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1/16/06

Thesis Proposal

Executive Summary

The Hershey Academic Support Center is a 5 story building that encompasses a total area of 150,000 square feet. The floor system is a conventional structural steel system with composite beam floor framing and a precast concrete and glass facade. The main lateral system for this building is varying partially restrained moment connections located at almost every column. These connections extend to all 5 floors of the buildings and brace the building in both the N-S and the E-W conditions. The three types of connections used are top & bottom angles, top & bottom plates, and top angles & bottom plates.

The proposal objective for the Hershey Academic Support Center is to research and examine the moment connections used throughout the building. The building was designed using the method of “Type 2 with Wind,” which deems moment connections as “smart connections.” These connections are supposed to determine what load is being used against them and act accordingly. There are three different levels of actual restraint found in the types of connections in this building. The three types of connections used range from partially restrained to fully restrained in the form of top & bottom angles, top angles & bottom plates, and top & bottom plates respectively. For this proposal, the different levels of restraint will be specifically determined and then used to see if the member sizes given by the original plans can be changed in size. This could cause the member size to decrease in different sections helping to reduce cost.

Another area that will be explored is the drift caused by the different moment connection types. Depending on how much moment is released by each connection directly affects the drift experienced by the moment frame. The framing will be checked to ensure that all drift calculations are within reasonable limits when compared with the actual amount of restraint.

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Breadth Summary

The breadth projects chosen will supplement the changes made in my thesis proposal. The first breadth topic will deal with Construction Management issues, specifically dealing with costs of the lateral system. The second breadth topic will address some Architecture in the building, specifically examining the Fire System. The current system could be modified to meet fire code if the slab thickness was increased by one inch. The second topic will look at the affects to the building system if the slab thickness was changed to meet fire code.

Topic #1: Construction Management
The first breadth proposal will focus on specific cost comparison of the current lateral system against other lateral options. The lateral system uses moment connections at almost every column in the building. Some steel fabricators will be consulted about the specific costs of partially restrained as well as fully restrained moment connections in conjunction with the cost of using braced frames. A second cost issue that connects the two breadth topics is the cost of the fire system before and after the slab thickness increase.

Topic #2: Architecture
The second breadth proposal will take the current fire system of 2.5” Lightweight concrete slab with spray on cementitious fireproofing and change it to a 3.5” slab with no fireproofing to see how this is advantageous. The new system will result in more weight on the structure, possibly affecting floor members or the foundation, but this should reduce labor costs and overall hours to complete.

General Information

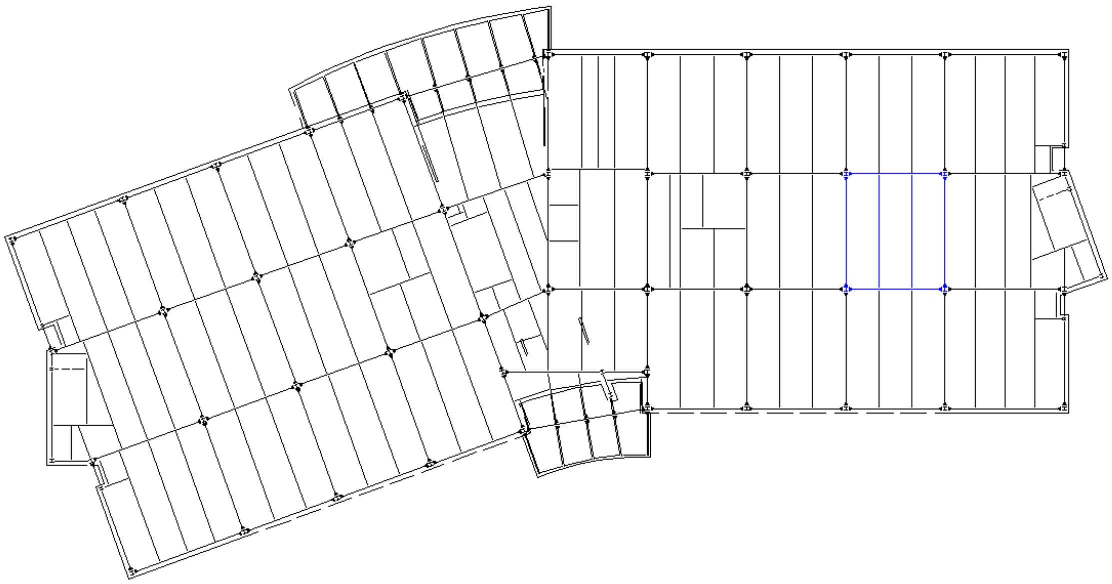
The Hershey Academic Support Center is part of the Hershey Medical Center complex and is owned by The Pennsylvania State University. Constructed from March 1999 to August 2000, The Penn State Geisinger Health System was designed as the primary occupant, but was dissolved before the building was occupied. Currently the building is used for auxiliary purposes of the Hershey Medical Center and accommodates 680 people. The building itself can be considered in two sections, an East and a West wing. The wings are structurally identical with the only difference between them found in the center section. The building footprint encompasses a total area of 150,000 square feet. The total height of the building over 5 stories is measured as 56'-0" with the height to top of the roof including the Mechanical Penthouse being 69'-0". The building consists of a conventional structural steel system with composite beam floor framing and a precast concrete and glass facade. Moment connections placed at the columns as well as braced steel frames help to resist the wind and lateral loads throughout the building.

