXPERIENCE
- DISCUSSED AREAS OF FOCUS IN SELECTING PROJECT TEAM MEMBERS
- REVIEWED PENN STATE'S "360 EVALUATIONS" FOR CONSISTENCY

Design Build Team Characteristics	
Positive Characteristics	Negative Characteristics
Technical Expertise	Owner Lacks Ultimate Decision Maker
Full Understanding of Work Scopes	Owner Wishes to Retain Competitive Bidding
Previous Experience	Unavailability of Project Managers
Full Disclosure	Delayed A/E Response to Design Changes
Productive Cooperation	Contractor Reluctance to Redesign/Coordinate Systems
Efficient Workers	Strong Egos
Ability to See Past "Hard Dollar" Approach	Complex Administrative Hierarchies
Active Involvement in Preconstruction	
Ability to Produce Detailed Estimates	
Respect	
Collaboration	

HIGHLIGHTS

- MOST TECHNICALLY VERSED SUBCONTRACTORS
- COOPERATION, COORDINATION, DETAIL OF WORK
- RESPECT AND COLLABORATION
- ABILITY TO SEE PAST TRADITIONAL APPROACH
- OWNER COMMITMENT
- DESIGN A/E COMMITMENT

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KEYS TO SUCCESS

CONTRACTORS

- BE VERY DETAILED IN ESTIMATES
- BE PREPARED TO PROVIDE FULL DISCLOSURE OF DECISIONS
- GET INVOLVED IN PRECONSTRUCTION
- COLLABORATION, COORDINATION AND RESPECT



OWNERS

- ESTABLISH WHO HAS ULTIMATE CONTROL EARLY IN PROJECT
- RELINQUISH DESIRE FOR COMPETITIVE BID PROCESS
- BE PREPARED TO MAKE TOUGH DECISIONS IN A TIMELY MANNER
- GET INPUT FROM END USER EARLY IN PROJECT

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MAE APPLICATIONS

- PRECONSTRUCTION REQUIREMENT IN CONTRACT
- SHARED SAVINGS CLAUSES
- CONTRACTUAL HIERARCHY BETWEEN D/B PARTNERS
- 360 EVALUATION REQUIREMENTS INCORPORATED IN CONTRACT
- "SET CONTRACT ASIDE AND FORGET IT"

MAE RESEARCH

- AE 570: PROJECT DELIVERY METHODS
- DESIGN-BUILD PROJECT APPROACH
- AE 598D: LEGAL ASPECTS
- DESIGN-BUILD CONTRACTS

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FINAL SUMMARY

- ANALYSIS #1: COLUMN RELOCATION
 - SAVINGS OF LESS THAN 0.1% OF DRYWALL CONTRACT
 - DOES NOT AFFECT DRYWALL CRITICAL PATH
- ANALYSIS #2: FAÇADE REDESIGN
 - 4% CUT OF MASONRY CONTRACT
 - ACCELERATES MASONRY CRITICAL PATH
- ANALYSIS #3: BIM IN THE FIELD
 - SAVES 10,500 MANHOURS
 - \$1.46M ADDED VALUE
- ANALYSIS #4: DESIGN BUILD TEAM DYNAMIC
 - BE AWARE OF OWNER RESERVATIONS
 - ENSURE EVERYONE IS READY TO MAKE COMMITMENT

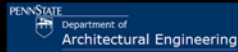
ACKNOWLEDGEMENTS

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QUESTIONS?



INDUSTRY

- CLARK CONSTRUCTION
 - JOE MAGNOTTA, DAVE PASTRICK, MIKE VITKOVICH, TOM SPIVEY, MIKE HUBER, AND PAUL BOMBERO
- BARTON MALOW COMPANY
 - NICK UMOSELLA, DAN BUCHTA, BOB GROTTENTHALER
- DAVIS CONSTRUCTION
 - JULIE KIRKWOOD, MIKE PITTSMAN, AND WILL COX
- TRADE CONTRACTORS
 - TRI-STATE DRYWALL, ETC. ETC.

