TECHNICAL REPORT 2

The Metro Museum of American Art

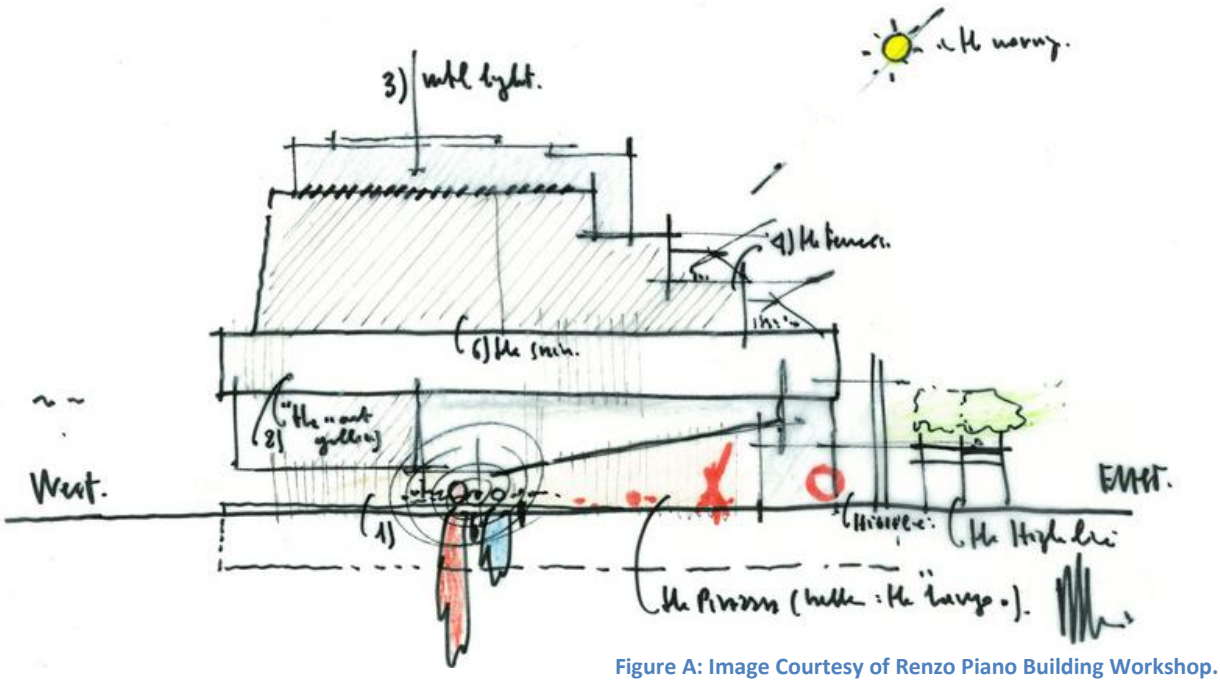

Figure A: Image Courtesy of Renzo Piano Building Workshop.

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AE 481W – Fall 2012
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This Technical Report will provide an overview of the construction of the Metro Museum of American Art construction project. Included will be a detailed analysis of the project schedule, structural and general conditions estimates, building information modeling use, and constructability challenges.

EXECUTIVE SUMMARY

This following technical report details the Metro Museum of American Art (MMAA) new construction building and the construction techniques employed to build it. The project's exact location is to be held confidential; however it can be known that the MMAA will be built in a major US city. This report analyzes the detailed project schedule, structural and general conditions estimates, building information modeling use, and constructability challenges.

The detailed project schedule breaks down the scope of the work by trade and provides enough detail that the sequencing of the work can be understood. The project start date is set at October 13, 2011, and it is scheduled to finish on Novemeber 28, 2014. This translates to a total project duration of approximately thirty seven months or 803 working days. The trade that drives the schedule the most is the gallery fit-out. This is the longest phase of the project at 539 working days. It drives the project schedule mainly because of the detailed gallery space fit-outs that take an average of 416 days to complete each.

A detailed structural systems estimate was calculated for the third and fourth floor office space. This includes the primary structral steel, structural braced framing at the third and fourth floors that resists the lateral loads on the building, composite metal decking, and the reinforced concrete slab-on-deck. It was found that the structural system for the third and fourth floors will cost $2,265,385, which translates to $55.45 per square foot. This is significantly lower than the $115 per square foot cost for the entire building. However, this can be attributed to the variability in the buildings structural system; and the fact that the office space will have the lowest cost per square foot in the building because of its simplistic nature in comparison to the structural system of the gallery space.

The general conditions estimate for the MMAA came out to be $14,497,108 for the project and $391,814 per month. The most costly general conditions section was the insurance and bonding at 57% of the estimate, followed by the personnel section at 34%, and the miscellaneous section makes up the rest at 9%. This estimate was closest to the $15.7M that Turner budgeted for the project.

The MMAA project team's main goal for implemeting BIM was to use it for 3-D coordination and clash detection. The mechanical, electrical, plumbing, and structural systems (MEPS) were the targeted systems for the 3-D coordination. Althought using 3-D coordination provided a great deal of value to the MMAA project team, there are many more BIM options that could have provided even more value to the project. The other most valuable options to the project team would have to be cost estimating, and site utilization planning.

Finally, the main constructability issues have arisen from the downtown site location and the constraints that come along with that. Some of these issues include the excavation and foundation dewatering, where to place the cranes on site, and public safety.

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DETAILED PROJECT SCHEDULE

The detailed project schedule for the Metro Museum of American Art (MMAA) was made using Primavera P6 scheduling and can be found in Appendix A. This detailed schedule breaks down the scope of the work by trade and details the work that will be performed by those different trades. The schedule consists of approximately 200 activities and milestones that starts with the installation of the cassions/piles and finishes with the issuance of the temporary certificate of occupancy for the building. The project start date is set at October 13, 2011, and it is scheduled to finish on November 28, 2014. This translates to a total project duration of approximately thirty seven months or 803 working days. The level of detail in this schedule allows for the sequencing of the work to be understood without being too excessive in detail. The detailed schedule is organized by the different major trades / activites such as excavation and foundation, structural steel, and enclosure. Some of these phases that are driving the project will be discussed in detail in the following section. Below in Table 1, all of these major project phases are summarized in order to give a quick overview of the project.

Table 1: Detailed Project Schedule Overview

DETAILED SCHEDULE OVERVIEW			
Phase	**Start Date**	**Finish Date**	**Duration (Days)**
Excavation & Foundation	13-Oct-11	24-Aug-12	138
Structural Steel Erection	14-Aug-12	14-Feb-13	129
Superstructure Concrete	22-Oct-12	12-Mar-13	101
Enclosure	05-Feb-13	02-Apr-14	297
Building Watertight	N/A	07-Jan-14	1
Vertical Transportation	01-May-13	03-Apr-14	237
MEP Equipment Install	22-Jan-13	15-Jan-14	248*
Interior Fit Out	25-Oct-12	28-Nov-14	539**
Full Building TCO	N/A	28-Nov-14	1
Full Project	**13-Oct-11**	**28-Nov-14**	**803**

** MEP Equipment Install period does not include the dates between when the MEP equipment was set and when the actual work on the equipment began due to the fact that this large non-working time period skews the data.*
*** Interior Fit Out phase is so length mainly due to the large gallery fit-outs. This will be explained more in detail in the following section.*

Excavation & Foundation

The first scheduled activity for the excavation/foundation phase is the drilling of the caissons/piles. After this the general excavation can begin. The access for equipment and trucks to the site/ramp is located at the southwest corner of the site. Due to this the excavation, soil retention, and foundation work will begin on the east side of the site and work its way west until the excavation and foundation are fully complete. This is why the entire excavation/foundation schedule is divided into two main sections; the west side and the east side. The west side activities will start approximately one week after the east side's do. Also,

these main sections are broken down into sub-sections such as the north and the south/east sub-sections for the east side. This is done because the construction techniques for the excavation, soil retention and ultimately foundation construction are slightly different depending on the section of the site plan. For example, on the west side the north/south sub-section receives shotcrete, whalers, and cross lot bracing for its soil retention. Meanwhile the west subsection receives tiebacks and shotcrete to retain the soil.

Once this is complete the construction of the foundation can begin. This process will also progress from the east to the west side of the site starting with the pouring of the mud slab and waterproofing. The foundation consists of a 2.5' cast in place foundation wall that ties into a hydrostatic pressure concrete slab that is being supported by caissons/piles. There is also a 5" concrete wearing slab above a 19" gravel drainage layer that acts as the finish slab on grade for the cellar level.

Structural Steel

The important dates of the steel erection process can be seen in Table 2. As you can see once the excavation and foundation work is nearing completion the structural steel team will mobilize and start erecting the cranes that will be needed for the steel erection process. The crawler crane will be erected first, followed by the tower crane. From there the steel erection will start on the first floor. There is no special phasing for the steel erection; each floor's framing will be erected in its entirety before the erectors move up to the next building level. Once a floor is erected completely the raising gang can then move on to the next level and repeat until the steel is topped out. After the raising gang has moved on to the next level the steel detailing can begin. This includes tightening and plumbing the structure as well as laying the metal deck. See Table 3 for some of the typical durations for the steel erection process.

Table 2: Steel Erection Dates

IMPORTANT STEEL ERECTION DATES	
Description	**Date**
Crane Mobilization	02-Aug-12
Steel Erection Starts	14-Aug-12
Foundation Complete	24-Aug-12
Steel Erection Complete	14-Feb-13

Table 3: Typical Steel Erection Durations

TYPICAL STEEL ERECTION DURATIONS	
Description	**Days**
Average Erection Duration per Floor	11
Average Detailing Duration per Floor	22
Total Duration of Steel Erection / Detailing	129

Superstructure Concrete

Following the completion and turnover of a floor by the steel erection team the cast-in-place concrete contractor will be responsible for installing their work. Typically, for this project, there will be a scheduling lag with an average of 14 working days between the steel turnover of a floor until the concrete workers start roughing in their work. This is to allow the structural steel team to work their way up a few floors so that there is a few layers of metal decking protecting any workers below from safety hazards such as falling debries. The cast-in-place concrete team

consists of two teams of workers; the first will rough-in each floor and the next team of workers will install the rebar/mesh and place the slab on deck. Once the workers start their work it will take the rough in crew five to ten days to complete their work and the reinforcing/placing crew five to ten days to complete their work depending on the size of the floor. Once a crew is finished with their work they will move on to the floor above until all floors are complete.

Enclosure

As described in the first technical report the enclosure for the MMAA consists mainly of precast concrete panels and a carbon steel rain cladding system. The schedule of activities for the wall enclosure starts with the erection of the metal panels followed by the precast concrete panels and the windows and curtainwall. Also the roof installation starts at approximately the same time as the metal panel erection. A detailed overview of the building enclosure start dates, finish dates, and durations can be seen in Table 4.

Table 4: Enclosure Overview

DETAILED ENCLOSURE SCHEDULE OVERVIEW			
Activity	**Start Date**	**Finish Date**	**Duration (Days)**
Roofing Curb Placement	05-Feb-13	21-Mar-13	45
Metal Panels	06-Feb-13	12-Aug-13	132
Precast Concrete Panels	04-Mar-13	24-Apr-13	38
Install Roofing	11-Apr-13	26-Sep-13	169
Windows / Curtainwall	05-Jun-13	02-Apr-14	212
Building Watertight	N/A	07-Jan-14	1

As you can see from Tables 2 and 4 both the roofing curb placement and metal panel erection starts before the steel is topped out. Floors six an up all receive roof curbs due to the stepped nature of the building. The metal panel erection is split into two phases which include the erection of the back up system and then the finish metal panels themselves. The sequencing of the metal panels will start with floors two through five of the south elevation of the building and move counterclockwise to the west, north, and finishing on the east elevation. Once the back up panels start to be erected on the lower west elevation the erection of the back up panels on floors six through the roof will begin on the south elevation and continue in the same order as the lower back up panels. The construction of the finish metal panels will begin once the back up panels start to be erected on the upper east side of the

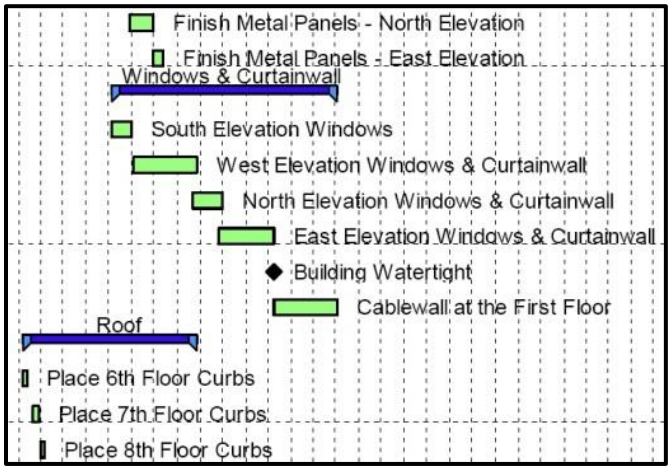


Figure 1: Excerpt from the detailed project schedule. Formed by Vincent A. Rossi.

building. The finish metal panels will also start on the south elevation and move counterclockwise.

An interesting note about the enclosure schedule is the fact that the building watertight milestone occurs before the end of the enclosure phase. This is atypical in building construction; however, it can be explained by looking at Figure 1 on the previous page. The windows and curtainwall sub-phase is the last to be completed in the enclosure phase. So, as you can see the building is watertight after the east elevation windows and curtainwall are complete and before the cablewall at the first floor is started. This is simply due to the fact that the cablewall at the first floor does not need to proctect the building from the elements outside and is mainly an aestetic element of the building enclosure.

Interior Fit-Out

The longest phase of the project as listed on the schedule is by far the interior fit-out. This is due mainly to the long durations for the gallery fit-outs. As you can see in Table 5, the average duration for a gallery fit-out is 416 working days which translates to approximately 19 months. The gallery fit-outs are really all inclusive and include everything from installing hangers in the above deck to completing punchlist items. A typical schedule of activities for a gallery fit out can be seen in Appendix A under the fifth floor gallery fit-out sub-phase. The sixth, seventh, and eighth floor galleries all have a similar scheduling of activities even though their durations are not exactly the same.