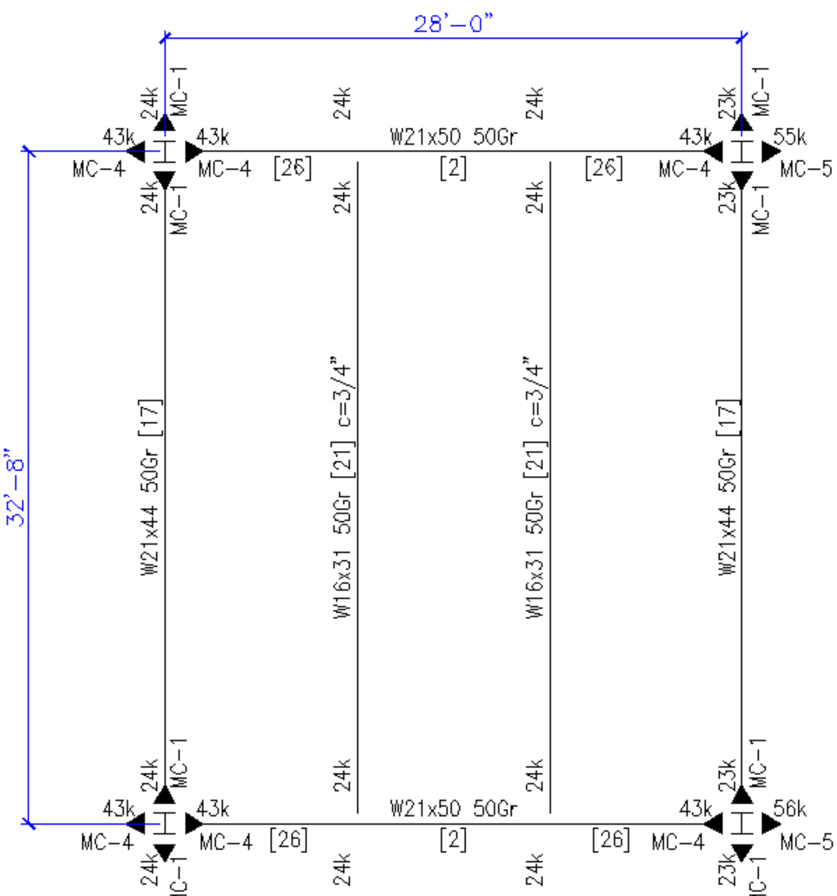
Foundation

The foundation for this structure is a deep foundation system consisting of caissons and grade beams. The concrete slab on grade is 4" thick and reinforced by WWF. Footings are placed under the columns and step footings were used at the corners of the building for extra support. All exterior footings must extend 3'-6" below the finished grade to protect from frost. Footings have been designed for a net soil bearing pressure of 6,500 psf. If spread footings are not desired, geopiles may be used in place as long as they meet the same criteria.

