

## Temporary Utilities

In order to complete the concrete work and steel erection for the Forest Resources Building, there are many different activities that each require different utilities. Because it was one of the first activities, and no connection to the University electrical system had been made yet, a large generator was brought on site to power the drilling rigs. These drills also needed a constant supply of water to function properly. Penn State provided access to their water lines throughout the duration of the project, so this was not a problem. All of the grout and most of the concrete is placed using a pump which can run off of its own engine power but may require refueling. Except for the elevated slabs, all of the concrete will be poured in decent weather so no temporary protection and heating is needed for this operation. When it is time to pour the elevated slabs, the concrete contractor will be enclosing one floor of the building and providing temporary heat so that the concrete can cure properly. Blankets will also be placed on the floor above the one being poured so that the heat does not escape upward. For all concrete activities a good supply of water will also be provided. This can be used for cleaning formwork and cleaning out trucks before they leave the site. A large crawler crane is being used to erect the steel, which requires a fairly large amount of fuel. A temporary fuel tank may be set up on site in order to make the refueling process easier. All electricity and water needed are provided by Penn State at a cost to the contractors and the trade contractors are responsible for any other utilities needed.

Some temporary utilities are specified in the contracts for each contractor. The plumbing is specifically tasked with installing the meters on the University water lines. From the meter point the plumbing contractor shall make and maintain all local distributions needed by the various trades. A similar situation arises with the electrical contractor. He is responsible for installing a meter on the University power supply, and then making all local connections needed for construction. The original contract did not have specifications for temporary heating during concrete placement. Through a change order the concrete contractor became responsible for enclosing whatever portions of the building necessary and maintaining a suitable temperature for concrete curing. Once the building is enclosed,



it is the HVAC contractor's responsibility to maintain the temporary heating, cooling and ventilation of the building. It may be possible for him to connect to and use the University steam lines, but if this is not possible, then he shall be responsible for all heaters and fuel needed. Each trade contractor is responsible for furnishing and maintaining their own office trailers, temporary sanitary facilities, and all hoisting equipment necessary for the duration of the project. Any temporary structures needed for storage or protection of materials or for protection of work in place are the responsibility of that contractor.



## Detailed Systems Estimate

The following two pages contain a detailed estimate for the structural system of the Forest Resources Building. This estimate includes all mini-piles, pile caps, grade beams, slabs on grade, elevated slabs, and all structural steel. Each of these elements is broken out to show the individual costs.

The following assumptions were made concerning the estimate:

- There are 224 mini-piles at an estimated length of 50' each.
- These are 7" diameter drilled pipe piles that are grout filled.
- The pile caps and grade beams are standard sizes with 4000 psi concrete.
- The slab on grade for the Meadow wing is a 6" slab.
- The Bigler wing has an 8" slab on grade.
- All elevated slabs are 6-1/2" composite deck.
- Steel beams are separated by floor to show pricing breakdown.
- All costs are bare costs with no overhead or profit included.