Table 5: Gallery Fit-out Overview

GALLERY FIT-OUT SCHEDULE OVERVIEW			
Gallery	**Start Date**	**Finish Date**	**Duration (Days)**
1st Floor Gallery	19-Dec-12	26-Jun-14	390
5th Floor Gallery	29-Jan-13	19-Aug-14	401
6th Floor Gallery	12-Feb-13	16-Sep-14	411
7th Floor Gallery	21-Feb-13	14-Oct-14	424
8th Floor Gallery	28-Feb-13	28-Nov-14	452
Average	*N/A*	*N/A*	*416*

DETAILED STRUCTURAL SYSTEMS ESTIMATE

This detailed structural estimate will focus on the office space that is located in the Metro Museum of American Art (MMAA). The office space is located almost completely on the third and fourth floors and therefore they will be the focus of this investigation. The third floor is approximately 21,000 square feet large. The office space takes up 18,000 square feet of this area with the MMAA's theatre occupying the remaining 3,000 square feet of the floor. Because the theatre takes up two floors of space for its seating, plus the fact that it is the only non office space or support space it will be included in this estimate so that the entire third and fourth floors can be evaluated as a whole. Also, the fourth floor is approximately 20,000 square feet large and it consists completely of office space and support areas. Included in this estimate will be the primary structural systems of these floors. This includes the primary structural steel, structural braced framing at the third and fourth floors that resists the lateral loads on the building, composite metal decking, and the reinforced concrete slab-on-deck.

Structural Steel

The structural steel framing, columns, and lateral bracing for the third and fourth floors consists of 629 pieces of W or HSS shaped members; most of which were W shaped. The W shapes ranged in size anywhere from a W44x335 to a W8x15. There was no consistent pattern throughout the framing plans due to the odd shape of the building and fact that it is a mixed use facility. The steel members for this estimate were taken off by hand and recorded into an Excel spreadsheed that can be seen in Appendix B1. The results of this takeoff are summarized below in Table 6.

Table 6: Structural Steel Estimate Summary

STRUCTURAL STEEL ESTIMATE SUMMARY		
Description	**Number of Members**	**Tonnage of Steel**
3rd Floor Framing	221	97.87
4th Floor Framing	175	76.58
Columns 2nd to 3rd Floor	52	60.84
Columns 3rd to 4th Floor	74	72.58
Braced Framing 3rd & 4th Floors	107	130.54
Total	**629**	**460.32**

As you can see the framing plans contribute the most number of members of any section. However, the braced framing for the two floors produces the most tonnage with almost half as many members as the framing plans. This shows that the braced framing has the heaviest member sizes. This could be an issue because these heavy members are typically located on the perimeter of the building. This is an important detail because the main tower crane is located in the center of the building in the shaft of the grand staircase. The distance from these large members' final locations to the tower crane will drive the size of tower crane that is needed to safely erect the steel.

Also worth noting is that the schedule calls for an average of eleven days to erect a floor of steel. From this the productivity of the steel erection team can be determined by dividing the total amount of steel members (629) by the amount of days scheduled (22). Therefore, the steel productivity must be 28 pieces of steel per day to meet the construction schedule. This is a high rate of steel erection that the team is scheduled to meet and will be a challenge during the construction of the building.

Concrete Slab-on-Deck

The MMAA's structure consists of upwards of ten different types of cast-in-place (CIP) concrete. However, there is only one type of CIP concrete for both the office space and the theatre respectively on the third and fourth floors. The slab-on-deck for the third and fourth floor office space is type 6.25 as denoted on the drawings. This type of slab is defined as a 3-1/4" lightweight concrete slab on 3"-18 gage composite metal deck that is reinforced with 6x6-W2.0xW2.0 WWF. The total thickness for this slab is 6-1/4". The only other type of slab-on-deck is located on the third floor and is for the MMAA's theatre. This type of slab is denoted as 9N on the drawings due to the fact that it is nine inches thick and consists of normal weight concrete. It is defined as a 6" normal weight concrete slab on 3"-18 gage composite metal deck reinforced with 4x4-W2.9xW2.9 WWF. The total thickness for this slab is 9". The square feet of concrete slab-on-deck for these floors was calculated using Autodesk Quantity Takeoff. The total area of the floors was quantified less the area of openings for elevators, MEP shafts, and other elements. The printouts from Quantity Takeoff can be seen in Figures 2, 3, and 4 on the next page. These display the areas where there will be a slab present in red. Non red areas of the building footprint are areas where there are slab openings or no slab planned.

Once the square footage of slab has been determined it can be multiplied by the thickness of the slab to determine the cubic feet of concrete needed. This can then be converted into cubic yards by dividing by a conversion factor of 27. These details can be seen in Appendix B2 with the rest of the concrete takeoff details; the summary of these details is reproduced below in Table 7. It is also worth noting that the WWF reinforcing takeoff is equal to the slab square footage. Also, the edge forms for the concrete pouring were taken off using Autodesk Quantity Takeoff as well by outlining the perimeter of the slab and any boxed out openings that were required.

Table 7: Concrete Takeoff Details

CONCRETE SLAB ON DECK TAKEOFF DETAILS		
Slab on Deck Type	**Square Footage**	**Cubic Yards of Concrete**
Type 6.25 Lightweight	37,956	556.5
Type 9N Normal Weight	2,899	67.1
Total	**40,855**	**626.6**

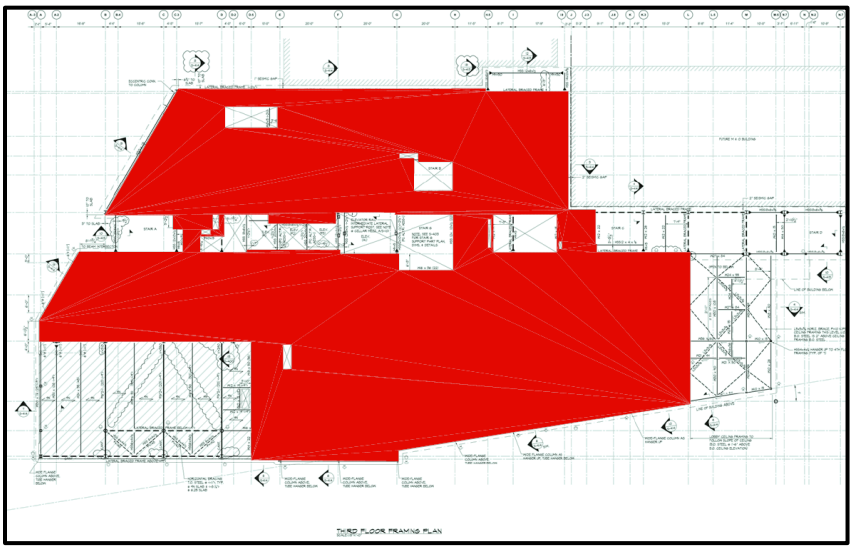


Figure 2 to the Left: Quantity Takeoff of the Type 6.25 slab on deck for the 3rd floor of the MMAA.

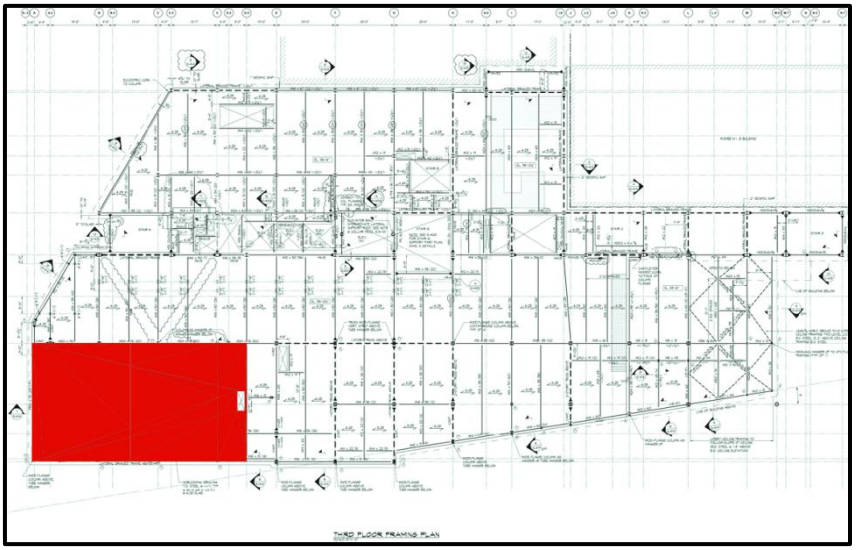


Figure 3 to the Right: Quantity Takeoff of the Type 9N slab on deck for the 3rd floor of the MMAA.

Figure 4 to the Left: Quantity Takeoff of the Type 6.25 slab on deck for the 4th floor of the MMAA.

Pricing

Before pricing was applied to the takeoffs they were grouped together by CSI division. The only divisions that were needed for this estimate were divisions 03 Concrete, and 05 Metals. The items that were grouped together in the 03 section were the concrete material, placement, finishing, reinforcing and forming. While in the 05 section the structural steel and metal decking were grouped together. This breakdown, along with the pricing details can be seen in Appendix B3 under the recap sheet for the structural system. All of the elements for this structural system were priced using RS Means Construction Cost Data, 2012. RS Means breaks down the cost data into material, labor and equipment unit costs for each line item. These were then extrapolated out to obtain the total material, labor and equipment costs in dollars for each line item and a total cost for each division. The RS Means data gives values for the national average construction costs. These costs have to be adjusted for location and time variations. The location adjustment factors can also be found in RS Means and are broken down by city and CSI code. This estimate does not have to be adjusted for time because the 2012 edition of RS Means was used and the work described is currently underway on the construction site during 2012. Table 8 summarizes the estimate by CSI code, applies their respective time and location factors, and totals the structural system estimate for the third and fourth floors of the MMAA.

Table 8: Structural Estimate Adjustments & Overview

STRUCTURAL SYSTEM ESTIMATE OVERVIEW				
Division	**National Average Cost**	**Location Factor**	**Time Factor**	**Adjusted Cost**
03 Concrete	$149,698	1.423	1.00	$213,021
05 Metals	$1,583,615	1.296	1.00	$2,052,365
Total	**$1,733,313**	**N/A**	**N/A**	**$2,265,385**

Note that these numbers reflect the cost of the material, labor, and equipment necessary to complete the work in question. No overhead or profit was included in this estimate due to the fact that this could be different depending on the job or company. Now we can break down the cost of the building systems into square foot costs. As you can see in Table 9 both the national average and the adjusted square foot costs have been calculated.

Table 9: Structural System Square Foot Costs

STRUCTURAL SYSTEM SQUARE FOOT COSTS				
Division	**National Average Cost**	**Average SF Cost ($/SF)**	**Adjusted Cost**	**Average SF Cost ($/SF)**
03 Concrete	$149,698	$3.66	$213,021	$5.21
05 Metals	$1,583,615	$38.76	$2,052,365	$50.24
Total	**$1,733,313**	**$42.43**	**$2,265,385**	**$55.45**
**Note that the total square footage of the 3rd and 4th floors is 40,855.*				

Analysis

The next step would be to extrapolate this square foot cost out to the entire building. However, this is not practical for the MMAA. Because the museum has office space, galleries, and many other uses the structural system is not consistent throughout the building. For example, the MMAA has the largest column free gallery in the city. The structural steel that allows that to occur is much larger and heavier than the typical steel used for the office spaces on the third and fourth floors. So, extrapolating this $55.45/SF value that was determind for the office space to the rest of the building would be incorrect and irrelevant. The only real way to make a detailed estimate for this building would be to go repeat the estimating process that was done here for the third and fourth floors and apply that to the whole building.

One way that this estimate can be evaluated is by comparing it to the actual cost data that Turner estimated for before they started the project. They produced a total cost per square foot for the various systems of the building. The structural steel system and the superstructure concrete cost per square foot was estimated to be approximately $115/SF. This cost for the whole building is approximately two times the size of the cost for the third and fourth floor office space. This is partialy due to the variability in the building as described above. However, this would not account for a doubling in the overall cost per square foot. I believe that another reason for this is the fact that the RS Means data that was used in this estimate priced the structural steel by the ton. This is problematic because the MMAA is not a cookie cutter structural steel system and because of that the productivity per ton would not be nearly as good as a typical office building which is what RS Means is more closely targeted to. In conclusion, I believe that the only proper way to perform a detailed estimate for the structural system of the MMAA would be to take off the entire structure as noted before.

GENERAL CONDITIONS ESTIMATE

The general conditions estimate for the Metro Museum of American Art (MMAA) can be considered the operating costs for the job site. It can be seen on page 14 and its costs include personnel, field offices, temporary utilities, insurance and bonding, and other miscellaneous costs. The estimate is broken down into three main sections: personnel, insurance and bonding, and miscellaneous items. Personnel costs are the costs of the staff's salary and benefits. Insurance and bonding costs include builders risk insurance, general liability insurance, payment and performance bonds, permiting, and Turner's subguard program. Finally, the miscellaneous costs are associated with items such as the field office rent, supplies, temporary utilities, telephone bills, and job clean up.

Table 10: General Conditions Summary

GENERAL CONDITIONS SUMMARY		
Section	**Total Cost ($)**	**Cost per Month**
Personnel	$4,965,000	$134,189
Miscellaneous	$1,342,225	$36,276
Insurance & Bonding	$8,189,883	$221,348
TOTAL	**$14,497,108**	**$391,814**
***Note that the estimate is based on a project duration of 37 months.*		

The general conditions estimate is based off of a 37 month construction schedule. Because of this a monthly cost for general conditions can be determined . This along with a summary of the general conditions estimate can be seen above in Table 10. The final general conditions estimate came out to be $14,497,108 for the project and $391,814 per month. In order to price the estimate the 2012 RS Means Construction Cost Data reference was used. Also, some of the items in the estimate were previously known so those actual costs were used. The most costly general conditions section was the insurance and bonding at 57% of the estimate, followed by the personnel section at 34%, and the miscellaneous section makes up the rest at 9%. This is expressed visually in Figure 5.

