I. Project Overview

The City Hospital is currently in the process of undergoing a huge expansion. The construction of the building, which is the focus of my research, is one of the many buildings affiliated with the hospital called the City Hospital. It is located in Southeast Pennsylvania. The Phase I of City Hospital currently exists only on the south side of the campus. This phase of the building will house research space, office space, and a central utility plant. Construction of this 266,000 square feet building began in March 2005 and will be completed in December 2007. The estimated cost of this 3.5-story facility is $156 million.

A. Project Team

The project team consists of:

Owner – City Hospital
Construction Manager – Turner Construction Company
Architect – Ballinger
Structural Engineer – LeMessurier Consultants
MEP Engineer – Bard Rao + Athanas
Civil Engineer – Pennoni Associates Inc

B. Client Information

The owner of this project is City Hospital. City Hospital has a team of professionals (user group) which include doctors, facility operators and advisors that direct and communicates the owner's requirements to the engineers responsible. City Hospital is one of the leading research facilities in the world. The research project is part of a second part master plan that will span across about eight acres of land located directly across from the Hospital's current clinical and research facilities. Once completed, City Hospital will house a state-of-the-art translational research facility, translating basic science research into real-life treatments and cures, which will include and underground parking. The project consists of an "L" shaped development that is being constructed in three phases. The owner will award separate contracts for each phase. The total facility development is estimated at $1 billion and could total more than one million square feet which is double the size of the main hospital when complete. The hospital received about $5 M in research support and $6 M overall for patient care services. The hospital plans to renovate another 165,000 square foot. This all signifies that business is good for City hospital.

C. Project Delivery Method

City Hospital is following the format of a construction management at risk system. As seen on the project organizational chart shown in Figure 5.1, the hospital holds a contract with both the architect and the construction manager. Ballinger was selected as the architect by the owner to design the project. The hospital holds a cost plus fee contract with Ballinger. Turner Construction Company (TCCO) was selected as the construction manager and holds a guaranteed maximum price contract with the hospital. Turner was selected based on their past performance with City Hospital through prior work and the working relationship that they have established.

TCCO holds a lump sum contract with each of the subcontractors shown on the organization chart. These subcontractors were selected on the criteria of experience, price and scope of bid. Ballinger does not hold a contract with TCCO, however there is a line of communication between these two companies throughout the term of the project in order to meet the needs of the owner.

Ballinger contracted Bard Rao + Athanas to handle all MEP engineering for the building. They also contracted LeMessurier Consultants to design the structural system for the facility and Pennoni Associates Inc. as civil engineers. All players on this particular project hold lines of communication with each other.

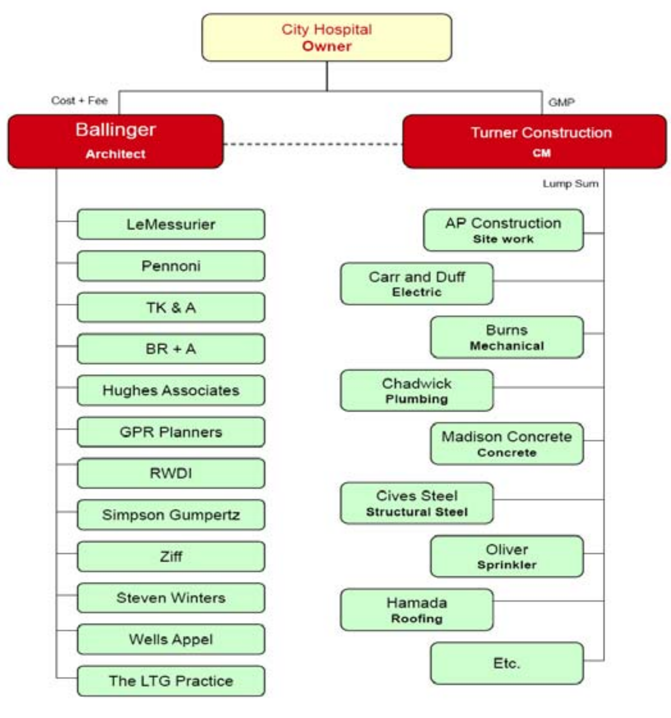

Figure 5.1: Project Delivery Method

D. Site Plan and Existing Conditions

The site plan of existing conditions for the project at City Hospital is located in Appendix A. The map shows neighboring buildings, parking locations, temporary facilities, utility lines, access roads, and pedestrian walkways around the site. The owner, City Hospital is currently located directly north of the project site. Directly to the east is a separate construction site for another research facility. Existing and new utilities are located at the perimeter of the building. The main water and electrical lines are located at the south side of the building. The plan provides a better idea of how the project fits into the existing structure of the campus.

