

MONONGALIA GENERAL HOSPITAL

1200 J.D. ANDERSON DRIVE, MORGANTOWN, WEST VIRGINIA

THESIS PROPOSAL: BLAST AND PROGRESSIVE COLLAPSE ANALYSIS (REVISED)

PROPOSAL



THE PENNSYLVANIA STATE UNIVERSITY
DEPARTMENT OF ARCHITECTURAL ENGINEERING
SENIOR THESIS 2008-2009

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STRUCTURAL

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Executive Summary

Purpose

The Monongalia General Hospital has recently completed the Hazel Ruby McQuain Tower; an expansion to the existing hospital. The new expansion to the Hospital will provide more patient rooms, intensive care units, the emergency department, imaging department, central sterile supply, a pharmacy, as well as a medical records department. Located in Morgantown, West Virginia, a part of the Pittsburgh Tri-State region and the largest city in North-Central West Virginia, located conveniently within the city and close to the West Virginia University, the Monongalia General Hospital is a well integrated health care facility servicing not only North-Central West Virginia but also Southwestern Pennsylvania. With this in mind, and for the purpose of this thesis, the Hospital has hypothetically decided to research and integrate higher levels of structural safety against blast and progressive collapse, should the unspeakable happen.

Building Description

The Monongalia General Hospital is a 405,994 square feet hospital located in Morgantown, West Virginia. The building project includes a 280,000 square feet addition as well as a 60,000 square feet renovation to the existing structure. The building envelope is a brick façade tied to structural concrete walls with openings for punch windows and curtain wall systems. Aluminum curtain wall systems can be seen all around the Hospital, oriented around lobbies and other major openings on plan. The system consists of insulated tempered spandrel glass framed by aluminum mullions which is tied into the concrete structural system. The main structural system of the Hospital consists of two-way flat slab supported by columns that follow a typical grid and edge beams located in the perimeter of each floor. The loads carried by the columns are transferred to the foundations. The lateral loads are resisted by twelve shear walls of varying height and width located in various portions of the building.

Methodology and Schedule of Tasks

In order to analyze blast and progressive collapse events; multiple scenarios, properties, loads, and characteristics need to be researched. The following is a tentative list of tasks required to complete the thesis by April 2009:

- Study of blast and collapse characteristics
- Study of structural members' response
- Determination of scenarios
- Modeling and analysis
- Structural analysis and redesign
- Checking the validity of redesign
- Conclusion and analysis of redesign
- Written and oral presentation of findings

Monongalia General Hospital

1200 J.D. Anderson Drive
Morgantown, WV

Thesis Proposal: Blast and Progressive Collapse Analysis

Introduction

The Monongalia General Hospital has recently completed the Hazel Ruby McQuain Tower; a new expansion to the existing hospital. The new expansion to the Hospital will provide more patient rooms, intensive care units, the emergency department, imaging department, central sterile supply, a pharmacy, as well as a medical records department. Located in Morgantown, West Virginia, a part of the Pittsburgh Tri-State region and the largest city in North-Central West Virginia, located conveniently within the city and close to the West Virginia University, the Monongalia General Hospital is a well integrated health care facility servicing not only North-Central West Virginia but also Southwestern Pennsylvania, a valuable lifeline in the region. With this in mind, and for the purpose of this thesis, the Hospital has hypothetically decided to research and integrate higher levels of structural safety against blast and progressive collapse, should the unspeakable happen.