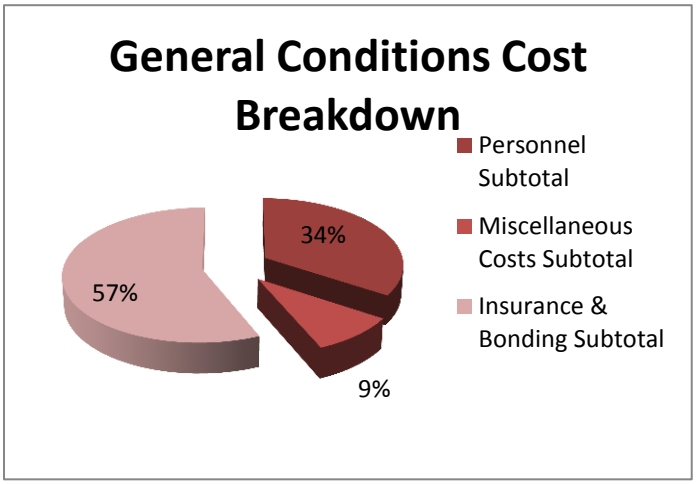


Figure 5: General Conditions Cost Breakdown

As you can see the insurance and bonding section was considerbly higher than the other sections. A contributing factor to this is the high cost per square foot of the building. As detailed in technical report one the cost per square foot of the MMAA is approximately $1200. This will naturally make the insurance and bonding very high on the project due to the fact that all of these items are based on a percentage of the contract value. Other items in the

general conditions estimate such as the field office rent or telephone bill would be the same if the building cost $200 per square foot or $1500 per square foot. Turner originally estimated general conditions to cost $15.7M so the two estimates match up closely overall. However, Turner did not release the details of their general conditions estimate so unfortunately the sub sections of the estimate cannot be compared in detail.

The main takeaway from this exercise is showing that any schedule overruns would be extremely costly by themselves through added general conditions costs, let alone adding on any of the liquidated damages that would be incurred from turnover delays. On the other hand if Turner is able to deliver the project early it would be extremely beneficial and save a significant amount of money on the project.

METRO MUSEUM OF AMERICAN ART

GENERAL CONDITIONS ESTIMATE

Estimator: Vincent A. Rossi
Date: October 10 2012

Description	EA	Quantity	Unit	Rate	Total Cost
Personnel Costs					
Project Manager	1	150	Week	3,500.00	$525,000.00
Project Engineer	1	150	Week	2,600.00	$390,000.00
Project Superintendent	1	150	Week	3,300.00	$495,000.00
Superintendent	3	150	Week	2,600.00	$1,170,000.00
Engineer	5	150	Week	2,200.00	$1,650,000.00
Safety	1	150	Week	2,500.00	$375,000.00
Accountant	1	150	Week	2,400.00	$360,000.00
Miscellaneous Costs					
CPM Schedule (Rule of Thumb Large Job)	1	0.30%	Job	266,345,323.00	$799,035.97
Computers	1	10	EA	1,800.00	$18,000.00
Temporary Utilities Electric - Project Duration	1	2229.5	CSF Flr	51.50	$114,819.25
Temporary Utilities Water	1	37	Month	250.00	$9,250.00
Field Office	1	37	Month	5,000.00	$185,000.00
Office Equipment Rental	1	37	Month	300.00	$11,100.00
Office Supplies	1	37	Month	400.00	$14,800.00
Coffee & Water Cooler	1	37	Month	100.00	$3,700.00
Internet	1	37	Month	450.00	$16,650.00
Postage	1	37	Month	600.00	$22,200.00
Telephone Bill	1	37	Month	1,200.00	$44,400.00
Lights & HVAC	1	38	Month	165.00	$6,270.00
Testing & Inspection Steel Building	1	1	Job	15,000.00	$15,000.00
Local Travel	1	37	Month	1,000.00	$37,000.00
Daily Clean Up	1	150	Week	300.00	$45,000.00
Insurance & Bonding					
Builders Risk Insurance	1	BY OWNER	Job	266,345,323.00	BY OWNER
General Liability Insurance	1	0.70%	Job	266,345,323.00	$1,864,417.26
Payment and Performance Bonds	1	0.60%	Job	266,345,323.00	$1,598,071.94
Permits	1	0.80%	Job	266,345,323.00	$2,130,762.58
Subgurad Program	1	1	Job	2,596,631.00	$2,596,631.00
				Personnel Subtotal	$4,965,000.00
				Miscellaneous Costs Subtotal	$1,342,225.22
				Insurance & Bonding Subtotal	$8,189,882.78
				GENERAL CONDITIONS TOTAL	**$14,497,108.00**

BUILDING INFORMATION MODELING USE EVALUATION

Building Information Modeling (BIM) can be very useful to a construction team. It is not simply a model but a tool and a resource that can provide many benefits to the project team and ultimately the owner. BIM can be used for a wide variety of uses including cost estimation, systems analysis, 3-D coordination, 4-D phase planning, facility maintenance and many other uses. All of these uses are designed to provide cost savings to the project and ultimately the owner. This is done by streamlining the construction sequences whether by allowing off-site prefabrication of MEP systems due to 3-D coordination or by reducing the number of conflicts and corresponding RFIs in the field. BIM is a powerful tool that is emerging in the construction industry and because of this it needs to be planned for and implemented in the correct way.

Having a BIM implementation plan is key to obtaining the most value out of a BIM project. This allows the project team to clearly define their goals for BIM and what uses and deliverables they want for the particular project. Two key processes for implementing BIM are completing the BIM use list and the level one process map. The BIM use list is a graphical chart that clearly defines all of the scheduled BIM uses on the project in the planning, design, construction, and operation phases of the project. The level one process map is a flow chart that describes the phasing of the BIM uses and defines who is responsible for providing the BIM deliverables throughout the project. One of the problems currently associated with the BIM process is that project team members are not always clear on what implementing BIM actually entails and who is responsible for what deliverables. This happens due to multiple reasons including poor contract language and a lack of clarity and definition on what exactly BIM is. Completing these two processes will allow the team to know and understand what the BIM uses will be for the project and who is responsible for each of the deliverables. Note Figure 6 displays the actual BIM model of the Metro Museum of American Art (MMAA) used by Turner Construction during the project.

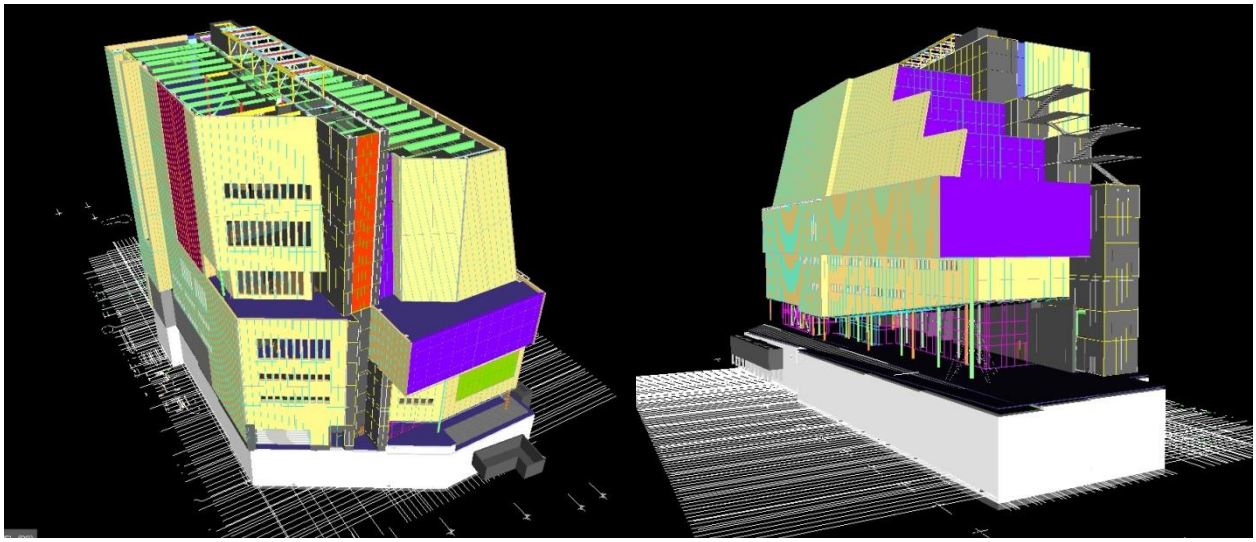


Figure 6: The image on the left shows the BIM model of the MMAA view from the northwest. The image on the right shows the BIM model of the MMAA view from the southeast. Both images are courtesy of Turner Construction Company.

In this section the BIM use list and process map will be completed for the MMAA. First, the BIM use list and process map will be completed using the actual uses and processes that are being implemented on site. Then I will discuss areas of BIM that could produce value to the project due to the site conditions and nature of the project.

Actual BIM Uses

Table 11 below details the BIM uses that were implemented on this project. Note the large amount of uses of BIM that are available to project teams.

Table 11: Bim Use List

X	PLAN	X	DESIGN	X	CONSTRUCT	X	OPERATE
	PROGRAMMING		DESIGN AUTHORING		SITE UTILIZATION PLANNING		BUILDING MAINTENANCE SCHEDULING
	SITE ANALYSIS		DESIGN REVIEWS		CONSTRUCTION SYSTEM DESIGN		BUILDING SYSTEM ANALYSIS
			3D COORDINATION	X	3D COORDINATION		ASSET MANAGEMENT
			STRUCTURAL ANALYSIS		DIGITAL FABRICATION		SPACE MANAGEMENT / TRACKING
			LIGHTING ANALYSIS		3D CONTROL AND PLANNING		DISASTER PLANNING
			ENERGY ANALYSIS		RECORD MODELING	X	RECORD MODELING
			MECHANICAL ANALYSIS				
			OTHER ENG. ANALYSIS				
			SUSTAINABLITY (LEED) EVALUATION				
			CODE VALIDATION				
	PHASE PLANNING (4D MODELING)		PHASE PLANNING (4D MODELING)		PHASE PLANNING (4D MODELING)		PHASE PLANNING (4D MODELING)
	COST ESTIMATION		COST ESTIMATION		COST ESTIMATION		COST ESTIMATION
	EXISTING CONDITIONS MODELING		EXISTING CONDITIONS MODELING		EXISTING CONDITIONS MODELING		EXISTING CONDITIONS MODELING

As you can see the MMAA project teams main goal for implemeting BIM was to use it for 3-D coordination and clash detection. The mechanical, electrical, plumbing, and structural systems (MEPS) were the targeted systems for the 3-D coordination. This is a valuable tool for the project team for multiple reasons. First, as detailed in technical report one the MEP systems on this project were very complex in nature. The mechanical system had many different units and systems to serve the various types of spaces throughout the building. Because of this the mechanical system alone could benefit from implementing 3-D coordination. Adding the electrical, plumbing, and fire protection systems on top of this creates a very complex coordination situation that would be nearly impossible without the assistance of 3-D modeling. By using the 3-D modeling all of the trades will know exactly where their work needs to go and greatly improves productivity on the job site. The other main use for BIM is the turnover of a record model to the owner at the completion of the project. The MMAA did not require this out of the contractor the job, however, Turner will provide this to them so that they can implement a BIM facility maintenance program in the future if they so desire.

The next step is to develop the level one process map. This can be seen in full in Appendix C. This map describes the flow of information and each parties responsibilities. The process map for the MMAA is rather simple due to the fact that the project team is only using BIM for 3-D coordination and for compiling a record model. The process starts with the owner validating the program and the architect developing the schematic design. The architect's deliverables for this step are an architectural, structural, and MEP model. After this the next process is for the contractor to run 3-D coordination on these models and provide feedback back to the project team. This is repeated for design development and with the final construction document. Then after the building is completed the contractor is responsible for compiling a record model and turning this over to the owner. In reality the architect will not be the only party developing these MEPS models. The trade specific subcontractors will be developing the advanced models in the design development and construction documents phases. However, the architect is listed as the party on the process map for simplicity. As you can see creating this model will allow everybody on the project team to know what they are responsible for and when it needs to be delivered. Even for an example as simple as this one, the value of going through this process is very evident.

Prospective BIM Uses

As shown previously in Table 11 outside of 3-D coordination and compliing a record model there are many other valuable BIM implemntation options. Although using 3-D coordination provided a great deal of value to the MMAA project team, there are many more BIM options that could have provided even more value to the project. The other most valuable options to the project team would have to be cost estimating, and site utilization planning.

Cost Estimation

One major advantage of BIM is the ability to extract quantities and values out of a model and use them for cost estimation. This is valuable for two main reasons. First, extracting quantites from a BIM is much quicker and easier than taking off 2-D drawing by hand or with computer software. Also, if the building is modeled correctly extracting quantities from a BIM can be much more accurate due to the fact that an element of human error was removed. Secondly, and perhaps more advantageous is the fact that once a BIM model is made, it is very easy to estimate cost implications for any changes to the building. The model can be adjusted for the alternate at hand and taken off to estimate what the change in price would be. This all provides value to the owner because it is saving a large amount of time spent on the project.

Site Utilization Planning

As noted before the MMAA's site is located in a very constricted downtown location. Due to this planning the site logistics of the construction sequences is very important. Technical report one started to look at the different phasing plans for the project in 2-D paper format. Implementing BIM site utilization would create a clear picture of what is going on at the site at all times. This is beneficial to all members of the project team because they will know exactly where they will be working from, where their material locations will be, and any obstales that will be presented to them on the job site. This will also improve productivity and will allow the project to prevent conflict before they occur.

CONSTRUCTABILITY CHALLENGES

This section will provide insight into some of the constructability challenges that are present on the Metro Museum of American Art (MMAA) project. The MMAA is a complex job in a downtown location with a tight schedule considering the size of the project. Some of the main constructability issues have arisen from the downtown site location and the constraints that come along with that. Some of the issues include the excavation and foundation dewatering, where to place the cranes on site, and public safety.

Excavation, Foundation, & Dewatering

In the past the MMAA's project site was underwater in the cities river. For years the project site was used as a landfill for unwanted excavated material. This continuous dumping of unwanted soil in this area eventually moved the river back to its current location. However, it did not leave the site with suitable soil conditions for construction. This becomes an issue because as you can imagine the bearing capacity of the soil on the site cannot hold the pressure associated with such a large building as the MMAA. A geotechnical investigation confirmed this and the project team decided that due to the poor soil conditions under the site that a deep foundation will be used that consists of caissons/piles that are socked into bedrock.

Another issue with this phase of the project is that the site location is still very close to the cities river. The cellar floor of the MMAA is scheduled to be 20' below grade even though the water table is anywhere from 6 to 12 feet below grade. This creates a constructability challenge during the excavation phase of the project. As you can see from Figure 7 the site would constantly fill up with water once excavation progressed past the water table. In order to stop this from becoming a problem Turner installed 8 deep wells which pumped the on-site water into a sedimentation tank, then through a filter back into the city sewer system.