# PSU SCHOOL OF FOREST RESOURCES

## STRUCTURAL SYSTEM DETAILED ESTIMATE

| | DESCRIPTION | UNIT | QUANTITY | LABOR | MATERIAL | EQUIPMENT | TOTAL UNIT COST | TOTAL COST |
|---|---|---|---|---|---|---|---|---|
| **MINI-PILES** | | | | | | | | |
| | 7" DIAMETER DRILLED PIPE PILE | LNFT | 11,200 | $3.70 | $8.70 | $1.81 | $14.21 | $159,152.00 |
| | 7" DIAMETER STEEL CASING | LNFT | 11,200 | $4.75 | $10.18 | | $14.93 | $167,216.00 |
| | DRILLING THROUGH EARTH | CUYD | 110 | $25.50 | | $11.08 | $36.58 | $4,023.80 |
| | PUMPED GROUT | CUYD | 110 | $15.92 | $51.00 | $5.28 | $72.20 | $7,942.00 |
| | RE-STEEL FOR PILES | TONS | 82.14 | $305.00 | $760.00 | | $1,065.00 | $87,479.10 |
| | **TOTAL** | | | $354.87 | $829.88 | $18.17 | $1,202.92 | $425,812.90 |
| | | | | | | | | |
| **PILE CAPS** | | | | | | | | |
| | MACHINE EXCAVATE | CUYD | 727 | $6.95 | | $0.95 | $7.90 | $5,743.30 |
| | FINE GRADE | SQFT | 2,644 | $0.48 | | | $0.48 | $1,269.12 |
| | MACHINE BACKFILL | CUYD | 325 | $8.50 | | $0.50 | $9.00 | $2,925.00 |
| | PILE CAP RE-STEEL | TONS | 6.4 | $635.00 | $585.00 | | $1,220.00 | $7,808.00 |
| | PILE CAP FORMWORK | SQFT | 7,452 | $4.43 | $1.04 | | $5.47 | $40,762.44 |
| | PUMPED CONCRETE | CUYD | 402 | $9.45 | $56.00 | $5.28 | $70.73 | $28,433.46 |
| | **TOTAL** | | | $664.81 | $642.04 | $6.73 | $1,313.58 | $86,941.32 |
| | | | | | | | | |
| **GRADE BEAMS** | | | | | | | | |
| | GRADE BEAM FORMWORK | SQFT | 6,224 | $2.61 | $1.36 | | $3.97 | $24,709.28 |
| | GRADE BEAM RE-STEEL | TONS | 7.25 | $635.00 | $585.00 | | $1,220.00 | $8,845.00 |
| | PUMPED CONCRETE | CUYD | 268 | $12.10 | $56.00 | $5.28 | $73.38 | $19,665.84 |
| | **TOTAL** | | | $649.71 | $642.36 | $5.28 | $1,297.35 | $53,220.12 |
| | | | | | | | | |
| **SLAB ON GRADE** | | | | | | | | |
| | MACHINE FINE GRADE | SQFT | 16,105 | $0.26 | | $0.02 | $0.28 | $4,509.40 |
| | UNDERSLAB FILL | CUYD | 298 | $16.19 | $16.35 | | $32.54 | $9,696.92 |
| | SLAB EDGE FORMS | LNFT | 3,525 | $3.07 | $0.85 | | $3.92 | $13,818.00 |
| | WELDED WIRE FABRIC | SQFT | 17,716 | $0.24 | $0.20 | | $0.44 | $7,795.04 |
| | PUMPED CONCRETE | CUYD | 360 | $13.75 | $56.00 | $5.28 | $75.03 | $27,010.80 |
| | VAPOR BARRIER | SQFT | 17,716 | $0.01 | $0.03 | | $0.04 | $708.64 |
| | FINISHING AND CURING | SQFT | 16,105 | $0.44 | $0.02 | | $0.46 | $7,408.30 |
| | **TOTAL** | | | $33.96 | $73.45 | $5.30 | $112.71 | $70,947.10 |
| | | | | | | | | |
| **SLAB ON DECK** | | | | | | | | |
| | SLAB EDGE FORMS | LNFT | 5,545 | $3.07 | $0.85 | | $3.92 | $21,736.40 |
| | WELDED WIRE FABRIC | SQFT | 56,084 | $0.24 | $0.20 | | $0.44 | $24,676.96 |
| | 2" METAL DECK | SQFT | 50,985 | $0.44 | $0.87 | | $1.31 | $66,790.35 |
| | PUMPED CONCRETE | CUYD | 865 | $12.60 | $56.00 | $5.28 | $73.88 | $63,906.20 |
| | FINISHING AND CURING | SQFT | 50,985 | $0.39 | $0.89 | | $1.28 | $65,260.80 |
| | **TOTAL** | | | $16.74 | $58.81 | $5.28 | $80.83 | $242,370.71 |
| | | | | | | | | |
| **STEEL COLUMNS** | | | | | | | | |
| | STEEL COLUMNS | TONS | 197.2 | $575.00 | $700.00 | $100.00 | $1,375.00 | $271,150.00 |
| | SPRAY ON FIREPROOFING | BDFT | 10,364 | $44.81 | $0.45 | $0.08 | $45.34 | $469,903.76 |
| | **TOTAL** | | | $619.81 | $700.45 | $100.08 | $1,420.34 | $741,053.76 |

