THE PENNSYLVANIA STATE UNIVERSITY –
DEPARTMENT OF ARCHITECTURAL ENGINEERING

AE Fifth Year Senior Thesis

Technical Report # 2:
Cost & Methods Analysis

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The Carl J. & Ruth Shapiro Cardiovascular Center at the Brigham & Women's Hospital in Boston MA

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Executive Summary

During this Technical Assignment, the goal was to become more acclimated with the details of the project; in essence to become engrossed in all the specifics of the project, notably regarding the schedule and estimation of key components of the construction. The most difficult part of this assignment was finding an appropriate estimation tool to apply to this unique building. Alas, many of the tools employed (RS Means, MC^2) to find estimates for the Detailed Structural System were not helpful in getting an accurate estimate. Therefore, minimizing the total amount of types of shapes in the estimate and creating a lot of typical bays for construction were implemented, causing a large difference between the estimated figures and actual figures.

The assemblies estimate created the most enjoyable part of the project, allowing for the exploration of escalators and elevators in a hospital; truly the latter have been employed in hospitals before, but the former lends some imagination. But the results of the Assemblies Estimate followed rather closely the actual costs for those components of the project.

When referring to detail, and specifics, the two proponents of Tech 2 to incorporate this theme were the Detailed Project Schedule and the Site Layout Plan. The schedule is different from the first technical assignment in that it gives many more activities and shows certain sequencing decisions as well as some of the phases of the project that were not shown before. The Site layout again refers to a specific phase on the project; in this case the superstructure phase of the project. With the attention to detail during the planning of the site, a construction project can flow safely and smoothly while accomplishing the tasks laid out in the schedule on time and this enables the owner to receive their project on time.