Figure 7: View of the MMAA excavation from the North. Note the puddles throughout the site. Photo courtesy of the Metro Museum of American Art.

Tower Crane Placement

One of the main issues on site is the fact that there is little or no room for any staging or equipment. The site is very constricted due to its downtown location. Plus in order to keep up with the project schedule more than one crane would be necessary on site. So, the queston is where to locate the cranes on site?

A crawler crane will be the first on site and will be located at the south central perimeter of the building. A tower crane will also be needed on site for the steel erection. However, it cannot be placed on the east or north perimeter of the building due to the existing highline and building structures. If a crane is put on the west perimeter of the building the staging and trailer area would become nonexistant and then neither of the cranes would be able to reach the north east corner of the site to place the steel. It would not make any sense to place the crane on the south perimeter with the crawler crane. So, the crane would have to be located within the site. It was determined that the tower crane should be place in the shaft of the grand staircase. This will provide the cranes the reach to place any steel member in the building and meet the productivity demands of the schedule. The placement of the tower and crawler cranes can be seen in Figure 8 below.

This placement produces one issue in itself. The grand staircase is lined by cast in place concrete panels. So, the tower crane will have to be deconstructed first, then the crawler crane will have to hoist these concrete panels down the open shaft and into place well after the rest of the panels have allready been finished. Another interesting note about the cranes mobilization is that the crawler crane will erect the south central area of the first floor structural steel first so that a working platform could be created for the structural steel trailers and workers. This will also provide lateral bracing for the foundation structure and the cross lot bracing can be removed in those areas.

Figure 8: Locations of the crawler & tower cranes. Photo taken by Vincent A. Rossi.

Public Safety

Another construction issue that arises from the downtown location is preserving the safety of the public. The site is located in a downtown location that is in the middle of a developing shopping, restaurant, and bar area. Also, the pedestrian highline walkway is directly adjacent to the building's east side and is scheduled to remain open throughout the construction of the MMAA. Because of all of this there will be a very high level of pedestrian activity during and after work hours on the site.

In order to protect the public Turner implemented a few safety measures. First an eight foot high barricade was put up around the entire perimeter of the site. There is signage throughout the barricade warning the public of the construction zone. At the three gates there is a staff member insuring that nobody from the public enters the site unless they are required to and have the proper personal protective equipment. Next, an overhead protection barrier was built above the open pedestrian walkway. This can be seen Below in Figure 9. Finally on the west side of the site a five foot wide covered pedestrian walkway was constructed between the site barricade and the adjacent roadway. This can be seen below in Figure 10. All of these measures are necessary to keep the public safe while around the MMAA.

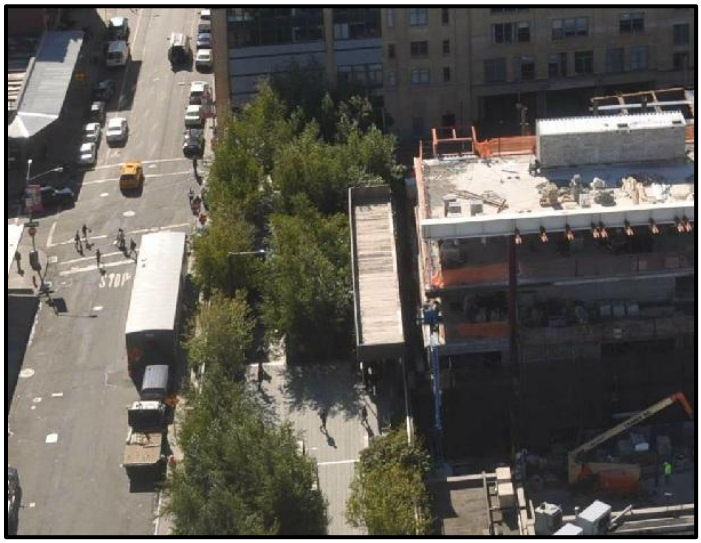


Figure 9: View of the overhead protection above the highline. Image courtesy of the Metro Museum of American Art.

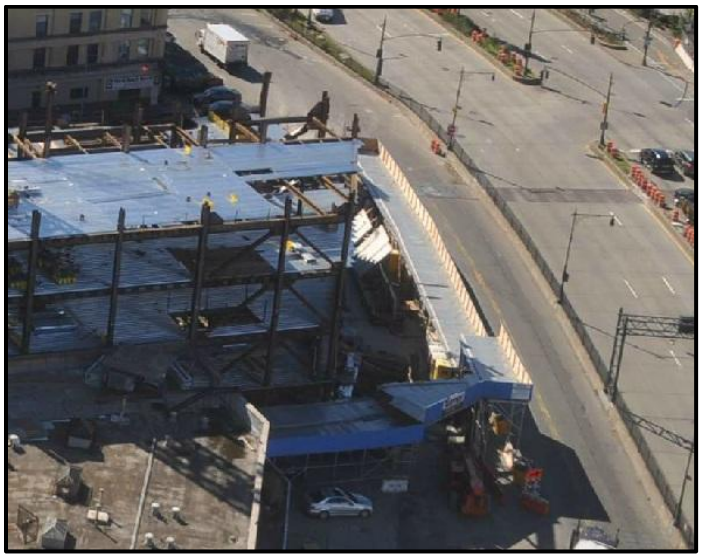


Figure 10: View of the west side pedestrian walkway. Image courtesy of the Metro Museum of American Art.

APPENDIX A

DETAILED PROJECT SCHEDULE

Metro Museum of American Art: Detailed Project Schedule

Classic Schedule Layout

03-Oct-12 19:30

Activity ID	Activity Name	Start	Finish	Original Duration	Remaining Duration
Metro Museum of American Art: Detailed Project Schedule		13-Oct-11	28-Nov-14	803	803
Excavation, Foundation & Superstructure		13-Oct-11	25-Jul-13	455	455
Excavation & Foundation		13-Oct-11	24-Aug-12	222	222
EX010	Install Cassions/Piles	13-Oct-11	17-Feb-12	89	89
EX020	Install Dewatering System	03-Jan-12	24-Feb-12	39	39
West Side		13-Feb-12	24-Aug-12	138	138
EXW102	General Excavation & Shotcrete: -5' N&S	13-Feb-12	16-Mar-12	25	25
EXW103	Install Top Tier Wale & Cross Lot Bracing N&S	27-Feb-12	30-Mar-12	25	25
EXW104	Excavate & Shotcrete: -15' N&S	12-Mar-12	27-Apr-12	35	35
EXW105	Install Lower Tier Wale & Cross Lot Bracing N&S	02-Apr-12	11-May-12	30	30
EXW106	Excavate & Shotcrete to Subgrade: N&S	23-Apr-12	25-May-12	25	25
EXW107	Perimeter Mud Slab/Waterproofing/Pour Perimeter Mat N&S	07-May-12	08-Jun-12	24	24
EXW108	Waterproof & Pour Lower Walls N&S	04-Jun-12	13-Jul-12	29	29
EXW109	Waterproof & Pour Upper Walls N&S	18-Jun-12	27-Jul-12	29	29
EXW110	Excavate Center Mat to Subgrade and Prep Pile Caps	14-May-12	06-Jul-12	38	38
EXW111	Center Mat Mud Slab/Waterproofing/Pour	04-Jun-12	27-Jul-12	39	39
EXW121	Excavate/Install Tiebacks (21 ea): -5' W	21-Feb-12	09-Mar-12	14	14
EXW131	Shotcrete to -5' & Install Tieback Heads & Lock Off: W	05-Mar-12	23-Mar-12	15	15
EXW141	Excavate & Shotcrete: -15' W	19-Mar-12	13-Apr-12	20	20
EXW151	Install Lower Tier Tiebacks (42 ea) with Heads & Lock Off: W	02-Apr-12	04-May-12	25	25
EXW161	Excavate & Shotcrete to Subgrade: W	30-Apr-12	25-May-12	20	20
EXW171	Mud Slab/Waterproofing/Pour Perimeter Mat: W	14-May-12	15-Jun-12	24	24
EXW181	Waterproof & Pour Lower Walls W	04-Jun-12	06-Jul-12	24	24
EXW191	Waterproof & Pour Upper Walls W	25-Jun-12	27-Jul-12	24	24
EXW201	Install Underslab MEP	16-Jul-12	03-Aug-12	15	15
EXW211	Place 19" Stone Backfill & 5" Conc Wearing Slab	30-Jul-12	24-Aug-12	20	20
East Side		03-Jan-12	24-Aug-12	167	167
EXE002	Install Dewatering System	03-Jan-12	24-Feb-12	39	39
EXE100	Install Top Tier Cross Lot Braces	23-Jan-12	17-Feb-12	20	20
EXE110	Excavate North Side & Wales: -17' N	06-Feb-12	16-Mar-12	30	30
EXE120	Excavate North Side & Install Inclined Braces & Heel Blocks: N	05-Mar-12	30-Mar-12	20	20
EXE130	Excavate North Berm to Subgrade	02-Apr-12	20-Apr-12	15	15
EXE140	Install Mud Slab/Waterproofing/Pour Perim Mat: N	16-Apr-12	18-May-12	25	25
EXE150	Remove Lower Bracing: N	21-May-12	01-Jun-12	9	9
EXE160	Waterproof & Pour Lower Walls N	29-May-12	06-Jul-12	28	28
EXE170	Waterproof & Pour Upper Walls N	18-Jun-12	27-Jul-12	29	29
EXE180	Excavate to Subgrade & Install Tiebacks: S&E	13-Feb-12	30-Mar-12	35	35
EXE190	Install Mud Slab/Waterproofing/Pour Perimeter Mat: S&E	19-Mar-12	20-Apr-12	25	25
EXE191	Install Mud Slab/Waterproofing/Pour Center of Mat: S&E	02-Apr-12	04-May-12	25	25
EXE200	Pour Lower / Upper Tier Walls: S&E	30-Apr-12	22-Jun-12	39	39
EXE210	Waterproof & Backfill Lower / Upper Tier Walls: S&E	18-Jun-12	20-Jul-12	24	24
EXE220	Install Underslab MEP	09-Jul-12	03-Aug-12	20	20
EXE230	Place 19" Stone Backfill & 5" Conc Wearing Slab	24-Jul-12	24-Aug-12	24	24
Structural Steel		02-Jul-12	25-Jul-13	272	272
Stairs		02-Oct-12	25-Jul-13	208	208
ST3000	Install Steel Stairs Celler to 5th Floors	02-Oct-12	05-Nov-12	25	25
ST3010	Install Steel Stairs 6th to 9th Floors	28-Jan-13*	08-Feb-13	10	10

Actual Work
Remaining Work
Critical Remaining Work
Milestone
Summary

TASK filter: All Activities

Metro Museum of American Art: Detailed Project Schedule

Classic Schedule Layout

03-Oct-12 19:30

Activity ID	Activity Name	Start	Finish	Original Duration	Remaining Duration
ST3020	Install Exterior Stairs 6th to 8th Floors	25-Apr-13*	15-May-13	15	15
ST3030	Install Struct/Precast - Grand Staircase	01-May-13*	25-Jul-13	60	60
Crane Setup		02-Jul-12	30-Apr-13	212	212
ST1000	Erect, Detail, & Pour Conc.for Crane Platform	02-Jul-12	01-Aug-12	22	22
ST1010	Erect Crawler Crane & Tower Crane	02-Aug-12	13-Aug-12	8	8
ST1020	Remove Tower Crane	15-Apr-13*	30-Apr-13	12	12
Steel Erection		14-Aug-12	14-Feb-13	129	129
ST2000	Celler & First Floor Steel Erection	14-Aug-12	06-Sep-12	17	17
ST2010	Celler & First Floor Detailing	07-Sep-12	08-Oct-12	22	22
ST2020	2nd Floor Steel Erection	07-Sep-12	21-Sep-12	11	11
ST2030	2nd Floor Steel Detailing	24-Sep-12	19-Oct-12	20	20
ST2040	3rd Floor Steel Erection	24-Sep-12	08-Oct-12	11	11
ST2050	3rd Floor Steel Detailing	09-Oct-12*	05-Nov-12	20	20
ST2060	4th Floor Steel Erection	09-Oct-12*	23-Oct-12	11	11
ST2070	4th Floor Steel Detailing	24-Oct-12*	27-Nov-12	24	24
ST2080	5th Floor Steel Erection	24-Oct-12*	07-Nov-12	11	11
ST2090	5th Floor Steel Detailing	08-Nov-12*	12-Dec-12	24	24
ST2100	6th Floor Steel Erection	08-Nov-12*	26-Nov-12	12	12
ST2110	6th Floor Steel Detailing	27-Nov-12*	02-Jan-13	25	25
ST2120	7th Floor Steel Erection	27-Nov-12*	12-Dec-12	12	12
ST2130	7th Floor Steel Detailing	13-Dec-12*	11-Jan-13	20	20
ST2140	8th Floor Steel Erection	13-Dec-12*	27-Dec-12	10	10
ST2150	8th Floor Steel Detailing	28-Dec-12*	25-Jan-13	20	20
ST2160	9th Floor Steel Erection	28-Dec-12*	14-Jan-13	11	11
ST2170	9th Floor Steel Detailing	15-Jan-13*	11-Feb-13	20	20
ST2180	Roof Steel Erection	15-Jan-13*	17-Jan-13	3	3
ST2190	Roof Steel Detailing	18-Jan-13*	14-Feb-13	20	20
Superstructure Concrete		22-Oct-12	14-Mar-13	101	101
SOD		22-Oct-12	14-Mar-13	101	101
CONC4000	Rough In, Install Rebar/Mesh, & Place Concrete - Cellar Mezz	22-Oct-12*	02-Nov-12	10	10
CONC4010	Rough In, Install Rebar/Mesh, & Place Concrete - 1st Floor	29-Oct-12*	16-Nov-12	15	15
CONC4020	Rough In, Install Rebar/Mesh, & Place Concrete - 2nd Floor	12-Nov-12*	29-Nov-12	13	13
CONC4030	Rough In, Install Rebar/Mesh, & Place Concrete - 3rd Floor	28-Nov-12*	26-Dec-12	20	20
CONC4040	Rough In, Install Rebar/Mesh, & Place Concrete - 4th Floor	13-Dec-12*	08-Jan-13	17	17
CONC4050	Rough In, Install Rebar/Mesh, & Place Concrete - 5th Floor	03-Jan-13*	16-Jan-13	10	10
CONC4060	Rough In, Install Rebar/Mesh, & Place Concrete - 6th Floor	17-Jan-13*	30-Jan-13	10	10
CONC4070	Rough In, Install Rebar/Mesh, & Place Concrete - 7th Floor	31-Jan-13*	19-Feb-13	14	14
CONC4080	Rough In, Install Rebar/Mesh, & Place Concrete - 8th Floor	14-Feb-13*	28-Feb-13	11	11
CONC4090	Rough In, Install Rebar/Mesh, & Place Concrete - 9th Floor	22-Feb-13*	07-Mar-13	10	10
CONC4100	Rough In, Install Rebar/Mesh, & Place Concrete - Roof	01-Mar-13*	14-Mar-13	10	10
Enclosure		05-Feb-13	02-Apr-14	297	297
Precast Panels		04-Mar-13	24-Apr-13	38	38
E1000	Erect Precast Panels - North Elevation (70 Panels)	04-Mar-13*	25-Mar-13	16	16
E1010	Erect Precast Panels - West Elevation (32 Panels)	26-Mar-13*	01-Apr-13	5	5
E1020	Erect Precast Panels - South Elevation (74 Panels)	02-Apr-13*	15-Apr-13	10	10
E1030	Erect Precast Panels - East Elevation (42 Panels)	16-Apr-13*	24-Apr-13	7	7
Metal Panels		06-Feb-13	12-Aug-13	132	132