Floor System

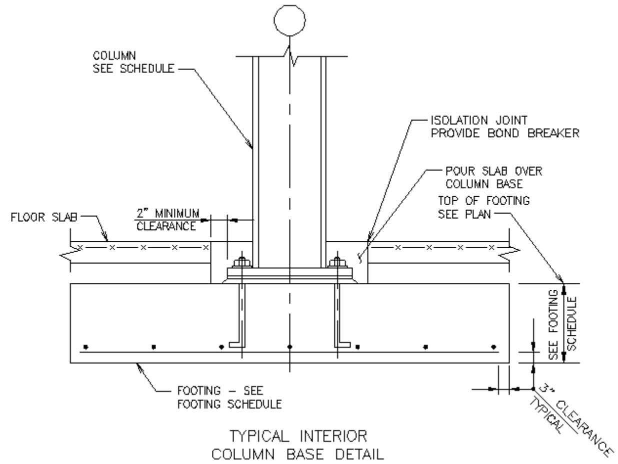
The floor system at the Hershey Academic Support Center utilizes a composite beam floor framing system with 3" 20 gage Vulcraft galvanized steel metal decking and 6x6 W1.4XW1.4 Welded Wire Fabric between the steel members and the concrete. The 2.5" Lightweight concrete along with the decking give an overall slab thickness of 5.5" and a total system depth at the girder of 26.5". To hold together the decking and concrete slab, 0.75" ø x 4.5" long headed steel studs were used. The most common connection used in a typical bay between the beams and columns is a L6 x 4 x 7/8 x 0'7" steel angle moment connection with 4 bolts to a beam and 2 bolts to a column. Each typical bay is 28' by 32'-8" and consists of W21x50 and W21x44 girders with W16x31 interior beams that have a ¾" camber. Material strength is given as 4000 psi for the concrete slab and Fy = 50 ksi ASTM A-572 steel in the beams and girders. Spray on cementitious fireproofing was used to meet the fire rating required for the building. The floor framing plan and a typical interior bay are shown below in blue.




28'–0"
32'–8"
W21x50 50Gr
[26]
[2]
[26]
W21x44 50Gr [17]
W16x31 50Gr [21] c=3/4"
W16x31 50Gr [21] c=3/4"
W21x44 50Gr [17]
24k
23k
43k
55k
56k
MC-1
MC-4
MC-5

Columns

Columns for the building vary in size but the typical column size is a W14x120 and a W14x176. The columns are spaced identically in each wing in 28’ to 33’-8” bays. Cross bracing is used for extra building support and is shown below (See Picture).



TYPICAL INTERIOR
COLUMN BASE DETAIL

DETAIL A

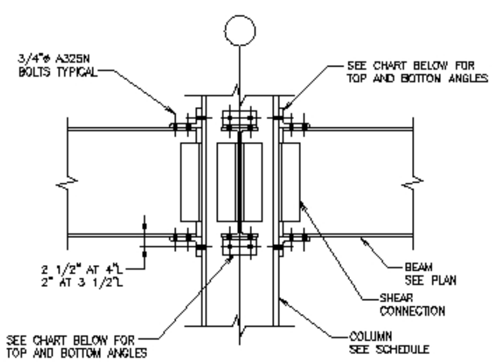
NOT TO SCALE

Roof

This building utilizes an EPDM membrane roofing system with rigid insulation placed on a 3” lightweight concrete slab with 3” deep 20 gauge composite steel metal deck underneath. Girder size is increased slightly to W18x40 and W21x76 and the moment connections at the columns were increased in strength with more bolts. The Mechanical Penthouse is located on the roof and houses all the major mechanical components for the entire building.

Connections

Almost every girder to column connection encountered in the Hershey Academic Support Center is a partially restrained moment connection with connecting angles used between beams and girders. The most common connection used in a typical bay is a L6 x 4 x 7/8 x 0’7” steel angle with 4 bolts to a girder and 2 bolts to a column. Top and bottom plates are also used for some connections for extra support. A diagram of a typical moment connection (Right) and a beam to girder connection (Left) is shown below.

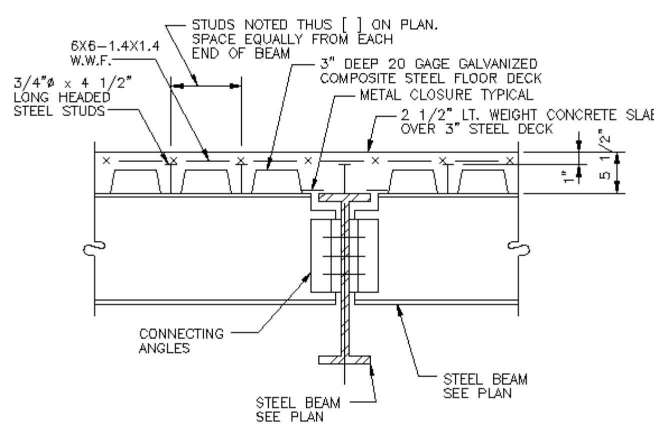


WIND MOMENT CONNECTION–
TOP AND BOTTOM ANGLES
MC–1 THRU MC–10

SEE PLAN FOR LOCATIONS

DETAIL A

NOT TO SCALE



TYPICAL BEAM TO GIRDER

DETAIL 1

NOT TO SCALE

Lateral System

The Hershey Academic Support Center sports a composite floor design on each floor of the building. The main lateral system for this building is varying partially restrained moment connections located at almost every column. These connections extend to all 5 floors of the buildings and brace the building in both the N-S and the E-W conditions. The top floor does not utilize moment connections in the E-W direction, but uses Cross Bracing to help prevent the lateral load instead. There are 3 different moment connections used and with bolt combinations, it comes to 16 total types. The three types of connections used are top & bottom angles, top & bottom plates, and top angles & bottom plates.