ACADEMIC

- DR. ROBERT LEIGHT: ADVISOR

SPECIAL THANKS

- CLARK CONSTRUCTION
- BARTON MALOW COMPANY
- DAVIS CONSTRUCTION
- T.J. KLEINSKY, BRIAN ROSE, MADDIE HAUS, DANIEL WIGGANS
- TRADE CONTRACTORS
- FAMILY & FRIENDS

Columns & Reinforced Slabs: 3000 PSI → Fc = 3000 PSI
 Grade: 60 STEEL → 2x REINFORC. PSI
 Live Loads: 60 (OFFICE) + 20 (REINFORC.)
 Slab Dead Loads (DL) (60 PSI) = 100 PSF
 S.F. Dead Loads: 10 PSF PER TYPICAL OFFICE AREAS

Time Loads:
 LL = 100 PSF
 LL = 800 PSF

$CL = 12(0.14) + 16(0.08) = 0.260$ P.F.K.

DETAILED STRUCTURAL ANALYSIS RESULTS

Frame A
 $M_u = (0.260)(10^3)(10^3)(10^3) = 467.2$ P.F.K.
 RELATIVE MOMENTS → M1 = 193.7 P.F.K.
 → 25% TO COLUMN STRIP = 48.4 P.F.K.
 → 25% TO JOINT STRIP = 48.4 P.F.K.

Frame B
 $M_u = (0.260)(10^3)(10^3)(10^3) = 650.6$ P.F.K.
 RELATIVE MOMENTS → M1 = 264.9 P.F.K.
 → 25% TO COLUMN STRIP = 66.2 P.F.K.
 → 25% TO JOINT STRIP = 66.2 P.F.K.

Frame C
 $M_u = (0.260)(10^3)(10^3)(10^3) = 240$ P.F.K.
 RELATIVE MOMENTS → M1 = 104.7 P.F.K.
 → 25% TO COLUMN STRIP = 26.2 P.F.K.
 → 25% TO JOINT STRIP = 26.2 P.F.K.

Frame D
 $M_u = (0.260)(10^3)(10^3)(10^3) = 572$ P.F.K.
 RELATIVE MOMENTS → M1 = 229.4 P.F.K.
 → 25% TO COLUMN STRIP = 57.4 P.F.K.
 → 25% TO JOINT STRIP = 57.4 P.F.K.

Frame B
 RELATIVE MOMENTS → M1 = 264.9 P.F.K.
 → 25% TO COLUMN STRIP = 66.2 P.F.K.
 → 25% TO JOINT STRIP = 66.2 P.F.K.

Frame C
 RELATIVE MOMENTS → M1 = 104.7 P.F.K.
 → 25% TO COLUMN STRIP = 26.2 P.F.K.
 → 25% TO JOINT STRIP = 26.2 P.F.K.

Frame D
 RELATIVE MOMENTS → M1 = 229.4 P.F.K.
 → 25% TO COLUMN STRIP = 57.4 P.F.K.
 → 25% TO JOINT STRIP = 57.4 P.F.K.

NOTE: BECAUSE THERE ARE NO INTERIOR BEAMS, $C_{\alpha} \frac{L}{2} = 0$
 AND NO INTERMEDIATE TOPS FOUND IN 401 13.4' PER COLUMN STRIP 1/2.

Frame B: Reinforcement Details → Long Direction

	2nd Column Strip	Joint Strip	Notes
M1	193.7	193.7	
STRIP WIDTH	102"	102"	
Effective Depth	4.302"	4.302"	1/2" MIN. WITH 4.302" WIDTH OF
M1/S	179.65	179.65	10/14
R	456.5	456.5	280.9
ρ	0.009	0.009	0.009
Aspld	5.81	5.81	5.81
Asmin	1.93	1.93	1.93
As	5.81	5.81	5.81
As/Aspld	1.00	1.00	1.00
As/Asmin	3.01	3.01	3.01
As/Aspld	3.01	3.01	3.01
As/Asmin	3.01	3.01	3.01

Frame D: Reinforcement Details → Short Direction

	2nd Column Strip	Joint Strip	Notes
M1	229.4	229.4	
STRIP WIDTH	152"	152"	
Effective Depth	4.302"	4.302"	1/2" MIN. WITH 4.302" WIDTH OF
M1/S	150.92	150.92	10/14
R	572.0	572.0	341.4
ρ	0.009	0.009	0.009
Aspld	8.67	8.67	8.67
Asmin	2.86	2.86	2.86
As	8.67	8.67	8.67
As/Aspld	3.03	3.03	3.03
As/Asmin	3.03	3.03	3.03

