# Construction Management Breadth

## *Introduction*

To determine whether the change from a steel structural system to a concrete system in the Washingtonian Center is justifiable, several factors from the construction management field of study were considered. The first and most obvious consideration was a cost analysis and comparison of the two systems. This comparison included not only the cost of materials, placement and erection of the structure but also considered the potential revenue from leasing the office space (this is different for the two systems because of the additional floor in the concrete structure) A second consideration, and one that is directly linked to the cost of the building; is the construction schedule of the building. From a financial standpoint, the schedule of a project is important because it allows the owner plan when to borrow how much money so that interest on the loans can be minimized. When the building costs are in the tens of millions of dollars, the interest on the loans accumulates very quickly. The owner doesn't begin to see any revenue from the investment until the building is completed and occupied. For this reason minimizing the construction process of the building is often very desirable and made a priority. A concrete and steel structure could potentially have very different construction time frames, and for this reason a scheduling comparison needs to be done to complete a cost effectiveness comparison.

## *Cost Estimate Comparison*

To estimate the costs of constructing the two different systems, a detailed take-off was done for each system. These take-offs accounted for each unit of material that are included in the structural design. For example, the linear feet of each different size of steel shape was tabulated and recorded, the cubic yard of concrete needed to fill and top the steel deck was calculated, and the tons of rebar were found. Once the unit take-off was completed, RS Means: Building Construction Cost Date 2008 was consulted to estimate the unit cost of each material. Along with the unit costs of the materials, an allowance for construction labor and equipment rental required for construction were used. To find the total cost estimate, the unit prices were multiplied by the unit take-off values and a final number was reached. It should be noted that an allowance for overhead and profit in the construction of the building was not included and therefore may not accurately represent the actual building construction costs in the real world. Generally about ten percent were be added to the estimate to account for these factors, however this wasn't done in this case because a straight comparison of the two systems is desired.

RS Means can be a very useful estimating tool but the numbers taken from it need to be considered within their intended contexts. The base costs are often specified for a specific type of building, or other applicable criteria and then adjustment factors are used to correct for other situations. The adjustment factors and the intended application of the numbers given in RS Means need to be fully understood before a meaningful estimate can be obtained. For this reason, the following subsections will address the specific intended application of the RS Means numbers and how if at all they were adjusted to create an accurate estimate for the Washingtonian Center. It should be noted that not all sections of the estimate need extra explaining, such as the foundations, and shear studs and for this reason only the tables used for the estimate are provided.

## Steel Structure Estimate

### *Structural Steel Members*

The basic numbers given are intend to accurately estimate a 1-2 story building with shop fabricated bolted connections, and a total steel weight of 100 tons. To adjust the numbers for a nine story office building, the total structural steel estimate is recommended to be increased by 5%. The Washingtonian Center does utilize shop fabricated bolted connections, therefore no adjustor is required for that aspect of the estimate. In addition to the structural steel estimate that is broken down by shape, an allowance of 10% of the steel cost is recommended to account for connection steel such as bolts, washers, connection angles and plates. Additionally allowances of 3% , 5% and 5% are suggested to be used for base plates for the columns, column splices, and other miscellaneous details. In all a total of 28% was added to the columns, and 18% was added to the beams and girders.

| Beams/Girders | Unit | Scheduling | | | Unit Costs | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Shape | Linear Feet | Crew | Daily Output | Labor Hours | Material | Labor | Equipment | Total | Actual Cost |
| W10x15 | 890 | E-2 | 600 | 0.093 | 18.15 | 3.91 | 2.61 | 24.67 | $21,956.30 |
| W10x77 | 1067 | E-2 | 560 | 0.09 | 20.1 | 3.96 | 2.66 | 26.72 | $28,510.24 |
| W12x16 | 60 | E-2 | 880 | 0.64 | 16.95 | 2.66 | 1.78 | 21.39 | $1,283.40 |
| W14x22 | 670 | E-2 | 990 | 0.057 | 31.5 | 2.37 | 1.58 | 35.45 | $23,751.50 |
| W16x26 | 4230 | E-2 | 1000 | 0.056 | 31.5 | 2.34 | 1.57 | 35.41 | $149,784.30 |
| W16x36 | 20 | E-2 | 800 | 0.07 | 48.5 | 2.93 | 1.96 | 53.39 | $1,067.80 |
| W18x35 | 372 | E-2 | 960 | 0.083 | 42.5 | 3.53 | 1.77 | 47.8 | $17,781.60 |
| W18x40 | 120 | E-2 | 960 | 0.083 | 48.5 | 3.53 | 1.77 | 53.8 | $6,456.00 |
| W18x50 | 660 | E-2 | 912 | 0.088 | 60.5 | 3.72 | 1.86 | 66.08 | $43,612.80 |
| W21x44 | 2038 | E-2 | 1064 | 0.075 | 53 | 3.19 | 1.6 | 57.79 | $117,776.02 |
| W21x50 | 372 | E-2 | 1064 | 0.075 | 60.5 | 3.19 | 1.6 | 65.29 | $24,287.88 |
| W24x62 | 100 | E-2 | 1110 | 0.072 | 75 | 3.06 | 1.53 | 79.59 | $7,959.00 |
| W24x68 | 40 | E-2 | 1110 | 0.072 | 82.5 | 3.06 | 1.53 | 87.09 | $3,483.60 |

