Construction Management Study

CONSTRUCTION MANAGEMENT STUDY

A construction management study of the alternate concrete system was done to examine the impact that changing the building's superstructure material had on both cost and construction schedule. Cost analysis and construction schedules had been completed based on material quantity take offs for the concrete structural system. Material quantities for concrete found in beams and slabs, steel reinforcing tonnage, total post-tensioning weight and formwork areas were all obtained through the very helpful RAM Conc*ept* output. Similar material quantities were found for columns and shear walls by hand. These takeoffs can be found in Appendix E. Material and labor cost information was taken from RS Means 2005 via Cost Works. Construction schedules were created Microsoft Project.

The estimate for the existing steel system was obtained from Grossi & Sons Steel. This estimate included detailing, material and fabrication of steel beams, steel erection and metal deck furnishing and instillation. The additional cost of slab concrete was added by multiplying 2/3 the slab thickness (accounting for voids created by deck flutes) by the average area of 21,000 square feet per floor. This was then added to the estimate provided, which brought the total cost for the steel superstructure to $4,814,455. The steel estimate can be seen in the itemized list above. The total superstructure cost per square foot was found to be $13.95 per square foot based on a total area of 345,000 square feet.

Steel Estimate For Eight Tower Bridge			
Steel	**QTY**		
Beams	3200		
Columns	350		
Angle Braces	280		$2,300,000
Moment Conncetions	834		
Instalation			$1,125,000
		TOTAL	$3,425,000
Decking	**QTY**		
Metal Deck			
Shear Studs	48000		$450,000
Instalation			$525,000
		TOTAL	$975,000
Concrete	**QTY**		
4000psi	3451 C.Y.		$310,590
Placing			$103,865
		TOTAL	$414,455
		TOTAL	**$4,814,455**

Figure 28: Steel superstructure building cost

The total construction duration for the steel system was reported by Grossi & Sons to be 28 weeks, totaling steel erection and connections and metal deck installation. A crane was on site for 20 weeks of the total time Grossi & Sons was on site, and was owned by the company. An additional cost that will not be factored into the building total cost, but is of considerable note is the $500,000 worth of change orders placed.

The concrete estimates carried out for the concrete structural system took into account total cubic yards of concrete pf varying strengths in columns, beams and shear walls. It was also assumed that formwork would be reused a minimum (or maximum by RS Means) of four times each. It was also assumed that adjustable steel shoring would be rented for the duration of the construction, and each floor would be reshored. Finally, the appropriate adjustment factors were applied for construction projects in the Philadelphia area. Detailed estimates for both of these systems can be found in Appendix E.

Estimates for the concrete superstructure were conducted, using formwork, post-tensioning, and concrete totals for both floor systems designed. The same quantities for columns and shear walls were used. The total costs for system #1, using less post-tensioning and more concrete beams came to $5,338,047. The total cost for the post-tensioned slab system totaled $5,242,839, slightly less than the first system. Both of these costs were based on crane placement of concrete.

However, both of these costs are based on average cost estimates for materials in 2005. The steel contract was received by Grossi & Sons in February of 2001, so all building costs are in 2001 dollars. In order to create a similar cost comparison to the one a design engineer or owner would have gone through at the time, the total costs mentioned above were converted into 2001 dollars. This was done by using the following equation:

$$(P/F)= (1+ i)^{n}$$

This equation is used to calculate the future value of money given the present value. However, the "future" value is actually the present value for the concrete structure

designed, so the reciprocal equation will be used. With an assumed constant interest rate of 3% and a time period, n=4 years, the resulting cost for system #1 is $5,004,943 and the cost for system #2 is $4,903,700. This equates to a total cost per square foot of $14.51/sq. ft. and $14.21/sq. ft. respectively. On a side note, this proves that every cent an engineer can save in a design can add up to a good sum of money, even if it is only $.30/square foot.