COLUMN RELOCATION

Slab Edge Takeoffs	
Location	Slab Edge Perimeter (FT)
B1 - LL9	Mat Slab - No Extra Rebar Required
B1 - LL8 - South Finger	335
B1 - LL8 - Middle Finger	502
B1 - LL8 - North Finger	392
B1 - LL8 - Child Care	272
B1 - LL8 - Spine	1000
B1 - LL7 - South Finger	335
B1 - LL7 - Middle Finger	436
B1 - LL7 - North Finger	375
B1 - LL7 - Spine	1000
B1 - LL6 - South Finger	276
B1 - LL6 - Middle Finger	436
B1 - LL6 - Spine	509
B1 - LL5 - South Finger	164
Total	6032

Column Relocation Productivity Analysis		
Item	Units	Quantity
Original Duration	Days	237
Updated Duration	Days	213
	Differential	24

DETAILED TAKEOFFS

Column Relocation Driveway Takeoffs and Productivity Analysis												
Location	Partition Driveway (SF)	# of Columns	Affected Driveway (SF Per Column)	Total Affected Driveway (SF)	% Affected	Inc. in Productivity of Affected Area (%)	Original Dur. (Days)	Original Dur. (Hrs.)	Original Col. Dur. (Hrs.)	New Col. Dur. (Hrs.)	Updated Duration (Hrs.)	Updated Duration (Days)
B1 - LL8 - South Finger	5960	18	64	1152	0.19	50	10	80	15.46	7.73	72.27	8.03
B1 - LL8 - Middle Finger	9792	34	64	2176	0.22	50	15	120	26.67	13.33	106.67	13.33
B1 - LL8 - North Finger	5176	25	64	1600	0.31	50	15	120	20.92	10.46	108.54	13.69
B1 - LL8 - Childcare	1984	25	64	1600	0.27	50	10	80	21.89	10.70	69.89	8.66
B1 - LL8 - Spine	16272	58	64	3712	0.23	50	30	240	36.50	18.25	141.75	17.72
B1 - LL8 - South Finger	5728	18	64	1152	0.20	50	15	120	24.13	12.07	107.93	13.48
B1 - LL8 - Middle Finger	9608	34	64	2176	0.25	50	15	120	30.26	15.13	124.67	15.72
B1 - LL8 - North Finger	5856	25	64	1600	0.30	50	15	120	22.07	11.48	108.52	13.56
B1 - LL8 - Child Care	5120	16	64	1024	0.20	50	10	80	16.00	8.00	72.00	9.00
B1 - LL8 - Spine	16272	58	64	3712	0.23	50	30	240	36.50	18.25	141.75	17.72
B1 - LL7 - South Finger	9016	22	64	1408	0.16	50	15	120	18.71	9.35	110.65	13.83
B1 - LL7 - Middle Finger	6768	18	64	1152	0.17	50	12	96	16.34	8.17	87.83	10.98
B1 - LL7 - North Finger	5992	15	64	960	0.16	50	15	120	19.23	9.61	110.39	13.80
B1 - LL7 - Spine	16272	58	64	3712	0.23	50	30	240	36.50	18.25	141.75	17.72
B1 - LL6 - Middle Finger	7344	22	64	1408	0.19	50	12	96	18.41	9.20	86.80	10.85
B1 - LL6 - Spine	10112	28	64	1792	0.18	50	18	144	25.52	12.76	111.24	13.91
Total	148832	424		38036			237	1936	262	132	1208	213

Note: Movement of Columns does not create benefits on LL6 and LL5 South Fingers w/ of unfinished mechanical spaces.
Note: Average Column width = 2' - Area affected = 2' column side + 2' on adjacent wall on either side of the column (As Seen in Area of Influence Calculation)
Note: The column durations were decreased by a factor of 50%, a portion of the 75% reduction implied by industry professionals.

Modified Rebar Sizing and Spacing						
Frame	Location	Moment	Rebar Size & Spacing	Rebar Weight (Per LF)	Rebar Length (Per 1' Strip)	Rebar Weight Per 1' Strip (LBS)
Frame B - Long Direction	Full Column Strip	+	#5's @ 4" O.C.	1.043	3	3.129
Frame B - Long Direction	Full Column Strip	-	#5's @ 2' O.C.	1.043	6	6.258
Frame B - Long Direction	Middle Strip	+	#5's @ 6" O.C.	1.043	2	2.086
			Averages #5's @ 4" O.C.		3.00	3.129