| STEEL BEAMS | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **FIRST FLOOR** | | | | | | | |
| | STEEL BEAMS | TONS | 49.45 | $575.00 | $700.00 | $100.00 | $1,375.00 | $67,993.75 |
| | SHEAR STUDS | EACH | 126 | $0.54 | $0.72 | $0.30 | $1.56 | $196.56 |
| | SPRAY ON FIREPROOFING | BDFT | 5,809 | $44.81 | $0.45 | $0.08 | $45.34 | $263,380.06 |
| | **SUB-TOTAL** | | | $620.35 | $701.17 | $100.38 | $1,421.90 | $331,570.37 |
| | **SECOND FLOOR** | | | | | | | |
| | STEEL BEAMS | TONS | 53.26 | $575.00 | $700.00 | $100.00 | $1,375.00 | $73,232.50 |
| | SHEAR STUDS | EACH | 147 | $0.54 | $0.72 | $0.30 | $1.56 | $229.32 |
| | SPRAY ON FIREPROOFING | BDFT | 6,786 | $44.81 | $0.45 | $0.08 | $45.34 | $307,677.24 |
| | **SUB-TOTAL** | | | $620.35 | $701.17 | $100.38 | $1,421.90 | $381,139.06 |
| | **THIRD FLOOR** | | | | | | | |
| | STEEL BEAMS | TONS | 53.26 | $575.00 | $700.00 | $100.00 | $1,375.00 | $73,232.50 |
| | SHEAR STUDS | EACH | 147 | $0.54 | $0.72 | $0.30 | $1.56 | $229.32 |
| | SPRAY ON FIREPROOFING | BDFT | 6,786 | $44.81 | $0.45 | $0.08 | $45.34 | $307,677.24 |
| | **SUB-TOTAL** | | | $620.35 | $701.17 | $100.38 | $1,421.90 | $381,139.06 |
| | **FOURTH FLOOR** | | | | | | | |
| | STEEL BEAMS | TONS | 53.26 | $575.00 | $700.00 | $100.00 | $1,375.00 | $73,232.50 |
| | SHEAR STUDS | EACH | 147 | $0.54 | $0.72 | $0.30 | $1.56 | $229.32 |
| | SPRAY ON FIREPROOFING | BDFT | 6,786 | $44.81 | $0.45 | $0.08 | $45.34 | $307,677.24 |
| | **SUB-TOTAL** | | | $620.35 | $701.17 | $100.38 | $1,421.90 | $381,139.06 |
| | **PENTHOUSE** | | | | | | | |
| | STEEL BEAMS | TONS | 26.03 | $575.00 | $700.00 | $100.00 | $1,375.00 | $35,791.25 |
| | SHEAR STUDS | EACH | 62 | $0.54 | $0.72 | $0.30 | $1.56 | $96.72 |
| | SPRAY ON FIREPROOFING | BDFT | 2,909 | $44.81 | $0.45 | $0.08 | $45.34 | $131,894.06 |
| | **SUB-TOTAL** | | | $620.35 | $701.17 | $100.38 | $1,421.90 | $167,782.03 |
| | **LOW ROOF** | | | | | | | |
| | STEEL BEAMS | TONS | 31.18 | $575.00 | $700.00 | $100.00 | $1,375.00 | $42,872.50 |
| | SHEAR STUDS | EACH | 79 | $0.54 | $0.72 | $0.30 | $1.56 | $123.24 |
| | SPRAY ON FIREPROOFING | BDFT | 4,184 | $44.81 | $0.45 | $0.08 | $45.34 | $189,702.56 |
| | **SUB-TOTAL** | | | $620.35 | $701.17 | $100.38 | $1,421.90 | $232,698.30 |
| | **HIGH ROOF** | | | | | | | |
| | STEEL BEAMS | TONS | 33.17 | $575.00 | $700.00 | $100.00 | $1,375.00 | $45,608.75 |
| | SPRAY ON FIREPROOFING | BDFT | 4,371 | $44.81 | $0.45 | $0.08 | $45.34 | $198,181.14 |
| | **SUB-TOTAL** | | | $619.81 | $700.45 | $100.08 | $1,420.34 | $243,789.89 |
| | | | | | | | | |
| | **TOTAL** | | | $4,341.91 | $4,907.47 | $702.36 | $9,951.74 | $2,119,257.77 |