| Columns | Unit | Scheduling | | | Unit Costs | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Shape | Linear Feet | Crew | Daily Output | Labor Hours | Material | Labor | Equipment | Total | Actual Cost |
| W10x33 | 853 | E-2 | 1080 | 0.052 | 37.5 | 2.17 | 1.45 | 41.12 | $35,075.36 |
| W10x39 | 320 | E-2 | 1032 | 0.054 | 54.5 | 2.27 | 1.52 | 58.29 | $18,652.80 |
| W10x49 | 1280 | E-2 | 1000 | 0.055 | 64.16 | 2.31 | 1.54 | 68.00724 | $87,049.27 |
| W10x68 | 640 | E-2 | 984 | 0.057 | 82.5 | 2.38 | 1.59 | 86.47 | $55,340.80 |
| W10x77 | 320 | E-2 | 976 | 0.058 | 94 | 2.43 | 1.6 | 98.03 | $31,369.60 |
| W12x40 | 348 | E-2 | 1060 | 0.052 | 43 | 2.18 | 1.52 | 46.7 | $16,251.60 |
| W12x53 | 160 | E-2 | 1020 | 0.055 | 67 | 2.35 | 1.54 | 70.89 | $11,342.40 |
| W12x58 | 240 | E-2 | 1008 | 0.056 | 73 | 2.36 | 1.57 | 76.93 | $18,463.20 |
| W12x65 | 560 | E-2 | 1000 | 0.57 | 80 | 2.38 | 1.58 | 83.96 | $47,017.60 |
| W12x87 | 240 | E-2 | 984 | 0.057 | 105 | 2.38 | 1.59 | 108.97 | $26,152.80 |
| W12x96 | 320 | E-2 | 976 | 0.058 | 114 | 2.42 | 1.62 | 118.04 | $37,772.80 |
| W12x106 | 240 | E-2 | 956 | 0.059 | 119 | 2.46 | 1.66 | 123.12 | $29,548.80 |
| W12x210 | 240 | E-2 | 840 | 0.064 | 156 | 2.96 | 2.1 | 161.06 | $38,654.40 |

### *Steel Decking*

The decking estimate values are based off of the type of deck and the number of squares (one square is one hundred square feet of deck) that are needed for the project. In the case of the Washingtonian Center, the floor decking is 3" deep 20 gauge composite deck, while the roof decking is 1.5" 22 Gauge type "B" decking. No adjustments were needed for either of the decks because RS Means specifically lists the type of deck and prices based on the number of squares required.

### *Fire Proofing*

The fire proofing estimate was based off of the requirements to provide two hours of protection to the structural steel members. It was assumed that a spray on cementitious fire proofing would be applied in the field. A 1" covering was applied to the beams, girders and the underside of the steel deck while a cover of 1-1/8" was applied to the columns. The surface area that requires fire proofing was calculated for each shape and is shown in its own table below.

| | Unit | Scheduling | | | Unit Costs | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Shear Studs** | Number | Crew | Daily Output | Labor Hours | Material | Labor | Equipment | Total | Actual Cost |
| 3/4" Dia. 5" Long | 1285 | E-10 | 920 | 0.017 | 0.62 | 0.77 | 0.39 | 1.78 | $2,287.30 |
| **Floor Deck** | Square Feet | Crew | Daily Output | Labor Hours | Material | Labor | Equipment | Total | |
| 3x20 GA, Comp. | 165000 | E-4 | 3000 | 0.011 | 1.86 | 0.46 | 0.04 | 2.36 | $389,400.00 |
| **Concrete Topping** | Cubic Yards | Crew | Daily Output | Labor Hours | Material | Labor | Equipment | Total | Actual Cost |
| Lightweight | 2420 | C-20 | 160 | 0.4 | 158.05 | 13 | 4.86 | 175.91 | $425,702.20 |
| **Welded Wire Fabric** | Hundred Square Feet | Crew | Daily Output | Labor Hours | Material | Labor | Equipment | Total | |
| W2.1xW2.1 | 1650 | 2 Rodm | 31 | 0.516 | 14.36 | 19.25 | 0 | 33.61 | $55,456.50 |
| **Roof Deck** | Square Feet | Crew | Daily Output | Labor Hours | Material | Labor | Equipment | Total | Actual Cost |
| 1.5x22 GA. "B" | 23000 | E-4 | 4900 | 0.007 | 1.25 | 0.28 | 0.03 | 1.56 | $35,880.00 |
| **Fire Proofing** | Surface Area: S.F. | Crew | Daily Output | Labor Hours | Material | Labor | Equipment | Total | |
| Beams/Girders | 4160.50 | G-2 | 1500 | 0.016 | 0.47 | 0.51 | 0.08 | 1.06 | $4,410.13 |
| Columns | 2468.42 | G-2 | 1100 | 0.022 | 0.53 | 0.7 | 0.12 | 1.35 | $3,332.36 |
| Floor Deck | 165000.00 | G-2 | 1250 | 0.019 | 0.71 | 0.62 | 0.1 | 1.43 | $235,950.00 |
| Roof Deck | 23000.00 | G-2 | 1250 | 0.019 | 0.71 | 0.62 | 0.1 | 1.43 | $32,890.00 |