Modified Rebar Sizing and Spacing Average						
Frame	Location	Moment	Rebar Size & Spacing	Rebar Weight (Per LF)	Rebar Length (Per 1' Strip)	Rebar Weight Per 1' Strip (LBS)
Frame D - Short Direction	Full Column Strip	+	#5's @ 6" O.C.	1.043	2	2.086
Frame D - Short Direction	Full Column Strip	-	#5's @ 4" O.C.	1.043	3	3.129
Frame D - Short Direction	Middle Strip	+	#5's @ 13" O.C.	1.043	1	1.043
			Averages #5's @ 8" O.C.		2.00	2.086

Slab Edge Rebar Sizing and Spacing						
Design	Edge LF	Rebar Size & Spacing	Rebar Weight (Per LF)	Rebar Length (Per 1' Strip)	Rebar Weight Per 1' Strip (LBS)	Total Rebar Weight (LBS)
Original	6032	#5's @ 12" O.C. Both Ways	1.043	4	4.172	25165.50
Modified	6032	#5's @ 4" O.C. Long Way #5's @ 8" O.C. Short Ways	1.043	5	5.215	31456.88
					Differential	6291.38

FAÇADE SIMPLIFICATION

DETAILED FAÇADE ANALYSIS RESULTS

Brick/Glass Façade Takeoff							
Location	Total Façade Area (SF)	Total Brick Area (SF)	Total Glass Façade (SF)	# of Recesses	Recessed Brick (SF)	Recessed Glass (SF)	Replacement Brick (SF)
B1-L19-South Finger	356	2244.50	1105.50	4	666.80	213.32	480
B1-L19-Middle Finger	920	3933.40	1956.60	11	1833.70	585.63	1320
B1-L19-North Finger	3920	2626.40	1293.60	8	1333.60	426.64	960
B1-L19-Child Care	2720	1822.40	897.60	4	666.80	213.32	480
B1-L19-Spine	10000	6700.00	3300.00	6	1000.20	319.98	720
B1-L18-South Finger	3350	2244.50	1105.50	5	833.50	266.85	600
B1-L18-Middle Finger	5020	3816.40	1956.60	11	1833.70	585.63	1320
B1-L18-North Finger	3920	2626.40	1293.60	8	1333.60	426.64	960
B1-L18-Child Care	2720	1822.40	897.60	4	666.80	213.32	480
B1-L18-Spine	10000	6700.00	3300.00	6	1000.20	319.98	720
B1-L17-South Finger	3350	2244.50	1105.50	5	1333.60	426.64	960
B1-L17-Middle Finger	4360	2921.20	1458.80	3	700.10	159.99	360
B1-L17-North Finger	3750	2512.60	1237.50	2	133.40	106.66	240
B1-L17-Spine	10000	6700.00	3300.00	3	500.10	159.99	360
B1-L16-South Finger	2760	1849.20	919.80	3	700.10	159.99	360
B1-L16-Middle Finger	4360	2921.20	1458.80	4	666.80	213.32	480
B1-L16-Spine	5090	3410.30	1679.70	0	0.00	0	0
B1-L15-South Finger	1640	1098.80	541.20	0	0.00	0	0
Total	49230	40414	19502	57	9502	3060	6840

Note: Glass Quantities Obtained By Applying 33% Factor To Total Façade Area (Typical Glass Brick Ratio for Entire Building)

As Designed Façade Productivity Analysis					
Item	Units	Quantity (SF)	Fraction of Brick Façade	Total Duration (Days)	Individual Duration
Linear Brick Façade (As Designed)	SF	40414	0.81	140	113.35
Recessed Brick Façade (As Designed)	SF	9502	0.19	140	26.65
Totals		49916	1	140	140

Altered Façade Productivity Analysis						
Item	Units	Quantity (SF)	Original Duration (Days)	% of Original Design	Productivity Factor	New Duration (Days)
Recessed Brick Façade (As Designed)	SF	9502	27	100	1	27
Replacement Linear Brick Façade	SF	6840	27	72	1.31	15
				Differential		12

Masonry General Conditions Calculation				
Base Bid	% G.C.	General Conditions	Contract Duration (Days)	G.C. (Per Day)
\$4,541,000.00	5	\$227,050.00	650	\$349.31
		Total		\$349.31

Note: General Conditions assumed to be 5% of Drywall Contract
Note: Drywall Contract Approximately (2.5 Years*52 Weeks*5 Days) = 650 Days Long