Actual Work | Critical Remaining Work | Summary
Remaining Work | Milestone

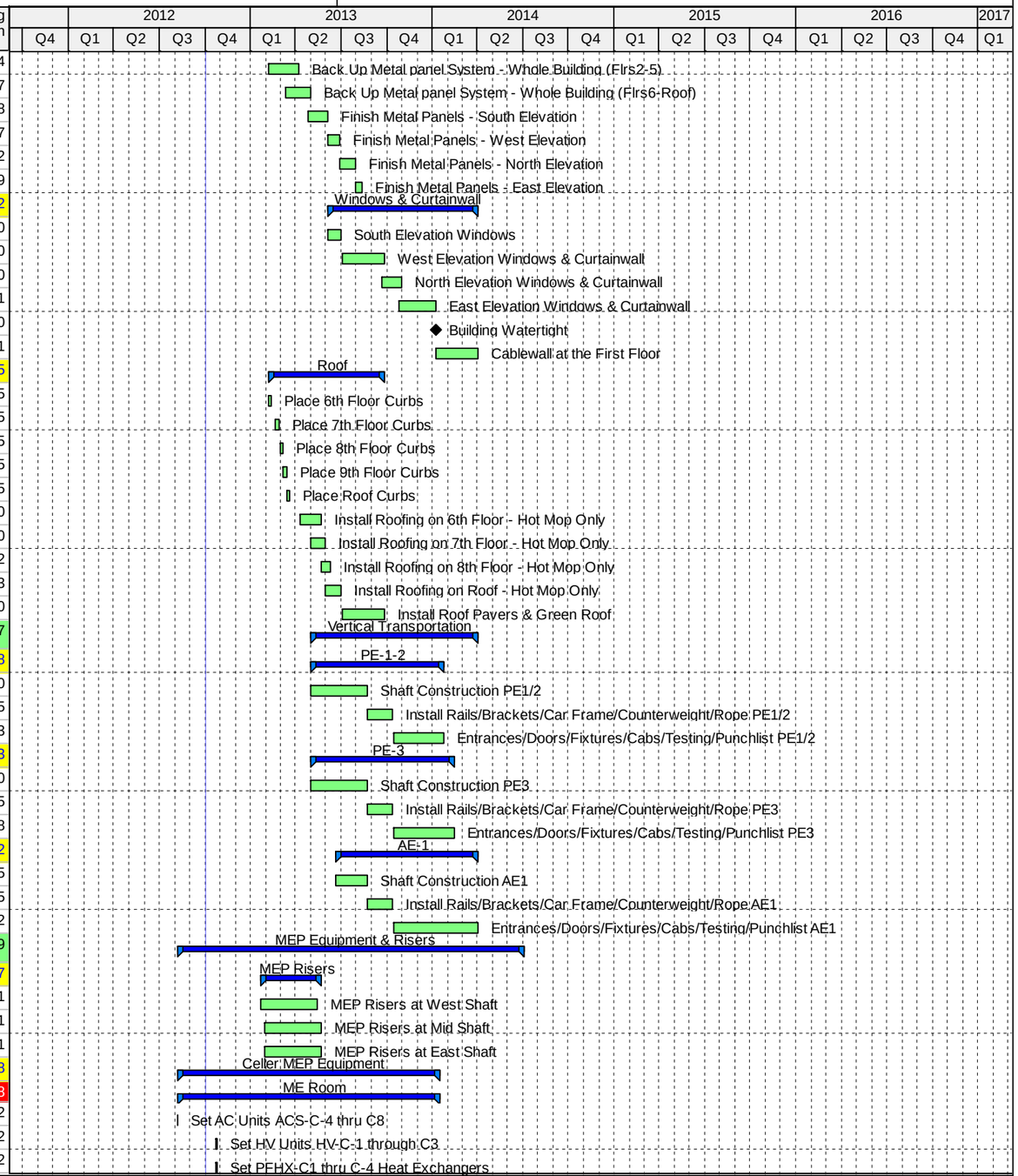
TASK filter: All Activities

Metro Museum of American Art: Detailed Project Schedule

Classic Schedule Layout

03-Oct-12 19:30

Activity ID	Activity Name	Start	Finish	Original Duration	Remaining Duration
E2000	Back Up Metal panel System - Whole Building (Flrs2-5)	06-Feb-13*	08-Apr-13	44	44
E2010	Back Up Metal panel System - Whole Building (Flrs6-Roof)	11-Mar-13*	30-Apr-13	37	37
E2020	Finish Metal Panels - South Elevation	25-Apr-13*	04-Jun-13	28	28
E2030	Finish Metal Panels - West Elevation	05-Jun-13*	27-Jun-13	17	17
E2040	Finish Metal Panels - North Elevation	28-Jun-13*	30-Jul-13	22	22
E2050	Finish Metal Panels - East Elevation	31-Jul-13*	12-Aug-13	9	9
Windows & Curtainwall		05-Jun-13	02-Apr-14	212	212
E3000	South Elevation Windows	05-Jun-13*	02-Jul-13	20	20
E3010	West Elevation Windows & Curtainwall	03-Jul-13*	26-Sep-13	60	60
E3020	North Elevation Windows & Curtainwall	20-Sep-13*	31-Oct-13	30	30
E3030	East Elevation Windows & Curtainwall	25-Oct-13*	07-Jan-14	51	51
E3035	Building Watertight		07-Jan-14	0	0
E3040	Cablewall at the First Floor	08-Jan-14*	02-Apr-14	61	61
Roof		05-Feb-13	26-Sep-13	165	165
E4000	Place 6th Floor Curbs	05-Feb-13*	11-Feb-13	5	5
E4010	Place 7th Floor Curbs	20-Feb-13*	26-Feb-13	5	5
E4020	Place 8th Floor Curbs	01-Mar-13*	07-Mar-13	5	5
E4030	Place 9th Floor Curbs	08-Mar-13*	14-Mar-13	5	5
E4040	Place Roof Curbs	15-Mar-13*	21-Mar-13	5	5
E4050	Install Roofing on 6th Floor - Hot Mop Only	11-Apr-13*	22-May-13	30	30
E4060	Install Roofing on 7th Floor - Hot Mop Only	02-May-13*	30-May-13	20	20
E4070	Install Roofing on 8th Floor - Hot Mop Only	23-May-13*	10-Jun-13	12	12
E4080	Install Roofing on Roof - Hot Mop Only	31-May-13*	02-Jul-13	23	23
E4090	Install Roof Pavers & Green Roof	03-Jul-13*	26-Sep-13	60	60
Vertical Transportation		01-May-13	03-Apr-14	237	237
PE-1-2		01-May-13	24-Jan-14	188	188
VT1000	Shaft Construction PE1/2	01-May-13*	22-Aug-13	80	80
VT1010	Install Rails/Brackets/Car Frame/Counterweight/Rope PE1/2	23-Aug-13*	11-Oct-13	35	35
VT1020	Entrances/Doors/Fixtures/Cabs/Testing/Punchlist PE1/2	14-Oct-13*	24-Jan-14	73	73
PE-3		01-May-13	14-Feb-14	203	203
VT2000	Shaft Construction PE3	01-May-13*	22-Aug-13	80	80
VT2010	Install Rails/Brackets/Car Frame/Counterweight/Rope PE3	23-Aug-13*	11-Oct-13	35	35
VT2020	Entrances/Doors/Fixtures/Cabs/Testing/Punchlist PE3	14-Oct-13*	14-Feb-14	88	88
AE-1		20-Jun-13	03-Apr-14	202	202
VT3000	Shaft Construction AE1	20-Jun-13*	22-Aug-13	45	45
VT3010	Install Rails/Brackets/Car Frame/Counterweight/Rope AE1	23-Aug-13*	11-Oct-13	35	35
VT3020	Entrances/Doors/Fixtures/Cabs/Testing/Punchlist AE1	14-Oct-13*	03-Apr-14	122	122
MEP Equipment & Risers		07-Aug-12	03-Jul-14	489	489
MEP Risers		21-Jan-13	21-May-13	87	87
R1000	MEP Risers at West Shaft	21-Jan-13*	13-May-13	81	81
R1010	MEP Risers at Mid Shaft	29-Jan-13*	21-May-13	81	81
R1020	MEP Risers at East Shaft	29-Jan-13*	21-May-13	81	81
Celler MEP Equipment		07-Aug-12	15-Jan-14	368	368
ME Room		07-Aug-12	15-Jan-14	368	368
MEP1000	Set AC Units ACS-C-4 thru C8	07-Aug-12	08-Aug-12	2	2
MEP1010	Set HV Units HV-C-1 through C3	23-Oct-12*	24-Oct-12	2	2
MEP1020	Set PFHX-C1 thru C-4 Heat Exchangers	23-Oct-12*	24-Oct-12	2	2