The Monongalia General Hospital

The Monongalia General Hospital is located on 1200 J.D. Anderson Drive, West Virginia (Photograph 2 for aerial view, Photograph 3 for façade). The current project the Hospital is going through is a 340,000 square foot expansion and renovation named the Hazel Ruby McQuain Tower, this new addition will provide more various facilities and departments to the Hospital. The construction started on June of 2006 and is scheduled to be completed on May of 2009 with a design-build contract with a guaranteed maximum price set at an estimated \$69,000,000 by the Turner Construction Company. The Tower has been designed by Freeman White, Inc. from North Carolina and the structure designed by Atlantic Engineering Services from Pittsburgh. (See Appendix A for Project Team Directory)

The Monongalia General Hospital's plan can be divided into four different quads, A, B, C, and D (Figure 1). The first floor of the Monongalia General Hospital occupies 92,086 square feet and houses a boiler/chiller room, electrical rooms, doctors' offices, labs, nurse stations, storage spaces, and a dining space equipped with a food services kitchen. The second floor follows a similar layout but provides more space for examination rooms as well as a gift shop and café on the southern face of Quad A. The third floor mainly consists of patient rooms with the central part of the plan dedicated to operation rooms. The third floor has a reduced square footage compared to those of the floors below with an area of 80,882 square feet; the western section of Quad D does not continue up to the third floor as patient room spaces but provides housing for two air handling units. The fourth floor sees an even less square footage on plan at 53,833 square feet, with the western section of Quad D no longer existing at this elevation. This floor only houses private patient rooms, each equipped with a private toilet and shower. The square footage

of the fourth floor continues up to the fifth, housing more private patient rooms as well as a Labor, Delivery, Recovery, and Postpartum (LDRP) rooms in Quad B and C. The sixth floor sees nearly a fifty percent reduction in square footage from the fifth floor with only Quads B and C serving rooms for private patients. The rooftop at Quad A is located at this elevation and houses five air handling units. Acoustic ceiling systems are utilized on each floor to provide acoustic insulation. The rooftop of the Monongalia General Hospital is used primarily to house mechanical equipment. Two different types of roof systems are utilized: an adhered roof system and a ballasted roof system. The ballasted roof system is only present on the rooftop of Quad A and all other roofs utilize the adhered roof system. (Refer to Figure 2 for building cross section)

The exterior façade of the Monongalia General Hospital is a brick façade tied to 8” structural concrete walls with openings for punch windows and curtain wall systems. Windows are typically aluminum punch window units and located where there are offices and patient rooms, located on the third floor and up. Aluminum curtain wall systems can be seen all around the Hospital, oriented around lobbies and other major openings on plan (Photograph 1 and 3). The system consists of insulated tempered spandrel glass framed by aluminum mullions which is tied into the concrete structural system. Two inch rigid insulation is provided all around the building for insulation.

Structural System

Introduction

The primary structure of the Monongalia General Hospital is reinforced concrete with several composite floor systems present in parts of the building where appropriate (i.e. canopy/wall junctions, canopy fascia, etc.). The concrete used for the Hospital ranges from 3000 pounds per square inch (psi) to 5000 psi depending on its use. All concrete, as specified by ASTM C150; is normal weight concrete with a minimum weight of 144 pounds per cubic foot, and the reinforcement used are all ASTM A615 – Grade 60 steel reinforcement bars.

Foundation and Columns

Concrete foundations are placed below every column located at a minimum depth of 3’-6” below grade and utilize 3000 psi cast in place concrete. The columns that transfer the loads to these foundations are all 24 inches by 24 inches utilizing 5000 psi cast in place concrete. A total of 100 columns are present in the structure ranging in height from 11’-6” (supports one floor) to the full height of the building 58’-5”. There are six columns in the structure in which the column’s material changes from concrete to steel. These columns support the canopy in Quad A as well as used as corner columns for the stair towers.

Slabs

The slab on grades are 5” thick normal weight concrete and the slabs used in floors above are two-way flat plate slabs that utilizes 4000 psi normal weight concrete and are used as the primary floor system with the exception of a few in Quad C where an emergency energy plant is

present: a composite concrete-steel floor system is used. The two way slab system is 8 inches thick and transfers its load to the columns and concrete edge beams present in the perimeter of each floor.

Beams

The beams are all variable in size although the dominant cross section is an 18 inch by 24 inch beam usually spanning 27' from column to column. Like the columns, the concrete used for the beams are 5000 psi normal weight concrete framed in by the two way slabs. As mentioned earlier, beams in this Hospital are all edge beams with an exception around openings in plan for elevator shafts, stairs, as well as for the energy plant located in the northern part of Quad C.