Turner performed site demolition and excavation. Site work included grading, paving, new water, storm and sanitary laterals, new curbs and sidewalks. Due to the hardness of the solid mica schist encountered onsite, excavation required six months of rock blasting. There were a total of forty-two blasts removing 150,000 cubic yards of material. A sheeting and shoring system was used for the support of excavation. An existing north and south retaining wall was removed and replaced with a system capable of supporting the seventy foot open excavation. The new system included soldier piles behind the existing retaining wall. During the early phases of construction, there was a planned destruction of the Hall located to the west of the project site. The Hall was imploded which was a success and posed minimal risk to the surroundings and progress of the City Hospital project. Cast in place structures have been a typical construction practice in the surrounding area so they were better prepared for the blasting. The area is classified as a high density commercial area, mixed-use and residential developments are generally found in the area. There are various area and open space requirements. For example, public spaces must be equal to 30% of the lot and seating and landscaping must be provided.

This project is aiming for a LEED® Silver credit rating, so in their bid to attain credits all trash and garbage disposal is being provided by an independent waste removal company; there are separate dumpsters for materials such as wood, metal, concrete, paper (office), etc. to provide for onsite separation of recyclables. Turner keeps precise records and receipt of these transactions, for later submittal to the construction administrator.

E. Building Systems Summary

Construction:

City Hospital holds a lump sum contract with Ballinger Architects to design the structure and the building systems. The project construction is being coordinated by Turner Construction Company and constructed by its prime contractors. Turner acts as a construction manager at

risk and holds lump sum contracts with its prime contractors. City Hospital holds a guaranteed maximum price contract with Turner.

Phase I which is the crux of my thesis includes four levels below grade as shown in Figure 5.2.

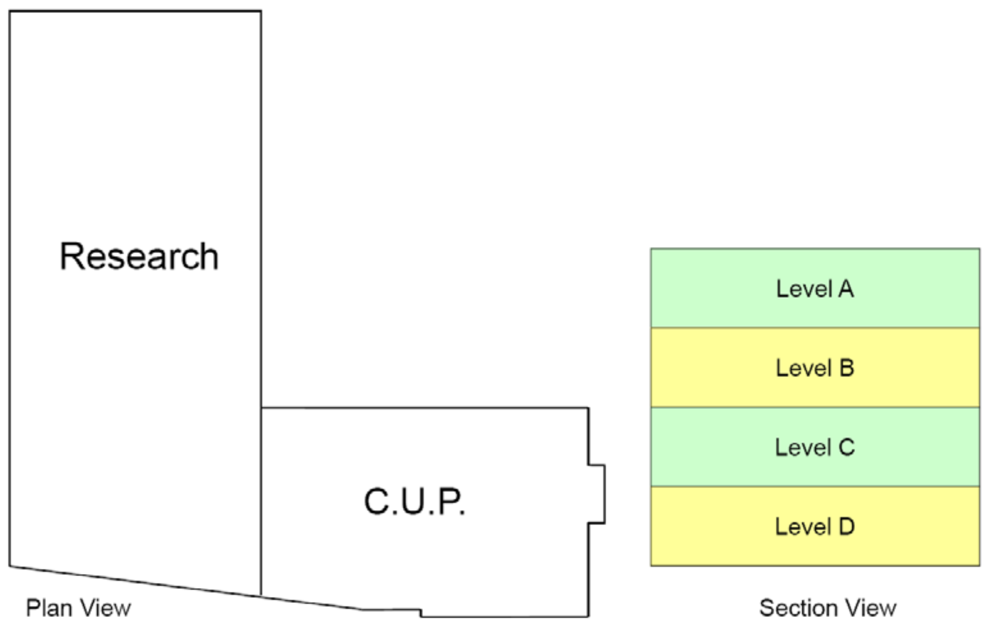

Figure 5.2 Building Plan

Electrical/Lighting:

The building has two normal power services at 13.2 KV which are located at the south entrance and (2) two megawatt emergency generator at 480V for backup power. Power is fed from the utility company into a medium voltage secondary selective system using three 5000 KVA double ended substations with tie-in. The substations service the electric chiller (2,000 ton), central utility plant, and research facility. Automatic transfer switches are used to divide power into branches of critical, life safety, and equipment in accordance with section 517.30 of the NEC code (2002). Wye-Delta transformers are used to step down the medium voltage supplied to the building to utilization voltages of 120V, 208V, 277V, and 480V as needed.

There are a variety of lighting fixtures used through out the city hospital project, ranging from strip lighting, direct/indirect fixtures, etc. These fixtures use a range of incandescent lamps, compact fluorescents, tubular fluorescents (T-5 and T-8), and HID lamps. Generally, lighting fixtures are mounted in a variety of ways, such as pendants, recessed, or suspended. A couple of specialized lightings, such as operating lights and procedure lights are used to focus a very high intensity of light when carrying out intricate procedures. The offices, research labs and conference rooms use continuous dimming tubular fluorescent ballasts. These types of dimming controls are implemented for the sustainability effect and bid to comply with LEED credit requirement of the project.