Actual Work | Critical Remaining Work | Summary

Remaining Work | Milestone

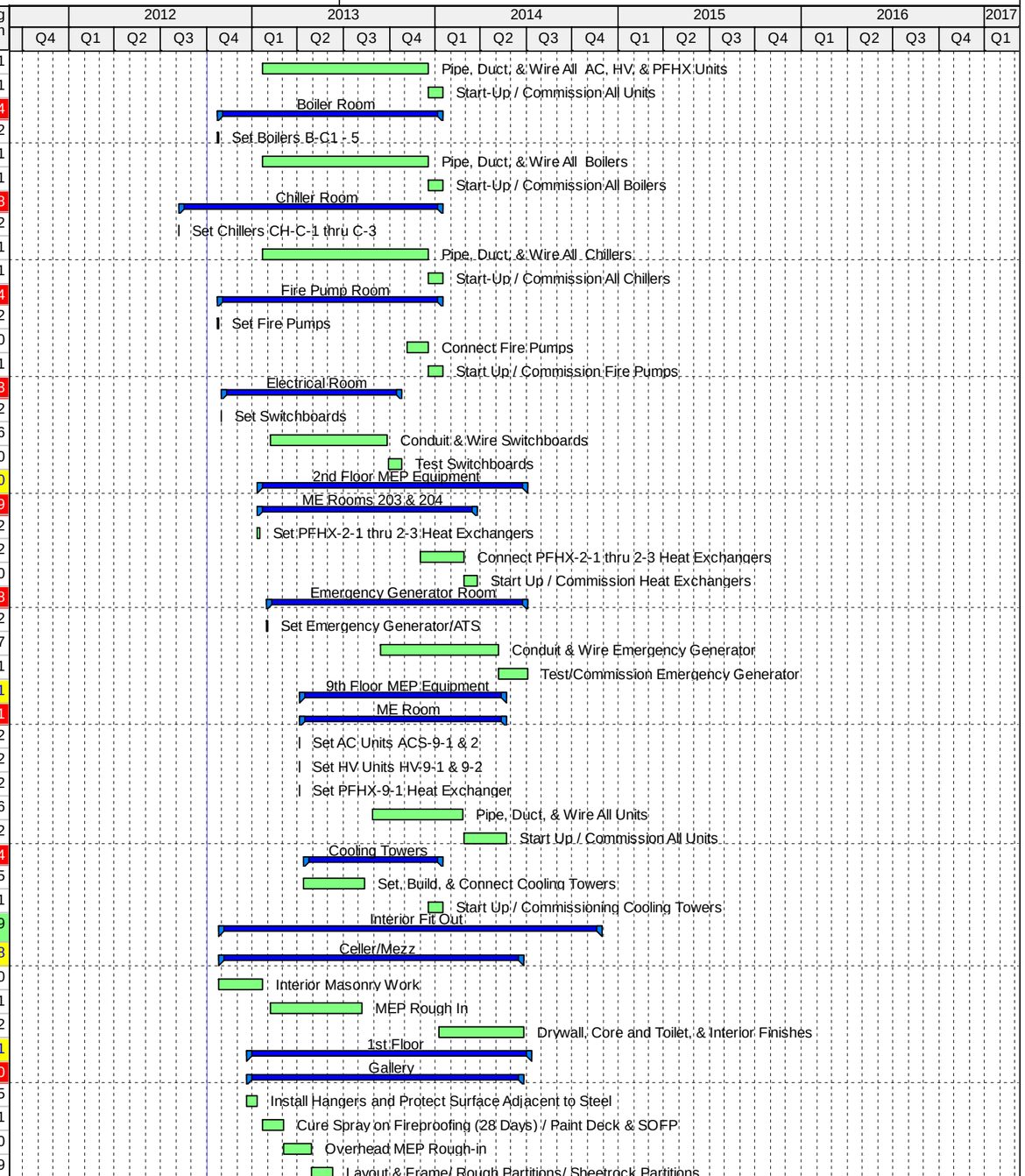
TASK filter: All Activities

Metro Museum of American Art: Detailed Project Schedule

Classic Schedule Layout

03-Oct-12 19:30

Activity ID	Activity Name	Start	Finish	Original Duration	Remaining Duration
MEP1030	Pipe, Duct, & Wire All AC, HV, & PFHX Units	22-Jan-13*	16-Dec-13	231	231
MEP1040	Start-Up / Commission All Units	17-Dec-13*	15-Jan-14	21	21
Boiler Room		23-Oct-12	15-Jan-14	314	314
MEP2000	Set Boilers B-C1 - 5	23-Oct-12*	24-Oct-12	2	2
MEP2010	Pipe, Duct, & Wire All Boilers	22-Jan-13*	16-Dec-13	231	231
MEP2020	Start-Up / Commission All Boilers	17-Dec-13*	15-Jan-14	21	21
Chiller Room		07-Aug-12	15-Jan-14	368	368
MEP3000	Set Chillers CH-C-1 thru C-3	07-Aug-12	08-Aug-12	2	2
MEP3010	Pipe, Duct, & Wire All Chillers	22-Jan-13*	16-Dec-13	231	231
MEP3020	Start-Up / Commission All Chillers	17-Dec-13*	15-Jan-14	21	21
Fire Pump Room		23-Oct-12	15-Jan-14	314	314
MEP4000	Set Fire Pumps	23-Oct-12*	24-Oct-12	2	2
MEP4010	Connect Fire Pumps	04-Nov-13*	16-Dec-13	30	30
MEP4020	Start Up / Commission Fire Pumps	17-Dec-13*	15-Jan-14	21	21
Electrical Room		30-Oct-12	25-Oct-13	253	253
MEP5000	Set Switchboards	30-Oct-12*	31-Oct-12	2	2
MEP5010	Conduit & Wire Switchboards	05-Feb-13*	27-Sep-13	166	166
MEP5020	Test Switchboards	30-Sep-13*	25-Oct-13	20	20
2nd Floor MEP Equipment		11-Jan-13	03-Jul-14	380	380
ME Rooms 203 & 204		11-Jan-13	26-Mar-14	309	309
MEP6000	Set PFHX-2-1 thru 2-3 Heat Exchangers	11-Jan-13*	14-Jan-13	2	2
MEP6010	Connect PFHX-2-1 thru 2-3 Heat Exchangers	02-Dec-13*	26-Feb-14	62	62
MEP6020	Start Up / Commission Heat Exchangers	27-Feb-14*	26-Mar-14	20	20
Emergency Generator Room		29-Jan-13	03-Jul-14	368	368
MEP7000	Set Emergency Generator/ATS	29-Jan-13*	30-Jan-13	2	2
MEP7010	Conduit & Wire Emergency Generator	13-Sep-13*	07-May-14	167	167
MEP7020	Test/Commission Emergency Generator	08-May-14*	03-Jul-14	41	41
9th Floor MEP Equipment		04-Apr-13	22-May-14	291	291
ME Room		04-Apr-13	22-May-14	291	291
MEP8000	Set AC Units ACS-9-1 & 2	04-Apr-13*	05-Apr-13	2	2
MEP8010	Set HV Units HV-9-1 & 9-2	04-Apr-13*	05-Apr-13	2	2
MEP8020	Set PFHX-9-1 Heat Exchanger	04-Apr-13*	05-Apr-13	2	2
MEP8030	Pipe, Duct, & Wire All Units	29-Aug-13*	25-Feb-14	126	126
MEP8040	Start Up / Commission All Units	26-Feb-14*	22-May-14	62	62
Cooling Towers		12-Apr-13	15-Jan-14	194	194
MEP9000	Set, Build, & Connect Cooling Towers	12-Apr-13*	12-Aug-13	85	85
MEP9010	Start Up / Commissioning Cooling Towers	17-Dec-13*	15-Jan-14	21	21
Interior Fit Out		25-Oct-12	28-Nov-14	539	539
Celler/Mezz		25-Oct-12	26-Jun-14	428	428
IFO00	Interior Masonry Work	25-Oct-12*	21-Jan-13	60	60
IFO10	MEP Rough In	05-Feb-13*	08-Aug-13	131	131
IFO20	Drywall, Core and Toilet, & Interior Finishes	08-Jan-14*	26-Jun-14	122	122
1st Floor		19-Dec-12	11-Jul-14	401	401
Gallery		19-Dec-12	26-Jun-14	390	390
IFO-1000	Install Hangers and Protect Surface Adjacent to Steel	19-Dec-12*	10-Jan-13	15	15
IFO-1010	Cure Spray on Fireproofing (28 Days) / Paint Deck & SOFP	21-Jan-13*	04-Mar-13	31	31
IFO-1020	Overhead MEP Rough-in	05-Mar-13*	29-Apr-13	40	40
IFO-1030	Layout & Frame/ Rough Partitions/ Sheetrock Partitions	30-Apr-13*	10-Jun-13	29	29



Actual Work | Critical Remaining Work | Summary

Remaining Work | Milestone

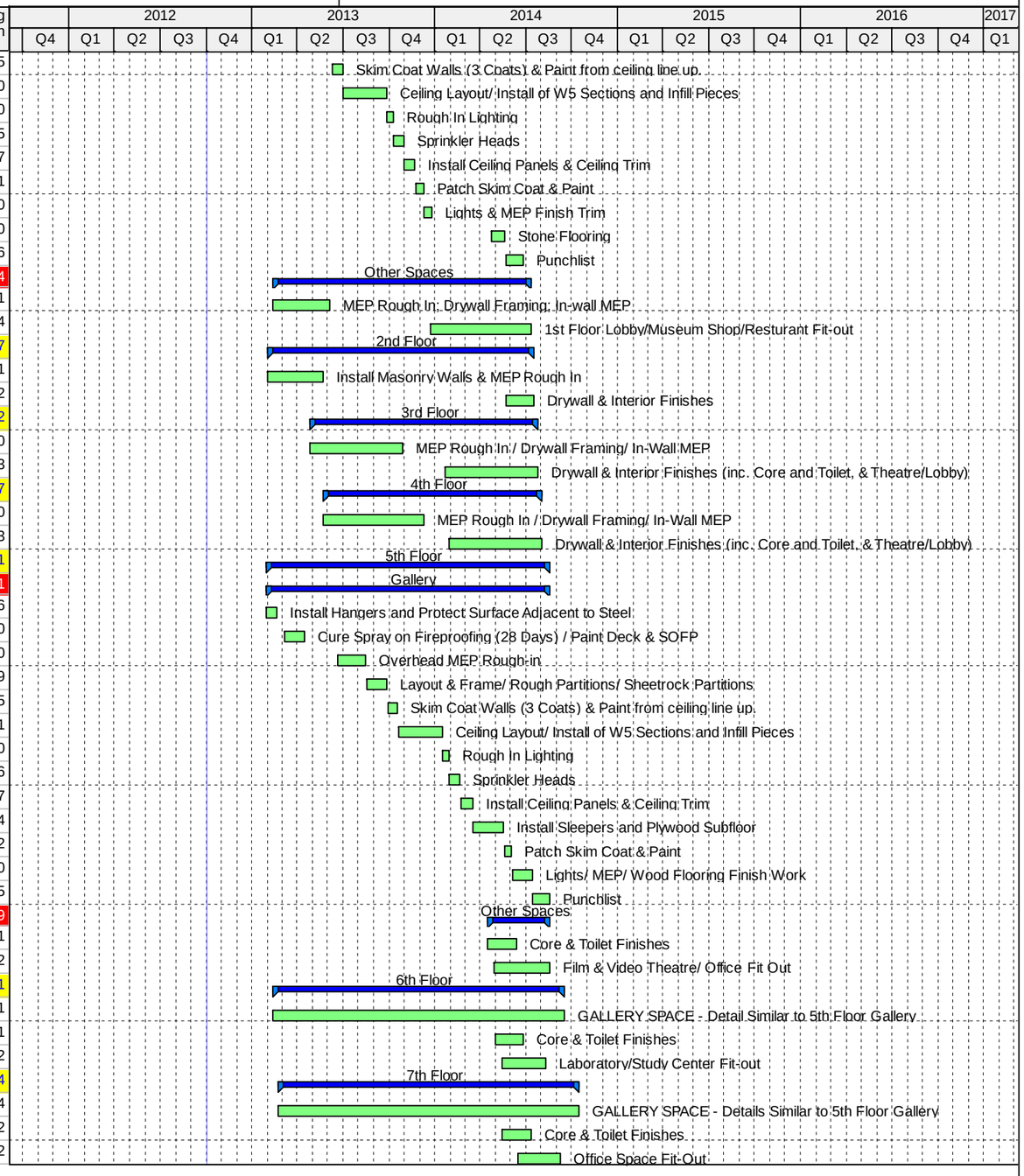
TASK filter: All Activities

Metro Museum of American Art: Detailed Project Schedule

Classic Schedule Layout

03-Oct-12 19:30

Activity ID	Activity Name	Start	Finish	Original Duration	Remaining Duration
IFO-1040	Skim Coat Walls (3 Coats) & Paint from ceiling line up.	11-Jun-13*	01-Jul-13	15	15
IFO-1050	Ceiling Layout/ Install of W5 Sections and Infill Pieces	02-Jul-13*	25-Sep-13	60	60
IFO-1060	Rough In Lighting	26-Sep-13*	09-Oct-13	10	10
IFO-1070	Sprinkler Heads	10-Oct-13*	30-Oct-13	15	15
IFO-1080	Install Ceiling Panels & Ceiling Trim	31-Oct-13*	22-Nov-13	17	17
IFO-1090	Patch Skim Coat & Paint	25-Nov-13*	10-Dec-13	11	11
IFO-1100	Lights & MEP Finish Trim	11-Dec-13*	24-Dec-13	10	10
IFO-1110	Stone Flooring	24-Apr-14*	21-May-14	20	20
IFO-1120	Punchlist	22-May-14*	26-Jun-14	26	26
Other Spaces		12-Feb-13	11-Jul-14	364	364
IFO-A-100	MEP Rough In; Drywall Framing; In-wall MEP	12-Feb-13*	05-Jun-13	81	81
IFO-A-101	1st Floor Lobby/Museum Shop/Resturant Fit-out	23-Dec-13*	11-Jul-14	144	144
2nd Floor		31-Jan-13	18-Jul-14	377	377
IFO2000	Install Masonry Walls & MEP Rough In	31-Jan-13*	23-May-13	81	81
IFO2010	Drywall & Interior Finishes	22-May-14*	18-Jul-14	42	42
3rd Floor		25-Apr-13	25-Jul-14	322	322
IFO3000	MEP Rough In / Drywall Framing/ In-Wall MEP	25-Apr-13*	28-Oct-13	130	130
IFO3010	Drywall & Interior Finishes (inc. Core and Toilet, & Theatre/Lobby)	22-Jan-14*	25-Jul-14	133	133
4th Floor		23-May-13	01-Aug-14	307	307
IFO4000	MEP Rough In / Drywall Framing/ In-Wall MEP	23-May-13*	10-Dec-13	140	140
IFO4010	Drywall & Interior Finishes (inc. Core and Toilet, & Theatre/Lobby)	29-Jan-14*	01-Aug-14	133	133
5th Floor		29-Jan-13	19-Aug-14	401	401
Gallery		29-Jan-13	19-Aug-14	401	401
IFO-5000	Install Hangers and Protect Surface Adjacent to Steel	29-Jan-13*	19-Feb-13	16	16
IFO-5010	Cure Spray on Fireproofing (28 Days) / Paint Deck & SOFP	06-Mar-13*	16-Apr-13	30	30
IFO-5020	Overhead MEP Rough-in	21-Jun-13*	16-Aug-13	40	40
IFO-5030	Layout & Frame/ Rough Partitions/ Sheetrock Partitions	19-Aug-13*	27-Sep-13	29	29
IFO-5040	Skim Coat Walls (3 Coats) & Paint from ceiling line up.	30-Sep-13*	18-Oct-13	15	15
IFO-5050	Ceiling Layout/ Install of W5 Sections and Infill Pieces	21-Oct-13*	15-Jan-14	61	61
IFO-5060	Rough In Lighting	16-Jan-14*	29-Jan-14	10	10
IFO-5070	Sprinkler Heads	30-Jan-14*	20-Feb-14	16	16
IFO-5080	Install Ceiling Panels & Ceiling Trim	21-Feb-14*	17-Mar-14	17	17
IFO-5090	Install Sleepers and Plywood Subfloor	18-Mar-14*	16-May-14	44	44
IFO-5100	Patch Skim Coat & Paint	19-May-14*	03-Jun-14	12	12
IFO-5110	Lights/ MEP/ Wood Flooring Finish Work	04-Jun-14*	15-Jul-14	30	30
IFO-5120	Punchlist	16-Jul-14*	19-Aug-14	25	25
Other Spaces		17-Apr-14	19-Aug-14	89	89
IFO-A501	Core & Toilet Finishes	17-Apr-14*	12-Jun-14	41	41
IFO-A502	Film & Video Theatre/ Office Fit Out	28-Apr-14*	19-Aug-14	82	82
6th Floor		12-Feb-13	16-Sep-14	411	411
IFO6000	GALLERY SPACE - Detail Similar to 5th Floor Gallery	12-Feb-13*	16-Sep-14	411	411
IFO6010	Core & Toilet Finishes	01-May-14*	26-Jun-14	41	41
IFO6020	Laboratory/Study Center Fit-out	16-May-14*	11-Aug-14	62	62
7th Floor		21-Feb-13	14-Oct-14	424	424
IFO7000	GALLERY SPACE - Details Similar to 5th Floor Gallery	21-Feb-13*	14-Oct-14	424	424
IFO7010	Core & Toilet Finishes	15-May-14*	11-Jul-14	42	42
IFO7020	Office Space Fit-Out	16-Jun-14*	09-Sep-14	62	62