| Fire Proofing Area: Beams/Girders | | | | | | | |
|---|---|---|---|---|---|---|---|
| Shape | Linear Feet | d (in) | $b_f$ (in) | $t_f$ (in) | $t_w$ (in) | perimeter | Area |
| W10x15 | 890.00 | 10.00 | 4.00 | 0.27 | 0.23 | 35.54 | 219.66 |
| W10x77 | 1067.00 | 10.60 | 10.20 | 0.87 | 0.53 | 60.94 | 451.55 |
| W12x16 | 60.00 | 12.00 | 3.99 | 0.27 | 0.22 | 39.52 | 16.47 |
| W14x22 | 670.00 | 13.70 | 5.00 | 0.34 | 0.23 | 46.94 | 218.40 |
| W16x26 | 4230.00 | 15.70 | 5.50 | 0.35 | 0.25 | 52.90 | 1553.94 |
| W16x36 | 20.00 | 15.90 | 6.99 | 0.43 | 0.30 | 59.17 | 8.22 |
| W18x35 | 372.00 | 17.70 | 6.00 | 0.43 | 0.30 | 58.80 | 151.90 |
| W18x40 | 120.00 | 17.90 | 6.02 | 0.53 | 0.32 | 59.25 | 49.38 |
| W18x50 | 660.00 | 18.00 | 7.50 | 0.57 | 0.36 | 65.29 | 299.25 |
| W21x44 | 2038.00 | 20.70 | 6.50 | 0.45 | 0.35 | 66.70 | 943.99 |
| W21x50 | 372.00 | 20.80 | 6.53 | 0.54 | 0.38 | 66.96 | 172.98 |
| W24x62 | 100.00 | 23.70 | 7.04 | 0.59 | 0.43 | 74.70 | 51.88 |
| W24x68 | 40.00 | 23.70 | 8.97 | 0.59 | 0.42 | 82.45 | 22.90 |
| | | | | | | Total Area (S.F.)= | 4160.50 |

| Fire Proofing Area: Columns | | | | | | | |
|---|---|---|---|---|---|---|---|
| Shape | Linear Feet | d (in) | $b_f$ (in) | $t_f$ (in) | $t_w$ (in) | perimeter | Area |
| W10x33 | 853.00 | 9.73 | 7.96 | 0.44 | 0.29 | 50.72 | 300.45 |
| W10x39 | 320.00 | 9.92 | 7.99 | 0.53 | 0.32 | 51.17 | 113.71 |
| W10x49 | 1280.00 | 10.00 | 10.00 | 0.56 | 0.34 | 59.32 | 527.29 |
| W10x68 | 640.00 | 10.40 | 10.10 | 0.77 | 0.47 | 60.26 | 267.82 |
| W10x77 | 320.00 | 10.60 | 10.20 | 0.87 | 0.53 | 60.94 | 135.42 |
| W12x40 | 348.00 | 11.90 | 8.01 | 0.52 | 0.30 | 55.25 | 133.52 |
| W12x53 | 160.00 | 12.10 | 10.00 | 0.58 | 0.35 | 63.51 | 70.57 |
| W12x58 | 240.00 | 12.20 | 10.00 | 0.64 | 0.36 | 63.68 | 106.13 |
| W12x65 | 560.00 | 12.10 | 12.00 | 0.61 | 0.39 | 71.42 | 277.74 |
| W12x87 | 240.00 | 12.50 | 12.10 | 0.81 | 0.52 | 72.37 | 120.62 |
| W12x96 | 320.00 | 12.70 | 12.20 | 0.90 | 0.55 | 73.10 | 162.44 |
| W12x106 | 240.00 | 12.90 | 12.20 | 0.99 | 0.61 | 73.38 | 122.30 |
| W12x210 | 240.00 | 14.70 | 12.80 | 1.90 | 1.18 | 78.24 | 130.40 |
| | | | | | | Total Area (S.F.)= | 2468.42 |