Mechanical:

The central utility plant (Levels A through D) houses most of the mechanical equipment. The central cooling towers are located above the A level loading dock. The primary components of the mechanical system include (1) 2,000 ton steam turbine chiller, (1) 2,000 ton electrical chiller, (4) 1,000 ton cooling towers, (4) 800 hp dual fuel boilers, 18 air handling units ranging from 2,500 to 100,000 CFM, and (2) 120,000 cfm exhaust air handling units with heat recovery. The supply air is distributed through industrial air handling units and variable air volume boxes that give occupants the ability to control specific temperature zones from a re-settable set point or by various ventilation motors. This controls help to enhance occupant comfort, thereby leading to greater productivity. Steam for this facility will be provided from the new CUP. 125 psig; steam shall be reduced in pressure as required and distributed to building heating, research and clinical equipment. The air conditioned source for the new building shall be from a new chilled water plant. The hydronic system will provide building reheat, primary chilled water, secondary chilled water, condenser water, process chilled water, heat recovery / OA glycol water, and future radiation heating.

The building is equipped with a building automation system called direct digital controls (DDC) which enables the facility managers and authorized personnel the ability to monitor and control various function of the mechanical equipment. The system also records the performance of the equipment and compares it to the expected performance. If there is a major difference (depending on how it is configured) a visible or audible alarm is used to signal the conditions.

Structural:

Masonry

The exterior of the research facility consist primarily of a concrete masonry unit (CMU) cavity wall system (4" CMU veneer, 2" air space, 2" rigid insulation, a fluid applied vapor permeable air barrier system, and 8" CMU). The interior partitions are also mainly constructed with 8" CMU; mortar and grout will be used for bonding. The units have an average compressive strength of 1900 psi. The CMU was erected using regular framing scaffold.

Steel Frame

The structural system for the City Hospital uses structural steel columns, wall bracing bays and beams ranging from W12x45 to W24x55. The slab construction consists of 3" deep composite steel deck with 6x6- W4.0x4.0 WWF throughout plus additional reinforcement as required. The steel decking is attached by means of welded shear connectors to the steel beams. A tower crane will be utilized for all steel erection.

Concrete

The foundation consists of cast-in-place concrete spread footings (4,000 psi) with a thick cast-in-place slab on grade. The steel deck carries a 4 ½" normal weight concrete fill. The roof of C.U.P. is constructed by a 4" pour in place concrete over a 5 ½" concrete slab with a waterproofed membrane roof system to accommodate traffic on the loading dock. The 4,000 psi concrete shear walls were formed and poured 72 ft high in one pour. To eliminate the need for internal vibration of the concrete, a ready-mix supplier was used to develop self-consolidating concrete. The steel stairs will require concrete fill-in. The below grade exterior of all precast concrete will be coated with an epoxy coating which is moisture insensitive. Coal tar epoxy will be applied to the exterior precast walls.

Support of Excavation:

The type of support used for excavation for the research facility is a temporary sheeting and shoring technique with rock bolting. Since the spread footing and rock is within the water table, temporary and permanent dewatering was provided. Water pumping is required for deep excavation. A storm water pollution prevention system is being enforced.

Plumbing:

The design for the research facility consists of several components which include sanitary drainage, storm water/roof drainage, foundation drainage, domestic hot water, cold water, and natural gas piping. A 10" domestic water service main enters the building through Level B and drops to a water meter and goes through a reduced pressure backflow preventer. The temperature for the hot water piping which is heated by steam is set at 140°F and runs to plumbing fixtures through out the building. This includes the sinks, water closets, showers, urinals, etc. The re-circulating pumps are used to keep the water in motion so it does not freeze in the pipes. The storm water system roof drains are located above B level research and A level C.U.P loading dock. The main sanitary waste lines leaves through the south end of the building and runs down to an interceptor drain.

Fire Protection:

The building is protected with a wet pipe system, which is complaint with the Americans with Disabilities Act, with recessed flush type sprinkler heads and fire hose standpipe connections. Unheated spaces and the loading docks are protected with a dry pipe sprinkler system. The electrically actuated pre-action sprinkler system protects zoned areas. Each zoned floor is furnished with flow switches, tamper switch, supervised shut off valves, test connections and associated drains in accordance with NFPA 13 and 14.

The preaction system is used in buildings that are susceptible to water damage. There is sensitive equipment like computers and research equipment that has to be protected from unnecessary water in the case of a false alarm. The double interlock preaction system is a system that allows the pipes to be filled with compressed air. When the smoke detector is triggered, the system sounds the alarm and releases the preaction valves; air pressure releases the water out into the previously dry pipes and stays there until a sprinkler head opens. Fire extinguishers will be located throughout the building to help put fire out manually.