Actual Work | Critical Remaining Work | Summary

Remaining Work | Milestone

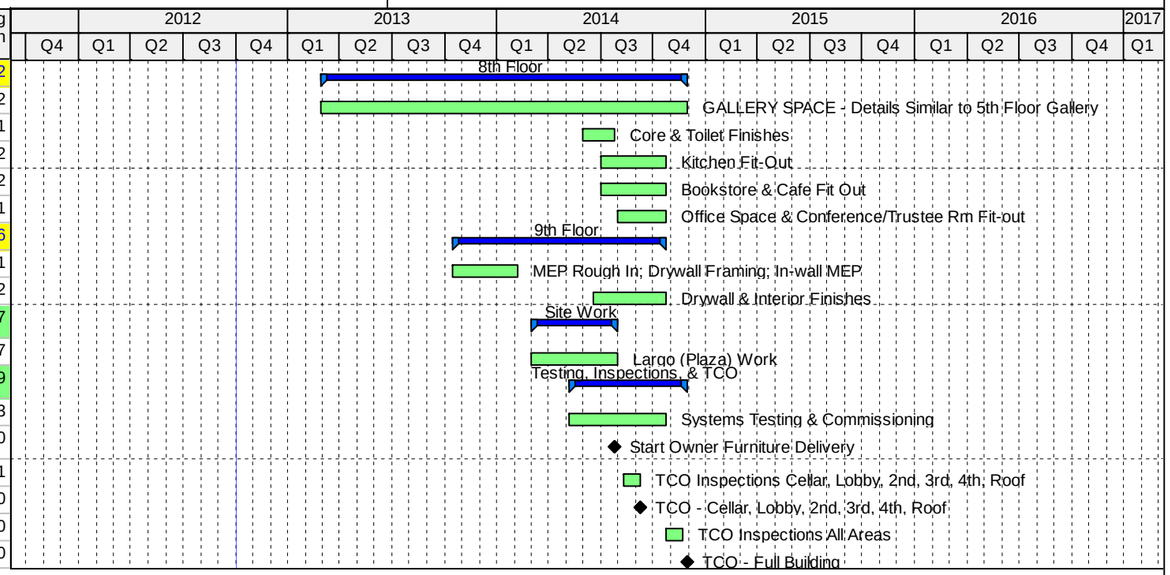
TASK filter: All Activities

Metro Museum of American Art: Detailed Project Schedule

Classic Schedule Layout

03-Oct-12 19:30

Activity ID	Activity Name	Start	Finish	Original Duration	Remaining Duration
8th Floor		28-Feb-13	28-Nov-14	452	452
IFO8000	GALLERY SPACE - Details Similar to 5th Floor Gallery	28-Feb-13*	28-Nov-14	452	452
IFO8010	Core & Toilet Finishes	30-May-14*	25-Jul-14	41	41
IFO8020	Kitchen Fit-Out	02-Jul-14*	23-Oct-14	82	82
IFO8030	Bookstore & Cafe Fit Out	02-Jul-14*	23-Oct-14	82	82
IFO8040	Office Space & Conference/Trustee Rm Fit-out	31-Jul-14*	23-Oct-14	61	61
9th Floor		15-Oct-13	23-Oct-14	266	266
IFO9000	MEP Rough In; Drywall Framing; In-wall MEP	15-Oct-13*	06-Feb-14	81	81
IFO9010	Drywall & Interior Finishes	18-Jun-14*	23-Oct-14	92	92
Site Work		03-Mar-14	29-Jul-14	107	107
SW1000	Largo (Plaza) Work	03-Mar-14*	29-Jul-14	107	107
Testing, Inspections, & TCO		06-May-14	28-Nov-14	149	149
TCO1000	Systems Testing & Commissioning	06-May-14*	23-Oct-14	123	123
TCO1010	Start Owner Furniture Delivery	25-Jul-14*		0	0
TCO1020	TCO Inspections Cellar, Lobby, 2nd, 3rd, 4th, Roof	11-Aug-14*	08-Sep-14	21	21
TCO1030	TCO - Cellar, Lobby, 2nd, 3rd, 4th, Roof		08-Sep-14	0	0
TCO1040	TCO Inspections All Areas	24-Oct-14*	20-Nov-14	20	20
TCO1050	TCO - Full Building		28-Nov-14	0	0



Actual Work
Remaining Work
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Summary

TASK filter: All Activities

APPENDIX B1

DETAILED STRUCTURAL STEEL TAKEOFF

METRO MUSEUM OF AMERICAN ART

DETAILED STRUCTURAL STEEL & METAL DECKING TAKEOFF

3RD & 4TH FLOORS

Estimator: Vincent A. Rossi
Date: October 8 2012

STRUCTURAL STEEL

Shape/Description	Linear Weight (lb/ft)	Length (ft)	Quantity (EA)	Weight (lb)	Weight (Tons)
3rd Floor Framing					
W10x	26.00	16.00	1	416	0.208
W24x	76.00	18.00	1	1,368	0.684
W30x	90.00	19.00	1	1,710	0.855
W18x	40.00	21.00	1	840	0.420
W12x	45.00	22.00	1	990	0.495
W24x	55.00	24.00	1	1,320	0.660
W18x	65.00	25.00	1	1,625	0.813
W18x	35.00	28.00	1	980	0.490
W21x	50.00	30.00	1	1,500	0.750
W18x	35.00	32.00	1	1,120	0.560
W16x	26.00	21.00	2	1,092	0.546
W12x	22.00	14.00	1	308	0.154
W12x	22.00	19.50	1	429	0.215
W18x	50.00	30.50	4	6,100	3.050
W36x	231.00	30.50	1	7,046	3.523
W24x	55.00	39.50	1	2,173	1.086
W30x	108.00	39.50	1	4,266	2.133
W30x	116.00	39.50	1	4,582	2.291
W14x	22.00	8.75	2	385	0.193
W18x	50.00	16.00	1	800	0.400
W18x	35.00	30.00	1	1,050	0.525
W18x	50.00	30.00	18	27,000	13.500
W18x	50.00	23.50	1	1,175	0.588
W24x	55.00	30.00	1	1,650	0.825
W16x	36.00	30.00	1	1,080	0.540
W18x	40.00	30.00	1	1,200	0.600
W30x	108.00	30.00	1	3,240	1.620
W30x	99.00	30.00	1	2,970	1.485
W18x	40.00	30.00	1	1,200	0.600
HSS18x6x1/2	76.07	14.33	2	2,180	1.090
W14x	30.00	14.33	1	430	0.215
W10x	15.00	14.33	1	215	0.107
W12x	22.00	14.33	3	946	0.473
W12x	26.00	14.33	1	373	0.186

HSS12x10x1/2	69.27	14.33	4	3,971	1.985
W12x	19.00	14.33	5	1,361	0.681
HSS12x8x1/2	62.46	14.33	1	895	0.448
HSS12x4x1/2	48.85	14.33	1	700	0.350
HSS14x4x1/2	55.66	14.33	1	798	0.399
W10x	15.00	9.00	2	270	0.135
HSS20x4x1/2	76.07	11.00	2	1,674	0.837
W10x	15.00	3.00	3	135	0.068
W10x	15.00	16.00	1	240	0.120
W10x	15.00	13.00	7	1,365	0.683
W14x	22.00	13.00	1	286	0.143
W14x	34.00	13.00	1	442	0.221
W16x	26.00	19.50	1	507	0.254
W10x	15.00	7.00	2	210	0.105
W24x	68.00	41.00	3	8,364	4.182
W16x	36.00	22.50	2	1,620	0.810
W16x	50.00	29.00	5	7,250	3.625
W16x	36.00	29.00	1	1,044	0.522
W14x	22.00	15.50	1	341	0.171
W10x	15.00	5.00	1	75	0.038
W16x	26.00	20.50	1	533	0.267
W16x	67.00	20.00	3	4,020	2.010
W10x	22.00	11.50	1	253	0.127
HSS12x6x1/2	55.66	26.50	1	1,475	0.737
W12x	19.00	9.00	3	513	0.257
W12x	19.00	11.50	1	219	0.109
W10x	15.00	10.00	1	150	0.075
W16x	40.00	20.00	1	800	0.400
W12x	19.00	10.00	1	190	0.095
W12x	19.00	20.00	1	380	0.190
W14x	22.00	20.00	1	440	0.220
W10x	15.00	8.50	1	128	0.064
W16x	40.00	20.00	4	3,200	1.600
W14x	30.00	20.00	1	600	0.300
W21x	55.00	24.00	1	1,320	0.660
W14x	34.00	15.50	1	527	0.264
W24x	62.00	20.00	1	1,240	0.620
W16x	36.00	20.00	2	1,440	0.720
W21x	44.00	20.00	1	880	0.440
W24x	55.00	17.75	1	976	0.488
W10x	15.00	7.50	2	225	0.113
HSS18x6x1/2	76.07	32.00	1	2,434	1.217
HSS12x4x3/8	37.69	17.00	1	641	0.320
HSS18x6x5/8	93.34	13.00	2	2,427	1.213
HSS18x6x5/8	93.34	19.00	2	3,547	1.773
W27x	84.00	20.00	1	1,680	0.840
W16x	45.00	15.00	1	675	0.338

W14x	26.00	7.50	1	195	0.098
W16x	36.00	17.75	1	639	0.320
W16x	36.00	20.00	6	4,320	2.160
W12x	22.00	11.50	1	253	0.127
W16x	50.00	20.00	1	1,000	0.500
W18x	50.00	30.00	1	1,500	0.750
W16x	36.00	10.00	1	360	0.180
W16x	50.00	15.50	1	775	0.388
W30x	116.00	49.00	1	5,684	2.842
W21x	55.00	27.00	1	1,485	0.743
W30x	90.00	16.67	1	1,500	0.750
W24x	76.00	20.00	3	4,560	2.280
W18x	55.00	20.00	2	2,200	1.100
W18x	86.00	20.00	1	1,720	0.860
W8x	15.00	10.00	2	300	0.150
W24x	55.00	11.33	1	623	0.312
W27x	84.00	11.33	1	952	0.476
W36x	160.00	20.00	1	3,200	1.600
W24x	55.00	11.00	1	605	0.303
W24x	68.00	11.00	1	748	0.374
W16x	36.00	6.00	1	216	0.108
W21x	50.00	11.00	1	550	0.275
W21x	44.00	8.00	1	352	0.176
W8x	48.00	10.00	1	480	0.240
W12x	19.00	10.00	6	1,140	0.570
W16x	31.00	10.00	1	310	0.155
W10x	15.00	8.00	1	120	0.060
W16x	31.00	20.00	4	2,480	1.240
W14x	22.00	10.00	2	440	0.220
W18x	60.00	20.00	4	4,800	2.400
W10x	15.00	10.00	2	300	0.150
W27x	84.00	20.00	1	1,680	0.840
HSS6x4x1/2	28.43	13.00	4	1,478	0.739
HSS6x4x1/2	28.43	8.50	2	483	0.242
L3x3x3/8	7.20	7.00	8	403	0.202
L5x5x3/8	12.30	15.00	2	369	0.185
L5x5x3/8	12.30	12.00	8	1,181	0.590
L5x5x3/8	12.30	10.00	1	123	0.062
Subtotal: 3rd Floor Framing			**221**	**195,741**	**97.87**
4th Floor Framing					
W30x	99.00	46.00	1	4,554	2.277
W44x	335.00	47.00	1	15,745	7.873
W24x	84.00	48.00	1	4,032	2.016

W16x	36.00	30.00	20	21,600	10.800
W27x	84.00	22.00	1	1,848	0.924
W14x	22.00	23.50	1	517	0.259
W14x	26.00	25.00	1	650	0.325
W16x	31.00	29.00	2	1,798	0.899
W16x	36.00	32.00	1	1,152	0.576
W12x	19.00	14.00	1	266	0.133
W12x	19.00	19.50	3	1,112	0.556
W12x	19.00	21.00	4	1,596	0.798
W12x	19.00	10.00	1	190	0.095
W16x	36.00	7.00	1	252	0.126
W14x	22.00	7.00	1	154	0.077
W16x	36.00	26.00	1	936	0.468
W24x	62.00	28.00	1	1,736	0.868
W21x	44.00	30.00	1	1,320	0.660
W18x	35.00	30.00	1	1,050	0.525
W16x	40.00	30.00	1	1,200	0.600
HSS18x6x1/2	76.07	14.33	1	1,090	0.545
W12x	26.00	14.33	1	373	0.186
W10x	15.00	14.33	1	215	0.107
W12x	19.00	14.33	6	1,634	0.817
W12x	22.00	14.33	3	946	0.473
W12x	26.00	14.33	1	373	0.186
HSS12x10x1/2	69.27	14.33	4	3,971	1.985
HSS12x8x1/2	62.46	14.33	1	895	0.448
HSS12x6x1/2	55.66	14.33	1	798	0.399
HSS12x4x1/2	48.85	12.00	2	1,172	0.586
W16x	36.00	14.33	1	516	0.258
W10x	15.00	8.50	2	255	0.128
W10x	15.00	3.00	2	90	0.045
HSS14x4x1/2	55.66	14.33	1	798	0.399
W24x	55.00	48.00	1	2,640	1.320
W10x	15.00	17.00	1	255	0.128
W10x	15.00	13.00	7	1,365	0.683
W14x	34.00	13.00	1	442	0.221
W16x	50.00	21.00	1	1,050	0.525
W16x	50.00	28.50	6	8,550	4.275
W14x	22.00	15.50	1	341	0.171
W10x	15.00	9.00	1	135	0.068
W12x	19.00	5.00	1	95	0.048
W16x	36.00	22.00	2	1,584	0.792
W10x	15.00	6.50	2	195	0.098
W16x	26.00	18.50	1	481	0.241
W12x	19.00	12.00	1	228	0.114
W24x	55.00	41.00	3	6,765	3.383
HSS18x6x5/16	48.86	8.00	2	782	0.391
HSS18x6x1/2	76.07	26.00	1	1,978	0.989