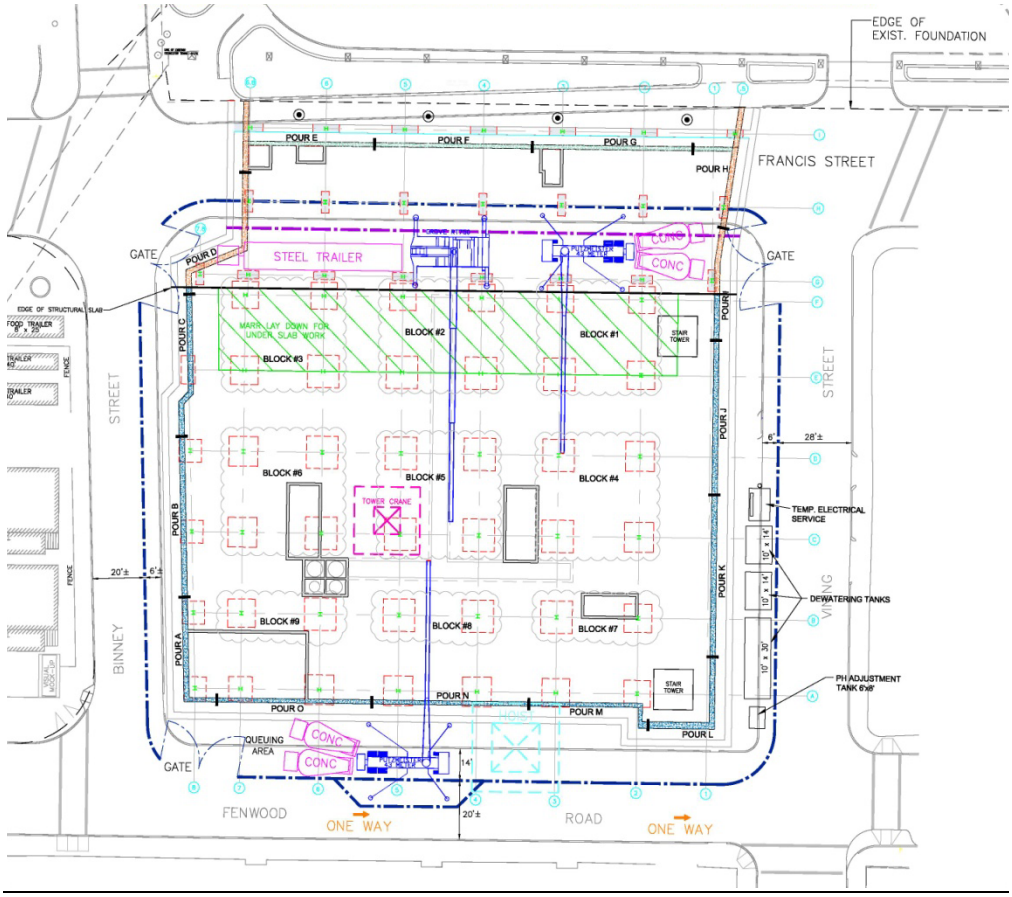
Detailed Project Schedule

The Technical Assignment #1 schedule incorporated mostly milestone dates in a summary format, keeping the schedule to about 50 activities at most. For this, the second Technical Assignment, a more thorough investigation of the schedule was necessary (Refer to Appendix A). More activities, specifically related to the different trades on the project, were illustrated in this schedule. Clearly, major milestones in the beginning and at the end of the project were maintained, but activities such as the steel erection and concrete pours, even earlier activities such as preparation for the erection of the crane and man-material hoist, were developed further. Relevant sequencing decisions and the recipe for the construction process can be seen a lot more clearly in this detailed schedule.

Notice in particular that before many of the construction even began, the activities of "planning" occurred, illustrating the necessity for careful attention to detail by the workers and the project management team. Another important attribute to this schedule is the steps that each process goes through. When looking at the Core & Shell Concrete work, the items which need to be completed first are shown in a logical manner; i.e. the formwork being constructed before concrete flatwork and before the pouring of concrete.

Finally, looking through the second page of the schedule, and the later activities, the phasing is clearly illustrated when examining the Fitout packages established by the project team. Due to the multitude of activities contained in each Fitout package, they were kept concise, but the fact that there are multiple packages for the Fitout activities shows the thought process and attention to detail when sequencing these activities.

Site Layout Planning



This is an image of the superstructure construction phase. The image illustrates the pouring of the concrete footings and other foundation elements to the project. A more detailed CAD image was to accompany this, but due to technical difficulties, it was not able to be transferred into this document. Notice however, the placement of the concrete trucks. This is important to note because the site was extremely congested, being surrounded on all sides by trafficked roads. Francis Street, on the top of the image, is a highly travelled road, leading directly to the Brigham & Women's main hospital. The sequencing of having these pumps on site and coordinating the delivery of concrete was extremely critical in staying on schedule and maintaining a high level of quality because the footings and foundations support the entire structure. The other important aspects of this phase regarded the continued occupancy of the sublevels in the existing hospital and how crucial it was to maintain a fairly quiet but also clean atmosphere nearby, and on a more technical level the care to maintain Francis Street during the construction. The street needed to be reinforced from underneath and also at the points where the existing hospital joined the new hospital below grade. Coordinating the structural integrity of these issues was vastly important, and with Site Layout planning, the process was made easier to manage and better for the overall quality of the project.

Assemblies Estimate

One of the more unique attributes of the Carl J. & Ruth Shapiro Cardiovascular Center is the multi-level lobby area adorning the east side of the building. Just by examining the drawings and renderings of the project, the feel from those first few levels does not illustrate a healthcare facility. The most interesting way that people move to the upper levels of the lobby and the building itself is via the three escalators on that east side of the Center. Adorned with a transparent glass balustrade, these means of ascension and decent in the building present a method of transportation commonly seen in airports and malls but rarely in a healthcare facility. Therefore I chose to use them as my system to analyze for the Assemblies Estimate.

RS Means Assemblies Cost Data gave the assemblies estimates for specific types of escalators, predominantly distinguished by their balustrade adornment or by their stairs or tracks (the flat escalators). Also, the RS Means values were given for one escalator in one direction; the ones in the Carl J. & Ruth Shapiro Cardiovascular Center have an escalator that goes up and one going down. Thus, the calculations were carried out for 3 sets of 2 escalators each, and all of the other assumptions and results of the estimate are located in Appendix B. Another point of interest in terms of movement throughout the building were the elevators, and since the RS Means section for elevators was right next to the Escalators section, I decided to perform an Assemblies Estimate on the elevators as well. The findings of the estimate are also included in Appendix B.