| Foundations | Unit | Scheduling | | | Unit Costs | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Spread Footings | C.Y./S.F.C.A. | Crew | Daily Output | Labor Hours | Material | Labor | Equipment | Total | Actual Cost |
| Concrete | | | | | | | | | |
| material | 340 | - | - | - | 100 | - | - | 100 | $34,000.00 |
| formwork | 3380 | C-1 | 414 | 0.077 | 0.63 | 2.79 | - | 3.42 | $11,559.60 |
| placement | 340 | C-20 | 150 | 0.427 | - | 13.9 | 5.2 | 19.1 | $6,494.00 |
| Combined Footings | C.Y./S.F.C.A. | Crew | Daily Output | Labor Hours | Material | Labor | Equipment | Total | Actual Cost |
| Concrete | | | | | | | | | |
| material | 428 | - | - | - | 100 | - | - | 100 | $42,800.00 |
| formwork | 648 | C-2 | 350 | 0.137 | 0.63 | 5.1 | - | 5.73 | $3,713.04 |
| placement | 428 | C-20 | 150 | 0.427 | - | 13.9 | 5.2 | 19.1 | $8,174.80 |
| Reinforcement | Tons | Crew | Daily Output | Labor Hours | Material | Labor | Equipment | Total | Actual Cost |
| #3-#7 | 13.94 | 4 Rodm | 2.1 | 15.238 | 890 | 655 | - | 1545 | $21,537.30 |
| #8-#12 | 16.48 | 4 Rodm | 3.6 | 8.889 | 890 | 380 | - | 1270 | $20,929.60 |

| System | Base Costs | Adjustment Percentage | Adjusted Costs |
|---|---|---|---|
| Beams/Girders | $447,710.44 | 18% | $528,298.32 |
| Columns | $452,691.43 | 28% | $579,445.03 |
| Foundations | $149,208.34 | 0 | $149,208.34 |
| Floor Deck | $389,400.00 | 0 | $389,400.00 |
| Roof Deck | $35,880.00 | 0 | $35,880.00 |
| Shear Studs | $2,287.30 | 0 | $2,287.30 |
| Concrete Topping | $425,702.20 | 0 | $425,702.20 |
| Welded Wire Fabric | $55,456.50 | 0 | $55,456.50 |
| Fire Proofing | $276,582.49 | 0 | $276,582.49 |
| **Total Structure Cost:** | | | $2,442,260.18 |

## Concrete Structure Estimate

The construction of the concrete structural system is very different from its steel counterpart. Steel is fabricated away from the site and then simply erected in pieces once it is delivered to the site. The design of the concrete structure utilizes cast in place floors, columns, and footings which require careful detailed creation in the field. It often is difficult to develop accurate cost estimates for a concrete system because of all of the variables that come into play. It is possible however to account for these details by using informed adjustments to the estimate that come from common practice and experience. The following sections give the cost estimate for the different components of the structure along with how the numbers were developed.

### *Post-Tensioned Flat Plates*

The floor plate was designed using Ram Concept which has a convenient feature that does a take-off for the design. These numbers were used as a starting point, and were adjusted to account for factors that would affect the actual construction cost. An additional 10% of concrete was added to the cubic yards required to account for waste, and concrete that goes unused. The concrete costs were taken for 5000 psi concrete, while labor and  The rebar weight was adjusted by 10% as well to make up for waste, and over lapping of bars at splice points. The formwork square footage didn't need any adjusting, and the unit prices were taken for plywood forms.

| **Post-Tensioned Floor** | | | Scheduling | | | Unit Costs | | | |
|---|---|---|---|---|---|---|---|---|---|
| Component | Unit | Quanity | Crew | Daily Output | Labor Hours | Material | Labor | Equipment | Actual Costs |
| Concrete | C.Y. | 5279.4 | C-20 | 160 | 0.4 | $109.00 | $13.00 | $4.86 | $669,744.68 |
| Formwork | S.F. | 213840 | C-2 | 560 | 0.086 | $1.42 | $3.18 | $0.00 | $983,664.00 |
| Reinforcing: #4-#7 | Ton | 76.221 | 4 Rodm | 2.9 | 11.034 | $990.00 | $475.00 | $0.00 | $111,663.77 |
| Tendons: 100' Span | lb. | 55380 | C-4 | 1650 | 0.019 | $0.51 | $0.84 | $0.02 | $75,870.60 |
| Tendons: 200' Span | lb. | 110760 | C-4 | 1700 | 0.019 | $0.51 | $0.82 | $0.02 | $149,526.00 |
| | | | | | | | | Total Costs | $1,990,469.05 |