Shear Walls

There are twelve lateral force resisting shear walls present in the Hospital (Figure 3). All of these are variable sizes ranging in height and width, the most representative shear wall being a 52'-9-1/8" x 70' wall with two sets of eight #5 bars used at each floor level.

Proposed Statement and Solution

For the interest and purpose of the thesis; as mentioned earlier, attacks to hospitals can cause catastrophic events: lives can be lost and significant monetary damages are inevitable. To ensure that such events do not occur, the Monongalia General Hospital has decided to research and integrate higher levels of structural safety against blast and progressive collapse due to accidents or attacks (Depth Topic). Within the initial stages of the research, various locations within the Hospital which may be vulnerable to attacks must be determined and analyzed. Through this analysis, the responsible structural members will be located, analyzed, and if required, redesigned to mitigate the effects of attacks and progressive collapse. Structural members such as beams and columns will be hypothetically loaded to resist blast loads, and removed from the rest of the structure as a part of the analysis, and then neighboring members will be designed accordingly to provide enough strength to carry the loads forfeited by the failed members.

Upon an intermediate completion of the research, architectural consideration must be given a high priority as to not hinder the current floor plan from losing its efficient layout, although one must keep in mind that enhancements to the structural system will inevitably cause such issues to arise (Breadth Topic). Cost must also be considered and studied in the event of a redesign—should there be issues as such, alternate materials and/or construction methods must also be considered (Breadth Topic).

Methodology and Research

In order to analyze blast and progressive collapse events; multiple scenarios, properties, loads, and characteristics need to be researched. The methodology will include inspection of the

building floor plans for possible blast and collapse scenarios at critical locations on the exterior and the interior of the Hospital. Some of the scenarios could include failed members in the lobby area, and multiple failed members within the mechanical room. Various resources will be utilized for the study and analysis. ETABS will be utilized as the primary structural analysis program to address the blast loads and collapse situations for the possible redesign of the critical structural members. For the analysis and possible redesign, various documents will be addressed and cited, to name a few:

- *ACI 318-08 Building Code Requirements for Reinforced Concrete*
- *AISC 13th Edition Steel Construction Manual*
- *AISC Design Guide 20 Steel Plate Shear Walls*
- *ASCE Progressive Collapse Resistant Design*
- *Departments of the Army, Navy, and the Air Force Structures to Resist the Effects of Accidental Explosions*
- *RSMMeans Building Construction Cost Data 2008*

From the aforementioned resources, the Hospital will be modeled and simulated in ETABS through various blast and collapse scenarios and redesigned accordingly to the data output by the program.

Schedule of Tasks

Tasks

A multitude of tasks will need to be accomplished by April 2009. The following is a tentative list of tasks required to complete the thesis:

1. *Study of Blast and Collapse Characteristics:* A study of blast and collapse characteristics must be conducted to understand, first and foremost where in the Hospital will be a primary target for such events. Secondly, the mechanics of such must be studied to understand how; in a structural analysis point of view, the blast loads affect the members.
2. *Study of Structural Members' Response to Blast and Collapse:* Once Task 1 is complete, the opposite end of the spectrum must be studied. The mechanics of the member experiencing the load must be understood to determine in more detail possible blast and collapse scenarios. Also, if through this task a certain type of structural member is found to be more efficient and/or more influential, a redesign of that member will be called for.