Upon completion of the Assemblies estimate, it was clear that this way of estimating is quick and fairly accurate to the actual cost of the Elevators systems, with a difference of about $500,000. The cost for the Escalators was not known, but given the ability to find approximate values in RS Means through interpolation, the estimate should be fairly close to the actual cost of the Escalators for this project.

Detailed Structural Systems Estimate

Structural Steel

The Structure of this project consisted of several different materials: concrete for the footings and foundations, and steel for the structural beams and columns. Using RS Means as a preliminary guide, the Detailed Structural Systems Estimate can be found in Appendix B. Several assumptions were made in order to expedite the estimation, and also typical beam sizes and bays were accounted for as well, which possibly created a difference in the estimated values from the actual.

The total weight of Steel in tons, according to the detailed estimate, after factoring in all assumptions, was roughly 2,500 tons. With a cost per ton assumed to be about $3,000 per ton (this includes erection and fabrication, and was given by Cives, the steel fabricator and supplier for the project), the estimated cost for the steel is $7, 302, 500. According to the original estimate, this number fell close to the number listed in the original budget from the CM.

Upon further discussion with Cives, the actual cost was much higher than that of my estimate. This is due to the general assumptions and typical bays and shapes used in the detailed estimate using RS Means. The actual values for the structural steel are as follows:

Total Steel weight = 3,650 tons

Total Column weight = 1,725 tons (521 pieces)

Total bracing weight = 204 tons (216 pieces)

Total Moment Frame weight = 820 tons (852 pieces)

Total Beam weight = 1,150 tons (2,945 beams)

Bridge connecting 2 buildings total weight = 18 tons (66 pieces)

Overall, 2 valuable lessons were learned through the discussion with Cives: the cost of steel per ton is solely based on the shapes being fabricated. Large column members, though they weigh more, will generally cost less overall per ton. However, several smaller pieces, i.e. plates and small beams, will be a larger cost per ton because of the larger quantity being fabricated to equal the tonnage of a single column. For this project, the overall estimated cost of fabrication was $1,700 per ton and overall erection cost was $1,300 per ton. Applying these figures to the total weight from Cives, the actual cost for the structural steel was $3,000 per ton x 3,650 tons = $10,950,000.

Structural Concrete

The concrete estimate encompassed the takeoffs of all the foundation walls, footings, and the slabs (Slab on Grade and some deck slabs). Again in the interest of time, a typical shape was used for piers and a gross floor area estimate was used for the Slab on Grade and floor decking from levels 4-10. While examining the concrete areas of the Detailed estimate, notice that the total cubic yards of concrete was determined for many of the forms. The concrete was placed using a pump, however it was difficult to determine which field from RS Means to use in estimating a total cost per cubic yard.

General Conditions Estimate

The General Conditions refer to the section of a contract for a building project that does not directly pertain to the cost of the materials and labor to build the project. It does however include temporary utilities, costs for the project team such as salary and travel expenses, and also includes temporary facilities and equipment, such as the trailers for meetings on site and expenses for furnishing those, and also the fences and signs that inform people of the project site.

The General Conditions Estimate, included in Appendix D at the end of this report, incorporates the above referenced costs and also calls out many other project items that indirectly go along with the direct act of building the Carl J. & Ruth Shapiro Cardiovascular Center for Brigham & Women's Hospital in Boston Massachusetts. Along with the total costs, monthly costs have also been calculated by simply summing the subtotal for personnel and dividing it by either their amount of time on the project or by the total duration of the project, estimated at 34 months.

When examining the schedule of the project, savings can be associated with the less time for labor, so less man hours to be paid out. However, the General Condition's savings stem from several items: less usage of temporary utilities, less amount of project staff costs, less rental time of trailers, and many others. However, it can also go the negative direction, in the case where a project delay during steel erection could mean more rental time for the crane, longer usage of temporary utilities and trailers, but worst of all is the possibility that the project is delivered late and the CM must pay either liquidated damages for the delay or other penalties incurred by the late delivery. So having the GC estimates on a monthly cost and also illustrating the percentage of time each personnel member spends with the project allows a diligent Project Manager to accurately track cost savings/ losses in direct relation to schedule changes.

Appendix A – Detailed Project Schedule

Appendix D – General Conditions Estimate