### *Shear Walls*

The shear wall take-off was done manually by hand based on the design done in Etabs. The same 10% allowance for additional concrete and rebar was used for the same reasons stated in the floor estimate. The pricing for formwork was taken for plywood forms. Concrete placement costs were estimated using the assumption that a pump truck would be used.

| **Shear Walls** | | | Scheduling | | | Unit Costs | | | |
|---|---|---|---|---|---|---|---|---|---|
| Component | Unit | Quanity | Crew | Daily Output | Labor Hours | Material | Labor | Equipment | Actual Costs |
| Concrete | C.Y. | 260 | C-20 | 105 | 0.611 | $109.00 | $19.89 | $7.43 | $35,443.20 |
| Formwork | S.F.C.A. | 17500 | C-2 | 395 | 0.122 | $0.77 | $4.51 | $0.00 | $92,400.00 |
| Reinforcing: #4-#7 | Ton | 16.08 | 4 Rodm | 3 | 10.67 | $890.00 | $460.00 | $0.00 | $21,708.00 |
| Reinforcing: #8-#12 | Ton | 2.86 | 4 Rodm | 4 | 8 | $890.00 | $345.00 | $0.00 | $3,532.10 |
| | | | | | | | | Total Cost | $153,083.30 |

## *Columns*

The columns were assumed to be formed using plywood just like the other components of the concrete structural systems. The same allowance for waste and overlap were also used for the concrete and reinforcing. Similarly placement costs came from the concrete being pumped into the forms.

| **Columns** | | | Scheduling | | | Unit Costs | | | |
|---|---|---|---|---|---|---|---|---|---|
| Component | Unit | Quanity | Crew | Daily Output | Labor Hours | Material | Labor | Equipment | Actual Costs |
| Concrete | C.Y. | 874 | C-20 | 90 | 0.711 | $109.00 | $23.00 | $8.65 | $122,928.10 |
| Formwork | S.F.C.A. | 56640 | C-1 | 236 | 0.135 | $0.81 | $4.89 | $0.00 | $322,848.00 |
| Reinforcing: #4-#7 | Ton | 38 | 4 Rodm | 1.5 | 21.33 | $935.00 | $915.00 | $0.00 | $70,300.00 |
| Reinforcing: #8-#12 | Ton | 110 | 4 Rodm | 2.3 | 19.91 | $935.00 | $600.00 | $0.00 | $168,850.00 |
| | | | | | | | | Total Cost | $684,926.10 |

## *Foundations*

All the same cost parameters and adjustments stated in the previous sections apply to the foundations as well.

| **Combined Footing 1** | | | Scheduling | | | Unit Costs | | | |
|---|---|---|---|---|---|---|---|---|---|
| Component | Unit | Quanity | Crew | Daily Output | Labor Hours | Material | Labor | Equipment | Actual Costs |
| Concrete | C.Y. | 557 | C-20 | 400 | 0.16 | $100.00 | $5.20 | $1.94 | $59,676.98 |
| Formwork | S.F.C.A. | 1392 | C-2 | 350 | 0.137 | $0.63 | $5.10 | $0.00 | $7,976.16 |
| Reinforcing: #4-#7 | Ton | 4.25 | 4 Rodm | 2.1 | 15.24 | $890.00 | $655.00 | $0.00 | $6,566.25 |
| Reinforcing: #8-#12 | Ton | 2.04 | 4 Rodm | 3.6 | 8.89 | $840.00 | $380.00 | $0.00 | $2,488.80 |
| | | | | | | | | Total Cost | $76,708.19 |

| **Combined Footing 2** | | | Scheduling | | | Unit Costs | | | |
|---|---|---|---|---|---|---|---|---|---|
| Component | Unit | Quanity | Crew | Daily Output | Labor Hours | Material | Labor | Equipment | Actual Costs |
| Concrete | C.Y. | 400 | C-20 | 400 | 0.16 | $100.00 | $5.20 | $1.94 | $42,856.00 |
| Formwork | S.F.C.A. | 1872 | C-2 | 350 | 0.137 | $0.63 | $5.10 | $0.00 | $10,726.56 |
| Reinforcing: #4-#7 | Ton | 5.1 | 4 Rodm | 2.1 | 15.24 | $890.00 | $655.00 | $0.00 | $7,879.50 |
| Reinforcing: #8-#12 | Ton | 0 | 4 Rodm | 3.6 | 8.89 | $840.00 | $380.00 | $0.00 | $0.00 |
| | | | | | | | | Total Cost | $61,462.06 |