3. *Determination of Blast and Collapse Scenarios:* Upon the completion of Tasks 1 and 2, different scenarios must be iterated and narrowed down to several cases in which the most catastrophic situations can occur.
4. *Modeling and Analysis:* Upon the completion of Task 3, the computer model on ETABS used for Tech 3 will be revised and the scenarios will be simulated for analysis. Through this analysis, loads required to be carried by the surviving members will be determined.
5. *Structural Analysis and Redesign:* From the results taken from Task 4, the individual building members will be analyzed to determine if they are adequate to carry the loads. In the event the members will fail to carry the loads, a redesign will be conducted.
6. *Validity of Redesigned Members in the Architecture:* Any redesigned members will be reflected on the architecture of the Hospital and its architectural integrity will be questioned.
7. *Validity of Redesigned Members With Respect to Cost:* Any redesigned members will be reflected on the overall cost of the project. In the event the redesigned members prove to be inefficient or if it has a negative impact on cost, further redesign will be required. During this task, different materials will be considered as a substitute.
8. *Validity of Redesign with respect to schedule:* In the event of a redesign, the changes must be implemented to the project schedule and reviewed for its validity.
9. *Conclusion of Analysis and Redesign:* The findings, analyses, and redesigns will be organized in a written form of the thesis.
10. *Presentation of Analysis and Redesign:* The findings, analyses, and redesigns will be organized in an oral and visual presentation to be presented to a panel of faculty jury.
11. Make weekly checks on progress and provide a recovery plan if schedule falls behind.

Schedule

Task/Week	Jan 12	Jan 19	Jan 26	Feb 2	Feb 9	Feb 16	Feb 23	Mar 2	Mar 9	Mar 16	Mar 23	Mar 30	Apr 6	Apr 13
1	Light Blue	Light Blue												
2		Light Blue	Dark Blue											
3				Light Blue										
4				Light Blue	Dark Blue	Light Blue	Dark Blue							
5							Dark Blue	Light Blue						
6								Light Blue	Light Blue					
7								Light Blue	Light Blue					
8									Light Blue	Dark Blue	Light Blue			
9											Light Blue	Light Blue	Light Blue	
10														Light Blue
11	Light Blue	Light Blue	Dark Blue	Light Blue	Dark Blue	Light Blue	Dark Blue	Light Blue	Light Blue	Dark Blue	Light Blue	Light Blue	Light Blue	

Conclusion

For a large hospital located in one of the biggest cities in West Virginia, building failure due to blast and progressive collapse will mean catastrophe. In the interest and purpose for the thesis, The Monongalia General Hospital will be modeled and simulated under multiple blast and collapse scenarios to see if the existing design is resistant to such events, if not a redesign will take place to provide a stronger and safer structure. During the process, architectural integrity and cost will be considered. The proposed schedule projects the completion of this study on the first week of April 2008.

MONONGALIA GENERAL HOSPITAL

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APPENDIX A

PROJECT TEAM

Owner	Monongalia General Hospital 1200 J.D. Anderson Dr. Morgantown, WV 26505	Phone: 304-598-7690 Fax: 304-598-7693 Website: http://www.monhealthsys.org/
Architect and Interiors	Freeman White, Inc. 8025 Arrowbridge Blvd. Charlotte, NC 28273-5665	Phone: 704-523-2230 Fax: 704-523-2235 Website: http://www.freemanwhite.com/
Civil Engineer	Alpha Associates, Inc. 209 Prairie Ave. Morgantown, WV 26502	Phone: 304-296-8216 Fax: 304-296-8216 Website: http://www.alphaaec.com/
Construction Manager	Turner Construction Company Two PNC Plaza, 620 Liberty Ave., 27 th Floor Pittsburgh, PA 15222-2719	Phone: 412-255-5400 Fax: 412-255-0249 Website: http://www.turnerconstruction.com/
Geotechnical and Environmental Consultant	Potesta Engineers and Environmental Consultants 125 Lakeview Drive Morgantown, WV 26508	Phone: 304-225-2245 Fax: 304-225-2246 Website: http://www.potesta.com/
Mechanical, Electrical, and Plumbing	Freeman White, Inc. 2300 Rexwoods Dr., Suite 300 Raleigh, NC 27607	Phone: 919-782-0699 Fax: 919-783-0139 Website: http://www.freemanwhite.com/
Structural Engineer	Atlantic Engineering Services 650 Smithfield St., Suite 1200 Pittsburgh, PA 15222	Phone: 412-338-9000 Fax: 412-338-0051 Website: http://www.aespj.com/