W18x	88.00	39.00	1	3,432	1.716
W18x	97.00	20.00	1	1,940	0.970
W16x	31.00	20.00	9	5,580	2.790
W27x	84.00	20.00	1	1,680	0.840
W36x	135.00	20.00	1	2,700	1.350
W27x	84.00	20.00	1	1,680	0.840
W16x	26.00	20.00	3	1,560	0.780
W16x	26.00	14.00	1	364	0.182
W14x	22.00	10.00	2	440	0.220
W21x	44.00	10.00	2	880	0.440
W16x	36.00	10.00	2	720	0.360
W14x	34.00	15.50	1	527	0.264
W14x	34.00	10.00	2	680	0.340
W21x	48.00	30.00	1	1,440	0.720
W16x	36.00	20.00	2	1,440	0.720
W8x	18.00	10.00	2	360	0.180
W14x	34.00	20.00	1	680	0.340
W24x	55.00	16.50	1	908	0.454
W12x	19.00	10.00	1	190	0.095
W14x	22.00	9.00	1	198	0.099
W16x	31.00	15.50	1	481	0.240
W30x	99.00	20.00	1	1,980	0.990
W18x	40.00	13.00	1	520	0.260
HSS18x6x5/8	93.34	19.00	2	3,547	1.773
HSS18x6x5/8	93.34	13.00	1	1,213	0.607
W24x	55.00	18.00	1	990	0.495
W24x	55.00	20.00	1	1,100	0.550
W16x	36.00	20.00	4	2,880	1.440
W16x	26.00	30.00	1	780	0.390
W10x	15.00	8.00	2	240	0.120
W21x	55.00	24.50	1	1,348	0.674
W16x	40.00	20.00	4	3,200	1.600
W12x	19.00	20.00	1	380	0.190
W16x	31.00	20.00	1	620	0.310
W10x	15.00	8.00	1	120	0.060
W12x	19.00	10.00	1	190	0.095
W12x	19.00	11.50	1	219	0.109
W12x	19.00	9.00	2	342	0.171
W14x	22.00	9.00	1	198	0.099
W14x	22.00	20.00	1	440	0.220
W12x	19.00	20.00	1	380	0.190
W16x	40.00	20.00	3	2,400	1.200
W12x	26.00	11.50	1	299	0.150
HSS2x4x3/8	10.00	17.00	1	170	0.085
Subtotal: 4th Floor Framing			**175**	**153,151**	**76.58**

Columns 2nd to 3rd Flr.					
W14x	370.00	12.33	1	4,562	2.281
W14x	233.00	12.33	4	11,492	5.746
W14x	257.00	12.33	3	9,506	4.753
W14x	370.00	12.33	1	4,562	2.281
W14x	99.00	12.33	2	2,441	1.221
W14x	120.00	12.33	3	4,439	2.219
W14x	210.00	12.33	1	2,589	1.295
W14x	342.00	12.33	4	16,867	8.434
W14x	283.00	12.33	1	3,489	1.745
W14x	311.00	12.33	5	19,173	9.587
W12x	136.00	12.33	1	1,677	0.838
W14x	90.00	12.33	4	4,439	2.219
W12x	96.00	12.33	4	4,735	2.367
W12x	79.00	12.33	1	974	0.487
W14x	132.00	12.33	1	1,628	0.814
W14x	159.00	12.33	3	5,881	2.941
W14x	283.00	12.33	3	10,468	5.234
W14x	109.00	12.33	1	1,344	0.672
W12x	53.00	12.33	1	653	0.327
W14x	68.00	12.33	1	838	0.419
W12x	58.00	12.33	1	715	0.358
W14x	53.00	12.33	1	653	0.327
W14x	145.00	12.33	3	5,364	2.682
W12x	106.00	12.33	1	1,307	0.653
W12x	152.00	12.33	1	1,874	0.937
Subtotal: Columns 2nd to 3rd Flr			**52**	**121,672**	**60.84**
Columns 3rd to 4th Flr.					
W14x	90.00	14.17	7	8,925	4.463
W14x	109.00	14.17	7	10,809	5.405
W14x	193.00	14.17	1	2,734	1.367
W14x	283.00	14.17	5	20,046	10.023
W14x	176.00	14.17	1	2,493	1.247
W14x	233.00	14.17	4	13,204	6.602
W14x	120.00	14.17	5	8,500	4.250
W14x	311.00	14.17	4	17,624	8.812
W14x	176.00	14.17	1	2,493	1.247
W14x	68.00	14.17	3	2,890	1.445
W12x	96.00	14.17	7	9,520	4.760
W10x	68.00	14.17	2	1,927	0.963
W12x	72.00	14.17	1	1,020	0.510

W12x	58.00	14.17	1	822	0.411
W14x	74.00	14.17	1	1,048	0.524
W14x	82.00	14.17	1	1,162	0.581
W14x	159.00	14.17	3	6,758	3.379
W14x	211.00	14.17	4	11,957	5.978
W12x	65.00	14.17	1	921	0.460
W14x	132.00	14.17	2	3,740	1.870
W12x	40.00	14.17	1	567	0.283
W14x	48.00	14.17	1	680	0.340
W12x	45.00	14.17	1	638	0.319
W14x	53.00	14.17	2	1,502	0.751
W14x	68.00	14.17	1	963	0.482
W14x	145.00	14.17	2	4,108	2.054
W12x	65.00	14.17	1	921	0.460
W12x	152.00	14.17	1	2,153	1.077
W14x	233.00	14.17	1	3,301	1.650
W14x	61.00	14.17	2	1,728	0.864
Subtotal: Columns 3rd to 4th Flr			**74**	**145,155**	**72.58**
Braced Framing 3rd & 4th Floor					
W14x	283.00	30.50	1	8,632	4.316
W14x	283.00	8.67	1	2,454	1.227
W14x	233.00	19.50	1	4,544	2.272
W14x	233.00	20.67	1	4,816	2.408
W14x	211.00	19.50	1	4,115	2.057
W14x	211.00	20.67	1	4,361	2.181
W14x	311.00	25.00	3	23,325	11.663
W14x	257.00	19.50	2	10,023	5.012
W14x	176.00	20.67	2	7,276	3.638
W14x	257.00	24.00	1	6,168	3.084
W14x	132.00	12.50	2	3,300	1.650
W14x	211.00	19.00	1	4,009	2.005
W14x	132.00	20.67	2	5,457	2.728
W14x	211.00	25.00	1	5,275	2.638
W24x	192.00	6.50	1	1,248	0.624
W14x	193.00	15.00	1	2,895	1.448
W14x	132.00	6.50	1	858	0.429
W14x	132.00	20.67	1	2,728	1.364
W24x	192.00	20.67	1	3,969	1.984
W14x	193.00	25.00	1	4,825	2.413
W14x	190.00	20.67	1	3,927	1.964
W24x	68.00	14.25	2	1,938	0.969
W10x	49.00	20.00	2	1,960	0.980
W10x	88.00	14.00	1	1,232	0.616

W14x	90.00	14.00	1	1,260	0.630
W12x	79.00	19.00	1	1,501	0.751
W12x	120.00	19.00	1	2,280	1.140
W18x	55.00	14.00	1	770	0.385
W14x	74.00	14.00	1	1,036	0.518
W12x	65.00	20.00	2	2,600	1.300
W14x	109.00	19.50	2	4,251	2.126
W14x	109.00	22.00	2	4,796	2.398
W14x	90.00	25.00	2	4,500	2.250
HSS14x10x5/8	93.34	20.50	2	3,827	1.913
W14x	90.00	20.50	2	3,690	1.845
W14x	132.00	25.00	2	6,600	3.300
W18x	50.00	14.25	2	1,425	0.713
W8x	40.00	20.00	2	1,600	0.800
W18x	197.00	20.00	2	7,880	3.940
W30x	90.00	27.00	1	2,430	1.215
W30x	90.00	35.00	1	3,150	1.575
W14x	120.00	20.00	2	4,800	2.400
W14x	120.00	22.00	1	2,640	1.320
W10x	68.00	27.00	2	3,672	1.836
W10x	68.00	24.50	4	6,664	3.332
W18x	86.00	35.00	1	3,010	1.505
W18x	86.00	25.00	1	2,150	1.075
W18x	119.00	35.00	1	4,165	2.083
W18x	119.00	25.00	1	2,975	1.488
HSS14x12x1/2	82.00	25.00	1	2,050	1.025
HSS12x12x3/8	58.10	25.00	1	1,453	0.726
HSS10x10x3/8	47.90	25.00	1	1,198	0.599
W24x	146.00	24.50	1	3,577	1.789
W27x	102.00	24.50	1	2,499	1.250
W14x	132.00	28.00	2	7,392	3.696
W24x	84.00	19.50	1	1,638	0.819
W16x	89.00	19.50	1	1,736	0.868
W14x	132.00	24.00	2	6,336	3.168
W14x	74.00	20.00	2	2,960	1.480
W8x	40.00	24.00	1	960	0.480
HSS16x12x5/8	110.36	27.00	2	5,959	2.980
W12x	65.00	30.50	1	1,983	0.991
HSS12x8x1/2	62.46	15.25	2	1,905	0.953
W12x	65.00	20.50	1	1,333	0.666
HSS12x8x1/2	62.46	20.00	2	2,498	1.249
W12x	65.00	24.00	1	1,560	0.780
W21x	73.00	16.00	1	1,168	0.584
W18x	50.00	16.00	1	800	0.400
HSS10x10x1/4	32.63	20.50	1	669	0.334
W21x	73.00	20.00	1	1,460	0.730
W18x	50.00	20.00	1	1,000	0.500

HSS10x10x1/4	32.63	24.00	1	783	0.392
W14x	48.00	8.50	2	816	0.408
HSS10x10x1/4	32.63	16.50	1	538	0.269
W24x	104.00	18.00	1	1,872	0.936
W24x	68.00	18.00	1	1,224	0.612
HSS10x10x1/4	32.63	22.00	1	718	0.359
Subtotal: Braced Framing			**107**	**261,089**	**130.54**
			Quantity (EA)	**Weight (lb)**	**Weight (Tons)**
STRUCTURAL STEEL TOTALS:			**629**	**876,809**	**438.40**
			ADD 5% For Connections		**21.920**
			TOTAL (Tons)		**460.32**

METAL DECKING

Type/Description	Quantity (SQFT)
Metal Decking	
3" 18 Gage (6.25 Slab)	37,956
3" 18 Gage (9N Slab)	2,899
TOTAL	**40,855**

APPENDIX B2

DETAILED CONCRETE TAKEOFF

METRO MUSEUM OF AMERICAN ART

DETAILED CONCRETE SOD, REINFORCING, AND FORM TAKEOFF

3RD & 4TH FLOORS

Estimator: Vincent A. Rossi
Date: October 8 2012

Slab on Deck Legend

Type	Description
6.25	Indicates 3-1/4 lightweight concrete slab on 3"-18 gage composite metal deck. Reinforce with 6x6-W2.0xW2.0 WWF. Total slab thickness: 6-1/4".
9N	Indicates 6" normal weight concrete slab on 3"-18 gage composite metal deck. Reinforce with 4x4-W2.9xW2.9 WWF. Total slab thickness: 9"

CONCRETE SLAB

Type/Description	Square Feet of Slab on Deck	Thickness of Slab (ft)	Cubic Feet of Slab	Cubic Yards of Slab
3rd Floor Slab on Deck				
Type 6.25	18,097	0.396	7,163.4	265.3
Type 9N	2,899	0.625	1,811.9	67.1
4th Floor Slab on Deck				
Type 6.25	19,859	0.396	7,860.9	291.1
TOTALS				
Type 6.25	37,956	0.396	15,024.3	556.5
Type 9N	2,899	0.625	1,811.9	67.1
OVERALL	*40,855*		*16,836.1*	*623.6*

REINFORCING

Type/Description	Square Feet of WWF	WWF (CSF)		
3rd Floor WWF				
6x6-W2.0xW2.0	18,097	180.970		
4x4-W2.9xW2.9	2,899	28.990		
4th Floor Slab on Deck				
6x6-W2.0xW2.0	19,859	198.590		
TOTALS				
6x6-W2.0xW2.0	37,956	379.560		
4x4-W2.9xW2.9	2,899	28.990		

EDGE FORMS

Type/Description	LF	SFCA (6.25" Tall)		
Curb Forms				
Curb Forms: Perimeter	1,424	742		
Slab Opening Box Out	898	468		
TOTAL	2,322	1209		

APPENDIX B3

DETAILED STRUCTURAL SYSTEMS ESTIMATE CALCULATIONS/RECAP SHEET

METRO MUSEUM OF AMERICAN ART

RECAP SHEET: STRUCTURAL SYSTEM

3RD & 4TH FLOORS

Estimator: Vincent A. Rossi

Date: October 8 2012

Description	Unit	Quantity	Material Cost/Unit	Labor Cost/Unit	Equipment Cost/Unit	Material Cost ($)	Labor Cost ($)	Equipment Cost ($)	Total Cost ($)
CONCRETE									
Concrete Slab on Deck									
Concrete Material									
LW 5000psi (Type 6.25)	CY	556.50	136.25	0.00	0.00	$75,823.13	$0.00	$0.00	$75,823.13
NW 4000psi (Type 9N)	CY	67.10	103.00	0.00	0.00	$6,911.30	$0.00	$0.00	$6,911.30
Placement									
Elevated Slab 6-10" Thick Pumped (6.25 & 9N Combined)	CY	623.60	0.00	15.10	4.80	$0.00	$9,416.36	$2,993.28	$12,409.64
Finishing									
Bull Float, machine float & machine trowel	SF	40,855.00	0.00	0.56	0.03	$0.00	$22,878.80	$1,225.65	$24,104.45
WWF Reinforcing									
6x6-W2.0xW2.0	CSF	379.56	21.50	25.50	0.00	$8,160.54	$9,678.78	$0.00	$17,839.32
4x4-W2.9xW2.9	CSF	28.99	41.50	29.00	0.00	$1,203.09	$840.71	$0.00	$2,043.80
Edge Forms									
Perimeter Curb Forms & Slab Openings	SFCA	1,209.00	1.29	7.45	0.00	$1,559.61	$9,007.05	$0.00	$10,566.66
								Concrete Subtotal	$149,698.29
								Location Adjustment Factor	1.423
								Time Adjustment Factor	1.000
								CONCRETE TOTAL	**$213,020.67**
METALS									
Structural Steel Members									
For Buildings Sized 7-15 Stories	Ton	460.32	2,600.00	440.00	126.00	$1,196,832.00	$202,540.80	$58,000.32	$1,457,373.12
Metal Decking									
For Buildind Sized 7-15 Stories	SF	40,855.00	2.49	0.56	0.04	$101,728.95	$22,878.80	$1,634.20	$126,241.95
								Metals Subtotal	$1,583,615.07
								Location Adjustment Factor	1.296
								Time Adjustment Factor	1.000
								CONCRETE TOTAL	**$2,052,365.13**
							SYSTEM TOTAL:		**$2,265,385.80**

APPENDIX C

LEVEL 1 PROCESS MAP

Developed with the BIM Project Execution Planning Procedure by the Penn State CIC Research Team.
http://www.engr/psu.edu/ae/cic/bimex

METRO MUSEUM OF AMERICAN ART
LEVEL 1 PROCESS DIAGRAM

VINCENT A ROSSI

October, 10th 2012