| **Spread Footings** | | | Scheduling | | | Unit Costs | | | |
|---|---|---|---|---|---|---|---|---|---|
| Component | Unit | Quanity | Crew | Daily Output | Labor Hours | Material | Labor | Equipment | Actual Costs |
| Concrete | C.Y. | 1037 | C-20 | 150 | 0.427 | $100.00 | $13.90 | $5.20 | $123,506.70 |
| Formwork | S.F.C.A. | 8282 | C-2 | 414 | 0.077 | $0.63 | $2.79 | $0.00 | $28,324.44 |
| Reinforcing: #4-#7 | Ton | 20.98 | 4 Rodm | 2.1 | 15.24 | $890.00 | $655.00 | $0.00 | $32,414.10 |
| Reinforcing: #8-#12 | Ton | 4.04 | 4 Rodm | 3.6 | 8.89 | $840.00 | $380.00 | $0.00 | $4,928.80 |
| | | | | | | | | Total Cost | $189,174.04 |

## *Total Concrete Structural Costs*

| **Structural Costs** | |
|---|---|
| Post-Tensioned Floors | $1,990,469.05 |
| Shear Walls | $153,083.30 |
| Columns | $684,926.10 |
| Foundations | $327,344.29 |
| Total | $3,155,822.74 |

## *Potential Revenue Leasing Office Space*

The goal of the cost analysis was to make the most accurate comparison possible between the steel structure and the concrete redesign. This goal requires that all variables between the two systems be examined and evaluated and a cost assigned to each variable that is different between the two. The preceding sections sought to find the costs associated with the materials, labor, and equipment needed to construct the two designs. That analysis accounted for the physical differences between the designs; however it missed one critical aspect that cannot be overlooked. The steel design had eight floors that could be leased out to tenants, while the concrete design included a ninth floor. This effectively added about 12.5% more leasable space to the building and therefore significantly increased potential revenue for the building owners. To put numbers to this difference, realtors in the Gaithersburg Maryland area were questioned to find what typical office space lease prices are. From their input, it was concluded that five dollars per square foot of space per year was a reasonable number to use for comparison purposes. The cost summary is shown below in tabular form.

| Concrete Design | | |
|---|---|---|
| Floor | Leasable Footage | Revenue |
| 9th | 19900 | $99,500.00 |
| 8th | 19900 | $99,500.00 |
| 7th | 19900 | $99,500.00 |
| 6th | 19988 | $99,940.00 |
| 5th | 19988 | $99,940.00 |
| 4th | 19988 | $99,940.00 |
| 3rd | 19988 | $99,940.00 |
| 2nd | 19988 | $99,940.00 |
| 1st | 15925 | $79,625.00 |
| | Total Revenue= | $877,825.00 |

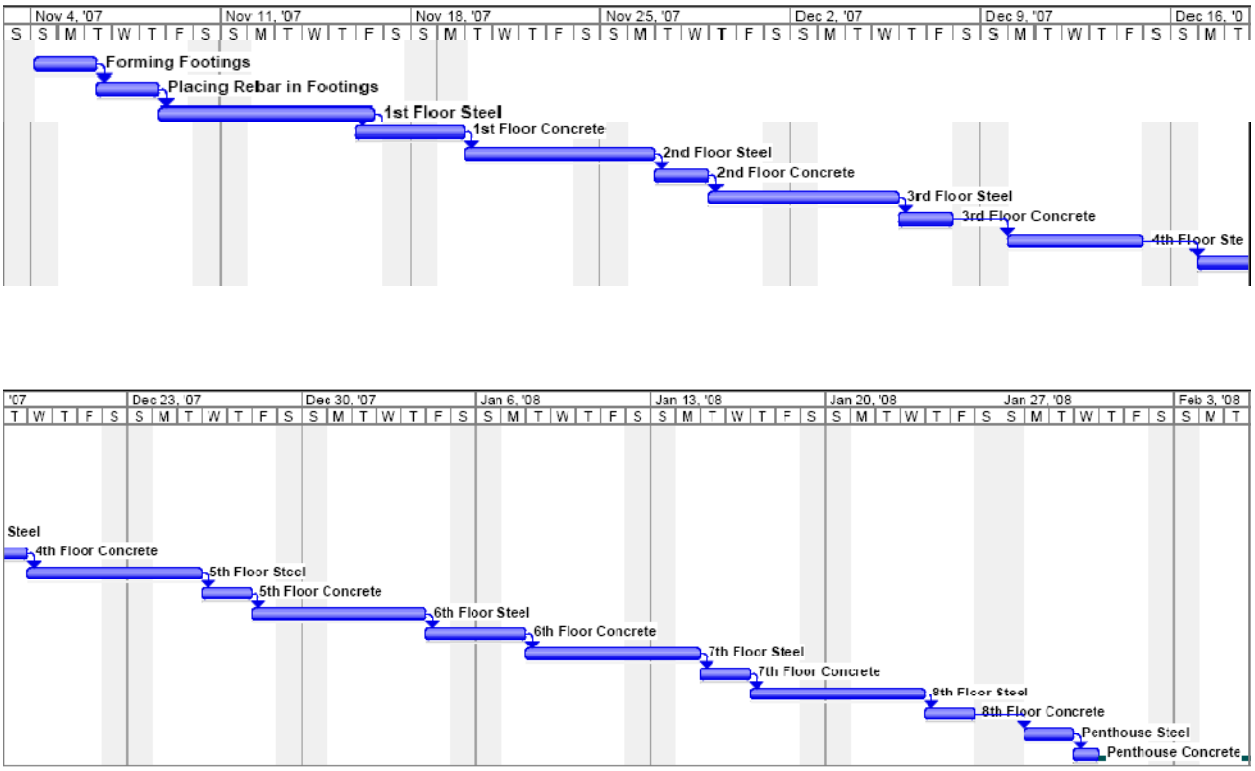
| Steel Design | | |
|---|---|---|
| Floor | Leasable Footage | Revenue |
| 8th | 19900 | $99,500.00 |
| 7th | 19900 | $99,500.00 |
| 6th | 19988 | $99,940.00 |
| 5th | 19988 | $99,940.00 |
| 4th | 19988 | $99,940.00 |
| 3rd | 19988 | $99,940.00 |
| 2nd | 19988 | $99,940.00 |
| 1st | 15925 | $79,625.00 |
| | Total Revenue= | $778,325.00 |