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APPENDIX B

FIGURES

Figure 1: Hospital Divided in Four Quads

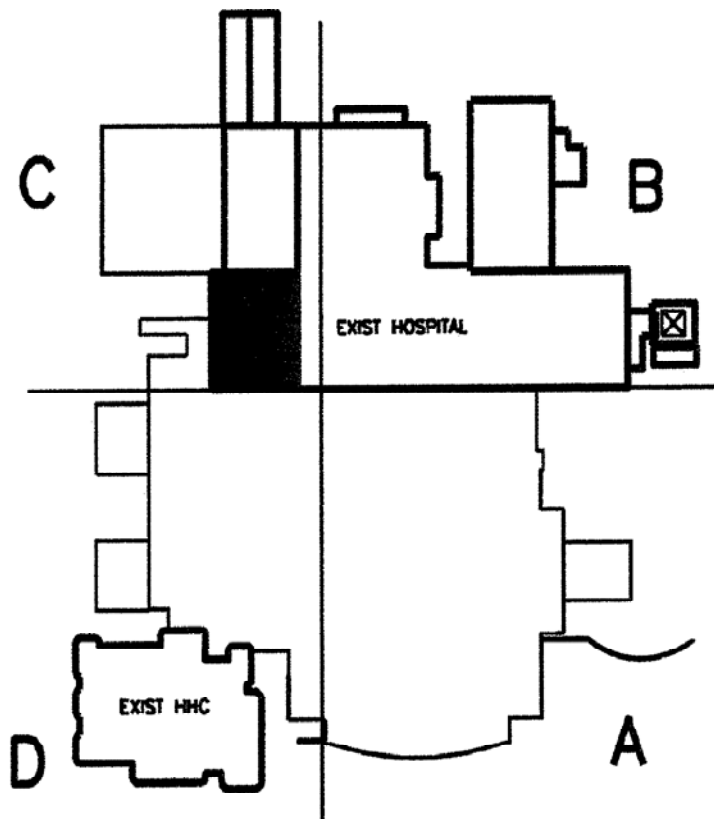


Figure 2: Cross Section of the Monongalia General Hospital

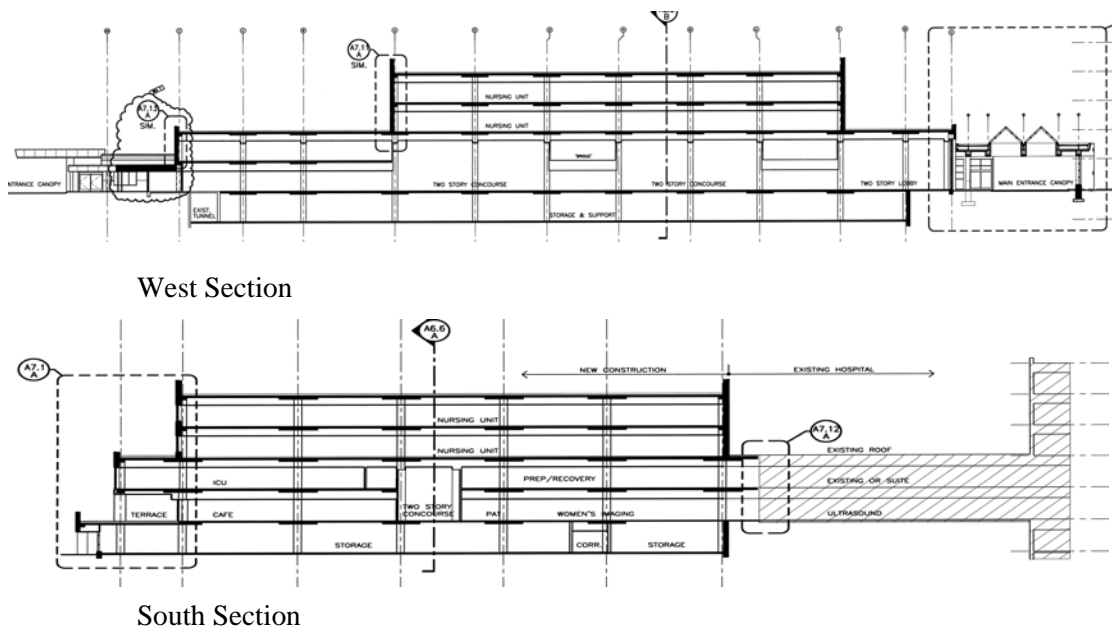


Figure 3: Location of Shear Walls (Colored in blue)