| | |
|---|---|
| TOTAL TONS OF STRUCTURAL STEEL | 496.81 |
| TOTAL CUBIC YARDS OF CONCRETE | 1895 |
| TOTAL COST FOR STRUCTURAL SYSTEM | $3,739,603.68 |
| LOCATION FACTOR ADJUSTMENT (0.947) | $3,541,404.68 |
| STRUCTURAL COST PER SF OF BUILDING | $38.49 |



## General Conditions Estimate

A General Conditions estimate for the Forest Resources Building is attached on the next two pages. There are several items in the general conditions that are difficult to estimate. For example, many of the items are shared by all four jobs that Gilbane is building on the East Sub-Campus. Items such as trailer rental may be lower than what is estimated due to the fact that the trailer is occupied by employees working on all four jobs ad the jobs therefore share the cost. Also, the Forest Resources and Food Science building are considered one project for Gilbane, so some items that are used solely for Food Science will technically be billed to the Forest Resources project as well. The construction fence is provided by PSU and was already set up around the entire sub-campus before the Forestry project began. Other items such as water and electric, Gilbane did not need to include in their estimate because Penn State provides this for the CM trailer at no charge. If Gilbane were charged for this it would simply be money that Penn State was paying Gilbane because it would be part of their proposal, and then Gilbane would be giving it back to Penn State. This just eliminates one step in the payment process. Other items such as cranes or hoisting are not included in the general conditions estimate because each trade contractor is responsible for providing their own hoisting equipment. The largest cost for Gilbane is the on-site personnel. This accounts for roughly 60% of the total cost. The Forestry project will last 24 months, and the total cost plus fee will be billed in 24 equal payments with no retainage.

# PSU SCHOOL OF FOREST RESOURCES

## GENERAL CONDITIONS ESTIMATE

| | | |
|---|---|---|
| **01300 Administrative Requirements** | | |
| | Permits | by PSU |
| | Bond | not required |
| | Excess Insurance | $22,000 |
| | Project Executive | $35,000 |
| | Project Manager | $169,000 |
| | General Superintendent | $156,000 |
| | MEP Superintendent | $145,600 |
| | Project Engineer | $104,000 |
| | Accountant | $88,000 |
| | Secretary | $72,000 |
| | Progress Photos | $1,750 |
| | Auto Travel Expense | $10,000 |
| | Air Travel Expense | $6,000 |
| | Project Manager Vehicle | $4,000 |
| | Superintendent Vehicle | $18,800 |
| | Cell Phones | $1,400 |
| | 2-Way Radios | $4,800 |
| | Printing Allowance | $30,000 |
| | Record Storage | $1,500 |
| | Petty Cash | $5,400 |
| | Ceremonies | $3,750 |
| | | |
| **01400 Quality Requirements** | | |
| | Surveying / Field Engineering | $12,500 |
| | Testing | $26,000 |
| | Safety Equipment / Incentives | $16,000 |