The additional space provided by the concrete redesign yields an additional $99,500 per year in leasing revenue. This is a rough estimate but it shows how significant the extra floor in the concrete structure is in terms of offering more revenue to the owner over the life time of the building. It should also be noted that the additional floor would also come with additional maintenance and operation costs but for the purposes of this report these factors were omitted.

## *Project Scheduling*

### *Steel Schedule*

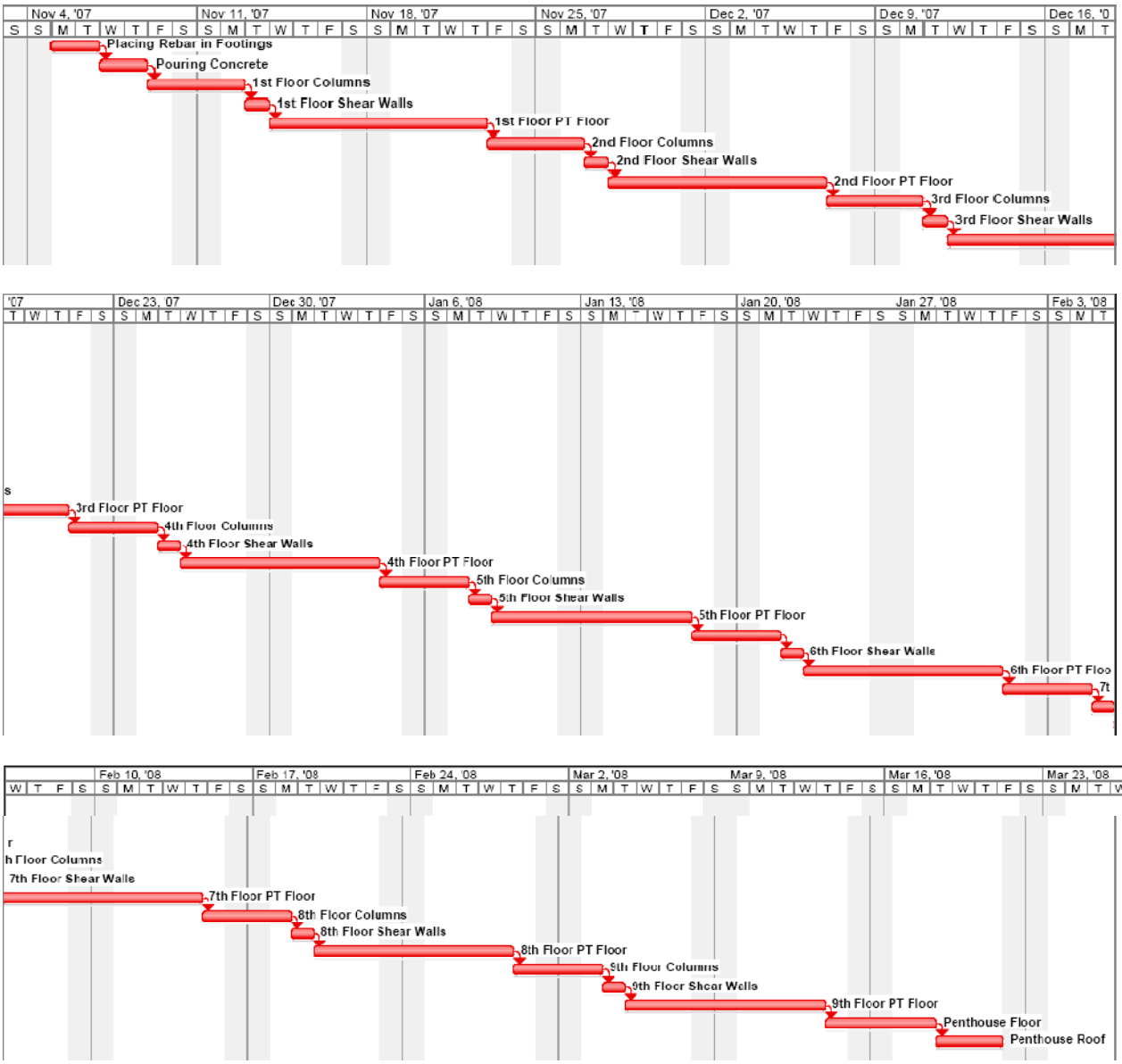
The schedule that was developed for the steel construction was based loosely off of the RS Means estimate and advice from experts who have experience with such things in the Gaithersburg area. The total time required to complete the construction came to seven weeks.