The fire protection system consist of a an electrically driven horizontal foot mounted, open drip proof, 250HP, 3575 RPM solid state soft start squirrel cage induction motor wound for 480V ac, three phase, 60Hz, fire pump system and a 3HP, 3500RPM three phase 60Hz 480V jockey pump system, and controllers.

Security:

The main security office is located near the south loading dock on "A" level. Some equipment that serves to enhance the security of the entire building are emergency generator annuciators, remote emergency generator start, fire department key box, security panel, and elevator control

panel. Door security hardware throughout the building consists of airlock and inter-lock doors, card reader access, etc. They are interfaced with security and the fire alarm system. Security cameras are installed at various locations in the building. Elevators and research rooms are also equipped with card readers for access. Security devices and wiring is provided by Carr & Duff and Truefit.

Transportation:

There is provision for eleven standard hydraulic elevators in the hospital. Ten of the elevators are located in the research portion of the building. There are seven elevators being installed as part of Phase 1 of the construction project that will service levels A to level D. Only one service elevator will service all the floors in the building (phase 1 and phase 2). There are six stairwells located throughout the building. These stairwells will play a crucial role in evacuation of occupants in the case of an emergency. The major means of egress on each level in research is through two parallel corridors running from north to south. In the C.U.P the major means of egress is a long corridor running from east to west.

Telecommunication:

The telecommunication system includes a raceway support system for all essential low voltage communication wiring provided in the building. The raceway support system shall include rough-in, outlet boxes, conduit, junction boxes, etc. to accommodate various parts of the system. Cabling will be installed for the telephone system, security system (door access, card reader system), data system (CAT 5E/6 copper cabling), and television system. Phones and data jacks are provided in each room. This wiring system installed will ensure the research space runs as a state of the art research facility and provides sufficient communication abilities.

F. Project Schedule

The detailed project schedule for City Hospital is a 34 month schedule for a 266,000 square foot research facility. This is a very tight schedule for a project of this size and magnitude due to the fact that future phases will be constructed as Phase I is closing out in an overlapping technique. So if any phase fails to meet its schedule, it will have a ‘domino’ effect that will affect all the other phases of the project and ultimately lead to inconveniencing other aspects of the project, if the project is going to meet its scheduled completion date. The schedule includes the design, procurement and the construction phases of the project.

Turner Construction divided the activities in the schedule between the central utility plant and the research space. This allows for trades to move as quickly as possible through the building while staying out of each other’s way in the process. The site work included in Phase I includes

grading and the paving of the South Road and installation of new water service, storm and sanitary sewers, and electrical services. The critical activities and key milestones are outlined in the schedule, Appendix B. For example, steel construction began on July 27, 2006. This date is a crucial date for the schedule due to the timing and delivery of the mill order. The building is scheduled to be weather tight on June 6, 2007 after 11 months of construction. Completing this milestone is important to avoid excess moisture that may cause serious damage or health risk. To save time in the schedule, the concrete shear walls were poured in single lifts ranging from forty to seventy-five feet. The shear walls were the highest ever poured in the region using the EFCO plate girder system as shown in Figure 2.5. The fit-out of the research space includes masonry partitions, drywall ceilings, resinous floors and epoxy paint. Whereas C.U.P fit-out consist of chillers, boilers, and air handler and is designed for future expansion.

The project schedule, Appendix B, is organized by the following trades or phases:

- Site work
- Concrete
- Steels & Metals
- Thermal/Moisture Protection
- Masonry
- Plumbing
- H.V.A.C.
- Electrical
- Fire Protection
- Equipment
- Finishes
- ATC
- Elevators
- Commissioning

Figure 5.3: Pouring of concrete shear wall

G. Project Cost

The following data is a cost evaluation for City Hospital in Southeast Pennsylvania. Included in this evaluation is building costs, total project costs, and various systems costs such as electrical, HVAC, plumbing, and equipment.

Construction Cost: $149 M
Total Project Cost: $156 M
Building Square Foot: 266,000

Building Systems		
Div.	**System**	**Cost**
GR	General Requirements	$3,000,000.00
03000	Concrete	$15,234,046.00
04810	Masonry	$5,707,757.00
05000	Steel & Metals	$12,663,863.00
14420	Conveying System	$1,757,799.00
08000	Doors & Windows	$392,243.00
07000	Thermal & Moisture	$4,357,769.00
15400	Plumbing	$5,670,468.00
15300	Fire Protection	$1,952,558.00
15700	HVAC	$20,747,890.00
16000	Electrical	$19,730,101.00
	Total	**$91,214,494.00**

Figure 5.4: Project Cost Data