| 01500 Temporary Facilities and Controls | | |
|---|---|---|
| | Temporary Toilets | $11,000 |
| | Temporary Electric | by PSU |
| | Water | by PSU |
| | Field Office Rental | $24,000 |
| | Field Office Furniture | $9,000 |
| | Stationary / Supplies | $8,500 |
| | Fax Machine | $800 |
| | Fax Supplies / Usage | $1,200 |
| | Telephones | $4,000 |
| | Telephone Usage | $6,500 |
| | Computers | $8,400 |
| | Printer | $1,200 |
| | Copier Lease | $8,400 |
| | Postage / Delivery | $7,900 |
| | Winter Protect. / Temp. Heating | $154,000 |
| | Scaffolding | by Trade |
| | Construction Fence | existing |
| | Dumpsters | $60,000 |
| | Small Tools | $8,000 |
| | First Aid (OCIP) | by PSU |
| | Hoisting / Equipment | by Trade |

| | |
|---|---|
| **TOTAL GC COST** | $1,246,400 |
| | |
| **FEE** | $360,000 |
| | |
| **TOTAL COST** | $1,606,400 |
| | |
| PROJECT WILL LAST 24 MONTHS | |
| | |
| **MONTHLY BILLING** | $66,933.33 |



## Research and Analysis Methods

My Thesis Proposal centers on the idea of MEP coordination. The Forest Resources Building has many laboratory spaces which require extra amounts of MEP piping and ducts. To compound this problem the building has a very limited plenum space. This combination makes the Forestry Building a bit of an MEP nightmare. Through my research and studies I hope to help alleviate some of these coordination issues and help introduce the idea of virtual reality and advanced visualization into the construction industry.

This idea of using virtual models to coordinate construction work is relatively new but is gaining acceptance in the marketplace as contractors begin to realize the benefits of using these techniques. Virtual models can help detect more inconsistencies and coordination problems than a standard 2D or even a 3D CAD model. These problems can be detected earlier and therefore save the contractor both time and money in the long run. By modeling some of the MEP intensive areas of the Forest Resources Building and viewing them in the Immersive Environments Lab, I hope to find some of the coordination issues that were not found during the actual 2D coordination by the contractors. My goal is to introduce the trade contractors to the immersive environments lab and show them around my models. This will help me receive feedback on the models to see how much they would help with the coordination, and also to introduce them to an emerging field in the construction industry that they may have little or no experience with. By trying to understand how many problem areas were detected in the virtual models and not the original drawings, I will be able to see the actual benefits of coordinating construction activities in the immersive environment. I might even be able to save the owner some money, if we catch something before it turns into a change order.

In order to quantify the effectiveness of using virtual models for coordination, I hope to use the trade contractors and other viewers to find inconsistencies in the 2D coordination drawings that might be easier to see in virtual reality. I hope to track any change orders that arise on the job due to MEP coordination and compare these to the virtual models to find out if the models could have solved the problem before installation. There are some good references and articles being published on the uses and benefits of using these virtual prototyping methods because it is a new and changing technology. Hopefully I can make some cost-benefit comparisons for jobs that have employed virtual modeling and even try to work a cost-benefit ratio for the Forest Resources Building.

All of the work in virtual reality that I do will be in the developing methods area, but there are other opportunities for research that go along with my studies. Another major area to examine would be a constructability review on the integration of structural and mechanical systems. MEP coordination can be made much less difficult if there are was to increase the plenum space or decrease the size and amount of duct, pipe, and conduit that must fit into the plenum space. I will need to research the subject more, but with buildings becoming increasing more complex, I am sure there have been some interesting developments in ways to squeeze more and more equipment and distribution into smaller and smaller plenum spaces.

Another interesting area to examine would be value engineering ideas. One way to save money without reducing quality for the building would be through a more complete coordination process. There may be some other areas for potential savings in the Forest Resources Building, but value engineering tends to be more difficult with Penn State buildings. There are certain standards and manufacturers that the University uses and they are not likely to budge on them to save a few bucks. I think if there were any big cost savings they could come from the MEP systems. The structural system and most of the finishes are not going to change without a very substantial savings for the owner.