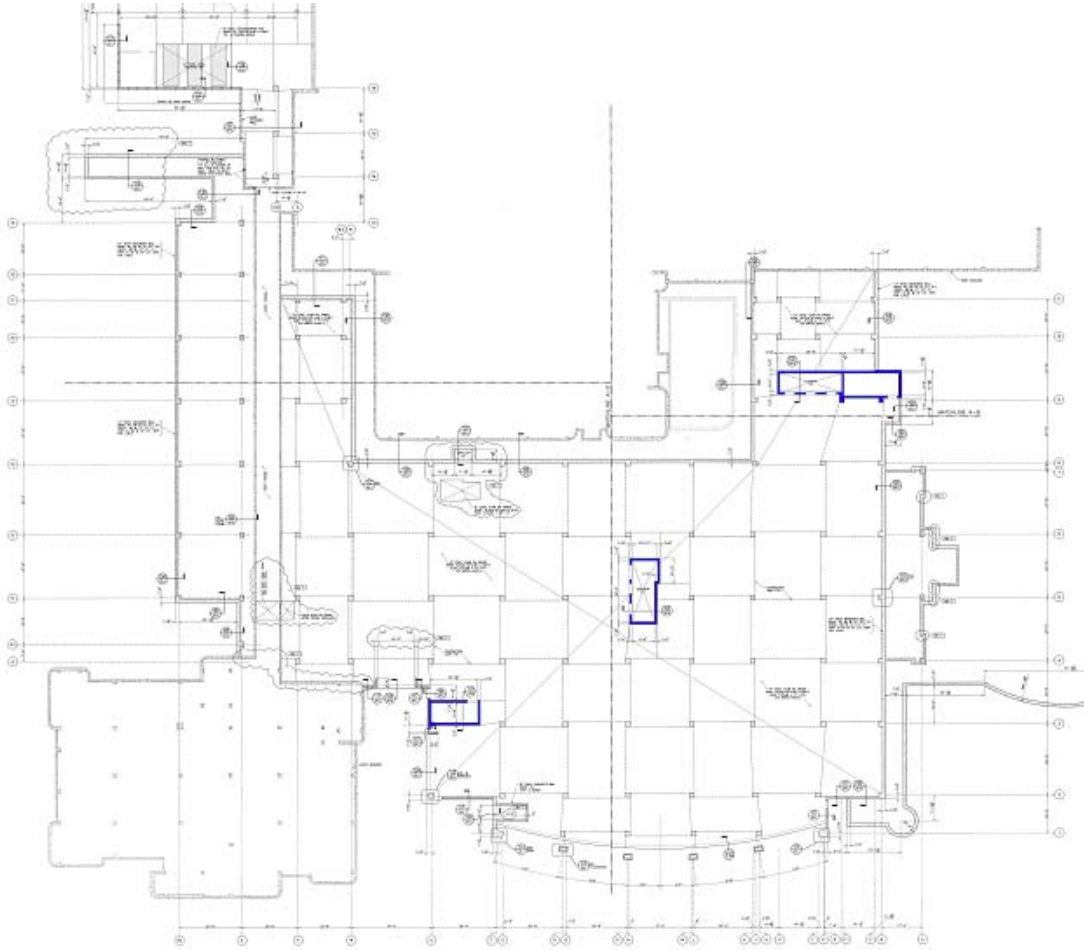
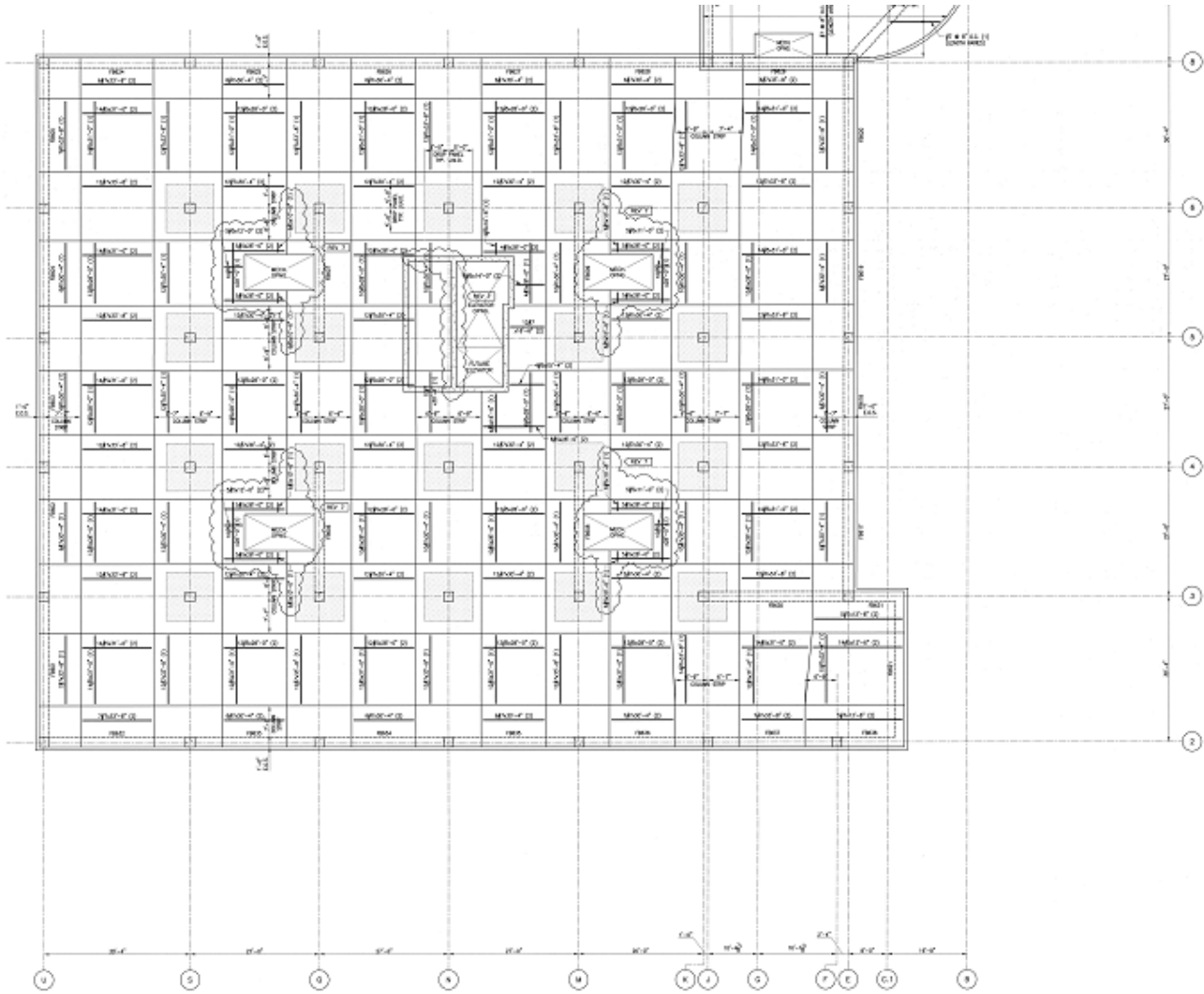


Figure 4: Typical Framing Plan (Taken from Quad A)



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APPENDIX C

PHOTOGRAPHS

Photograph 1: View from South-East



Photograph 2: Aerial Photo of the Monongalia General Hospital



Photograph 3: View from South-East showing the brick façade and curtain walls