Façade Alteration Cost Reduction Analysis							
Item	Units	Quantity	Material Unit Cost	Labor Unit Cost	Total Material Cost	Total Labor Cost	Total Cost
Window Reduction (Inside Recess)	SF	3040	\$17.31	\$25.98	(\$52,609.02)	(\$78,991.36)	(\$131,600.38)
Brick Reduction (Inside Recess)	SF	9502	\$4.93	\$12.99	(\$46,881.13)	(\$123,469.80)	(\$170,251.13)
Brick Addition (Recess Replacement)	SF	6840	\$4.93	\$12.99	\$33,690.01	\$88,865.28	\$122,555.29
General Conditions	Days	12	-	\$349.31	-	(\$4,191.72)	(\$4,191.72)
Totals					(\$65,720.55)	(\$113,576.06)	(\$183,488.33)

Note: All Unit Costs Were Obtained From R.S. Means Assemblies 2012 and have been adjusted for the project's location.

DETAILED MECHANICAL ANALYSIS RESULTS

Façade U-Value Calculations	
Item	R-Value
Brick/CMU - Cold Applied Waterproofing	2
Brick/CMU - 8" Backup Blocking - Grouted Cells	3
Brick/CMU - Nominal Brick Facing	0.45
Brick/CMU - 2" Insulation of Rigid Foam	13
Total U-Value	0.054
Insulating Glass - Double Seals - Low-E Viscron Glazing	34.48
Total U-Value	0.29

Trans Trade Inputs

Material: Single Glazing

Non-Resistant Glass Type: [Dropdown]

Properties:

- Frame: [Dropdown]
- Frame U-Value: [Input]
- Frame Area: [Input]
- Frame Perimeter: [Input]
- Frame Length: [Input]
- Frame Width: [Input]
- Frame Height: [Input]
- Frame Depth: [Input]
- Frame Material: [Input]
- Frame Color: [Input]
- Frame Finish: [Input]
- Frame Type: [Input]
- Frame Notes: [Input]

Window:

- Window U-Value: [Input]
- Window Area: [Input]
- Window Perimeter: [Input]
- Window Length: [Input]
- Window Width: [Input]
- Window Height: [Input]
- Window Depth: [Input]
- Window Material: [Input]
- Window Color: [Input]
- Window Finish: [Input]
- Window Type: [Input]
- Window Notes: [Input]

Window Schedule: [Dropdown]

TRANS TRADE INPUTS

COOLING COIL LOAD INFORMATION				
Load Component	Sensible Btu/h	Latent Btu/h	Total Btu/h	Percent of Total
Solar Gain	0	0	0.0%	
Glass Transmission	0	0	0.0%	
Roof Transmission	402	0	40.2%	
Wall Transmission	0	0	0.0%	
Floor Transmission	0	0	0.0%	
Agitation Transmission	0	0	0.0%	
Heat Gaining Loads	0	0	0.0%	
Lighting	0	0	0.0%	
Plenums	0	0	0.0%	
Other Equipment Loads	0	0	0.0%	
Cooling Infiltration	0	0	0.0%	
Sub-Total	402	0	40.2%	
Ventilation Load	0	0	0.0%	
Minimum Fresh Air	0	0	0.0%	
Supply Fan Load	0	0	0.0%	
Return Fan Load	0	0	0.0%	
Heat Loss to Plenum	0	0	0.0%	
Heat Loss to Plenum	62	0	6.2%	
Heat Loss to Plenum	624	0	62.4%	
AG Floor to Plenum	0	0	0.0%	
Lighting Load to Plenum	0	0	0.0%	
Other Equipment Load to Plenum	0	0	0.0%	
Glass Solar to Plenum	0	0	0.0%	
Roof Solar to Plenum	0	0	0.0%	
Overhead Lighting	0	0	0.0%	
Plenum Air Leakage	0	0	0.0%	
Underfloor Air Near Pickup	0	0	0.0%	
Supply Air Leakage	0	0	0.0%	
Total Cooling Load	464	0	46.4%	