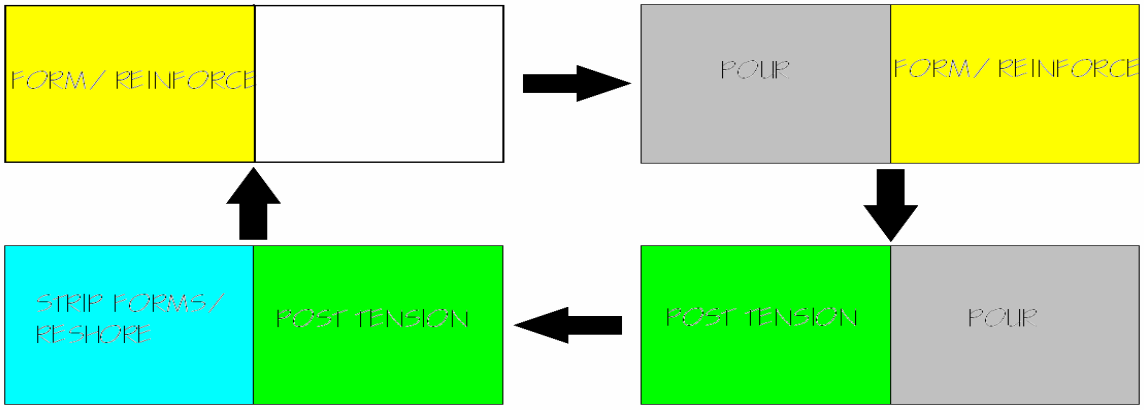
Costs estimates for placing the concrete with a pump were also conducted. While it is not standard practice to pump concrete 16 stories, it is still possible, and estimates for this delivery method came in almost a full dollar less than a crane placing method. However, this may be outweighed by costs incurred by the added difficulty of pump placement.

The construction schedule for both systems was also formed using the estimated quantities of material and crew output from RS Means. It was assumed that the daily output of any crew has not significantly changed since 2001. The duration of each task can be seen below:

Construction Duration/Floor					
Task	**Crew**	**QTY**	**# of crews**	**Output**	**Duration**
Shoring	C1	21000	5	1400	3
Formwork					
Beams/Slabs	C1	21570	5	545	7.92
Columns	C1	3070	5	240	2.56
Shear Walls	C2	2288	4	395	1.45
				Total	**11.92**
Reinforce				**MAX**	8
Beams/Slabs	4 Rdmn	9.96	3	2.2	1.51
Columns	4 Rdmn	5.75	3	2.3	0.83
Slabs	4 Rdmn	19.9	4	2.9	1.72
				Total	**4.06**
Placing Conc				**MAX**	2
Beams	C7	114	5	65	0.35
Slabs	C7	398	5	110	0.72
Shear Walls	C7	44	5	90	0.10
Columns	C7	48	5	63	0.15
				Total	**1.32**
				MAX	1
Post Tensioning	C4	16100	4	1650	2.44
Reshoring	2 CARP	21000	3	1400	5.00
				Total	**17.79**

The maximum duration was taken for the tasks of shoring, formwork and reinforcement, assuming that shoring and formwork could take place simultaneously on parts of each level, and crews of rodmen could follow formwork crews laying reinforcement. It was derived that placing all concrete on a given level would take

two days, so the each level would be placed in two separate pours with a construction joint placed between them. An assumption was made that post-tensioning could take place two days after the concrete has been placed, and formwork could be removed the day two days following that. It was also assumed that reshoring crews would work behind concrete and post tensioning crews. Below is a construction sequence schematic.



The durations calculated were found to be nearly identical for both flooring systems, as only the amount of concrete and post-tensioning differ. However, these amounts differ in a proportional relationship that evens the construction time. The only difference is in the total labor hours used. A final construction duration of 197 days was determined, equating to 28 weeks and 1 day for the concrete system using a crane to place the concrete. This is very comparable to the steel system's 28 week duration. However, like all schedules, this system requires 100% efficiency and flawless execution of each trade. A construction schedule was also created for concrete placed by pump. This construction duration came out to 163 days, or 23 weeks and 2 days. The same number of crews were used for this schedule, and resulted in an expedited construction schedule.

Below is a summary for the steel system and both concrete systems with both placement methods.

Superstructre System Summary						
	Cost per square foot			Duration (weeks)		
System		Crane	Pump		Crane	Pump
Steel	$13.94	-	-	28	-	-
Concrete System #1	-	$14.51	$13.75	-	28.14	23.7
Concrete System #2	-	$14.21	$13.51	-	28.14	23.7