| | |
|---|---|
| Forming Footings | 2 days |
| Placing Rebar in Footings | 2 days |
| 1st Floor Steel | 5 days |
| 1st Floor Concrete | 2 days |
| 2nd Floor Steel | 5 days |
| 2nd Floor Concrete | 2 days |
| 3rd Floor Steel | 5 days |
| 3rd Floor Concrete | 2 days |
| 4th Floor Steel | 5 days |
| 4th Floor Concrete | 2 days |
| 5th Floor Steel | 5 days |
| 5th Floor Concrete | 2 days |
| 6th Floor Steel | 5 days |
| 6th Floor Concrete | 2 days |
| 7th Floor Steel | 5 days |
| 7th Floor Concrete | 2 days |
| 8th Floor Steel | 5 days |
| 8th Floor Concrete | 2 days |
| Penthouse Steel | 2 days |
| Penthouse Concrete | 1 day |

### *Concrete Schedule*

The concrete schedule that was developed for the purposes of this report was based solely off of advice taken from design professionals who have extensive experience with post-tensioned concrete floors. Based on the geometric layout and size of the Washingtonian Center it was determined that a maximum of eight thousand square feet per day. This would mean that each floor could be poured in three days. Input from contractors in the field showed that this is an efficient cycle, because three different crews can be working on the same floor at once. One crew would be forming, one placing steel and the third making the pour. When all the activities were accounted for, the total duration of construction came to 20 weeks.



| Activity | Duration |
|---|---|
| Placing Rebar in Footings | 2 days |
| Pouring Concrete | 2 days |
| 1st Floor Columns | 2 days |
| 1st Floor Shear Walls | 1 day |
| 1st Floor PT Floor | 7 days |
| 2nd Floor Columns | 2 days |
| 2nd Floor Shear Walls | 1 day |
| 2nd Floor PT Floor | 7 days |
| 3rd Floor Columns | 2 days |
| 3rd Floor Shear Walls | 1 day |
| 3rd Floor PT Floor | 7 days |
| 4th Floor Columns | 2 days |
| 4th Floor Shear Walls | 1 day |
| 4th Floor PT Floor | 7 days |
| 5th Floor Columns | 2 days |
| 5th Floor Shear Walls | 1 day |
| 5th Floor PT Floor | 7 days |
| 6th Floor Columns | 2 days |
| 6th Floor Shear Walls | 1 day |
| 6th Floor PT Floor | 7 days |
| 7th Floor Columns | 2 days |
| 7th Floor Shear Walls | 1 day |
| 7th Floor PT Floor | 7 days |
| 8th Floor Columns | 2 days |
| 8th Floor Shear Walls | 1 day |
| 8th Floor PT Floor | 7 days |
| 9th Floor Columns | 2 days |
| 9th Floor Shear Walls | 1 day |
| 9th Floor PT Floor | 7 days |
| Penthouse Floor | 3 days |
| Penthouse Roof | 3 days |

## *Conclusions from the Construction Management Breadth*

A mixed bag of results came from the cost and scheduling examination, with both positives and negatives emerging for both the concrete and steel designs. On the cost side of things, the concrete structure was estimated to be almost $715,000 more than the steel structure to build, but it also provided almost $100,000 more in revenue per year. This would mean that the additional cost of constructing the concrete building would have a payoff period of about seven years, which in terms of the life of the building isn't very long. Looking at the situation from the scheduling point of view, the concrete building would take about two months longer to construct than the steel building. With proper planning of the construction period, these two additional months could be made to have a minimal impact on the building project as a whole.