BRICK

COOLING COIL LOAD INFORMATION				
Load Component	Sensible Btu/h	Latent Btu/h	Total Btu/h	Percent of Total
Solar Gain	0	0	0.0%	
Glass Transmission	28,966	0	28.966%	
Roof Transmission	0	0	0.0%	
Wall Transmission	0	0	0.0%	
Floor Transmission	0	0	0.0%	
Agitation Transmission	0	0	0.0%	
Heat Gaining Loads	0	0	0.0%	
Lighting	0	0	0.0%	
Plenums	0	0	0.0%	
Other Equipment Loads	0	0	0.0%	
Cooling Infiltration	0	0	0.0%	
Sub-Total	28,971	0	28.971%	
Ventilation Load	0	0	0.0%	
Minimum Fresh Air	0	0	0.0%	
Supply Fan Load	0	0	0.0%	
Return Fan Load	0	0	0.0%	
Heat Loss to Plenum	0	0	0.0%	
Heat Loss to Plenum	1,164	0	11.64%	
AG Floor to Plenum	0	0	0.0%	
Lighting Load to Plenum	0	0	0.0%	
Other Equipment Load to Plenum	0	0	0.0%	
Glass Solar to Plenum	0	0	0.0%	
Roof Solar to Plenum	0	0	0.0%	
Overhead Lighting	0	0	0.0%	
Plenum Air Leakage	0	0	0.0%	
Underfloor Air Near Pickup	0	0	0.0%	
Supply Air Leakage	0	0	0.0%	
Total Cooling Load	30,135	0	30.135%	

GLASS

Item	Test Area (SF)	Thermal Load Reductions and Energy Savings										
		Annual Load Gain (BTU/hr)	Design Load Gain Per SF (BTU/hr)	Annual Load Reduction (BTU/hr)	Peak Operation Hours	Annual Load Reduction (BTU)	Gas Conversion (BTU/Therm)	Gas Reduction (Therm)	Cost Conversion (\$/Therm)	Heat Conversion Efficiency (%)	Cost Savings	
Brick Façade	400	32037	80.0925	3040	243481.2	1440	326,632,920	100,000	3506,12928	50.50	85	\$2,062.43
Glass Façade	400	986	2	2562	4561.83	1440	9,449,035	100,000	94	50.50	85	\$55.58
Total												

Note: Peak Operation Duration - June Through September, 12 Hours Per Day = 340 Peak Hours
Note: Gas Conversions, Costs and Efficiencies are for Natural Gas, the operating fuel of the building's central utility plant

BIM IN THE FIELD

DETAILED BIM KIOSK RESULTS



BIM Kiosk Implementation Time and Budget Savings						
Personnel	Hourly Wage (w/ Fringe)	Time Savings (Hours Per Conflict)	Conflicts (Per Week)	Job Duration (Weeks)	Time Saved (Hours)	Total Savings
Foreman	\$125.00	0.75	40	156	4680	\$585,000.00
Project Manager	\$165.00	0.75	40	156	4680	\$772,200.00
Design Professionals	\$165.00	0.75	10	156	1170	\$193,050.00
Totals					10530	\$1,550,250.00

BIM Kiosk Implementation Costs						
Personnel	Hourly Cost	Time (Hours)	Quantity	Material Costs	Labor Costs	Total Cost
Foreman Training	\$125.00	2	8	\$400.00	\$2,000.00	\$2,400.00
Project Manager Training	\$165.00	2	12	\$600.00	\$3,960.00	\$4,560.00
Instructor	\$150.00	6	1	-	\$900.00	\$900.00
BIM Kiosk Costs	-	-	3	\$9,000.00	\$1,500.00	\$31,500.00
Network Allowance	-	-	-	\$10,000.00	\$25,000.00	\$35,000.00
Drawing Updates Allowance	-	-	-	\$2,500.00	\$35,000.00	\$37,500.00
Totals				\$22,500.00	\$61,500.00	\$111,860.00

BIM Kiosk Implementation Savings and Costs Comparison				
Item	Labor Cost	Material Cost	Labor Hours	Total Cost
Foreman Time Savings	(\$585,000.00)	-	(4680.00)	(\$585,000.00)
PM Time Savings	(\$772,200.00)	-	(4680.00)	(\$772,200.00)
DP Time Savings	(\$193,050.00)	-	(1170.00)	(\$193,050.00)
Foreman Training Costs	\$2,000.00	\$400.00	16.00	\$2,400.00
PM Training Costs	\$3,960.00	\$600.00	24.00	\$4,560.00
Instructor Fees	\$900.00	-	6.00	\$900.00
BIM Kiosk Costs	\$1,500.00	\$9,000.00		\$10,500.00
Networking Costs	\$25,000.00	\$10,000.00		\$35,000.00
Drawing Updates Costs	\$35,000.00	\$2,500.00		\$37,500.00
Totals	(\$1,481,890.00)	\$22,500.00	(10484.00)	(\$1,459,390.00)