Envelope

The two wings of the building form a slight angle out from the center and are clad with a repeating window pattern laced with precast concrete panels. The center of the building has a concrete slab canopy leading into the main lobby, which is encased by glass and extends across the entire first floor of the building. A sheet of glass is located from the canopy to the top of the building. To break up the repeating window pattern, both sides of the building have fire rated concrete encased stairwells that jut out to the side.

Problem Statement

After extensive studies on the building systems found in the Hershey Academic Support Center, the current system has been determined to be effective. All of the building loads and forces are sufficiently resisted by the building in concordance with ASCE 7-02. The problem that will be addressed for next semester is to analyze the different moment connection types and determine the true amount of moment that is resisted by each. The original system design is known as Type 2 with Wind and makes the assumption that the connections are "smart," meaning that they know which type of load is affecting them and act accordingly. In actuality, these connections range in degrees of restraint, causing different amounts of moment to be released and as a result, the member's sizes would be affected. Another factor to consider with differing connection restraint is the drift requirements. All of these factors will be analyzed and will hopefully lead to a more efficient and safer system when complete.

Proposed Solution

The proposal is to research and check the lateral system by determining the amount of moment resisted from the current partially and fully restrained moment connections located at each column in the building. The specific rotational value will be used to determine the appropriate member sizes as well as if the drift found on the moment frame is adequately covered by ASCE 7-02. Credible sources such as Penn State research and AISC articles will be used to determine both the theoretical concept of moment connections, but also the calculations associated with the Type 2 with Wind process. This research and application could lead to a cheaper structural system or could possibly create concern if the calculated member sizes are bigger than what is in place.

Solution Method

To begin to understand the complex system of moment restraint in connections, different sources will be consulted to find information. After a level of understanding is achieved, calculation methods of partially restrained moment connections will be found and applied to the system. The building will be broken down per floor and the different levels of moment restraint will be placed at each connection. Analysis for lateral loads will be performed by the SAP2000 computer program to keep things similar with the previous technical reports and appropriate hand checks will be performed as necessary. Each floor will be analyzed separately to ensure stability and then the system as a whole will be checked to confirm the critical regions. The floor redesign will still use the Type 2 with Wind approach where the negative wind moment is taken from the lateral system and directly used to design the floor system members. As with the previous technical reports, RAM Steel will be used to redesign the floor system for the most efficient floor design and then supporting hand calculations of member sizes will be checked in some areas to ensure validity. Drift checks will also be taken and compared to code, so that structural stability is ensured. All lateral checks will conform to the code requirements of ASCE 7-02 and all steel will be designed by the AISC Load and Resistance Factor Design, 3rd Edition.

Tasks and Tools

Task #1: Research and apply actual moment restraint of the system

1. Find the difference between partially and fully restrained moment connections
2. Locate calculations of fixity based on connection type
3. Layout plan of the building with levels of restraint
4. Determine the actual lateral load at the column
5. Use RAM Steel & hand calculations to determine member size
6. Compare new members sizes with previous specifications
7. Design SAP2000 Model of new lateral system
8. Check story drift

Task #2: Breadth Analysis: Construction Management

1. Obtain cost information for the current lateral system from steel providers
2. Obtain cost data relating to any change in the structural system from the research in moment restraint
3. Obtain cost data for other similar lateral systems that could be used
4. Do a comparative Cost Analysis
5. Analyze the current fire protection system and obtain cost
6. Increase the slab thickness by 1” and remove spray-on fireproofing

Task #3: Breadth Analysis: Architecture

1. Check previous fire system for labor costs and scheduling
2. Increase floor slab by 1" to meet 2 hour fire rating
3. Compare cost, labor, and duration between the two systems
4. Check to make sure extra weight of concrete does not have adverse effects

Task #4: Total Comparison of Old System vs. New System

1. Compare member sizes of old lateral system vs. new lateral system
2. List any other advantages of the new system
3. List any disadvantages of the new system
4. Give a final comparison of results in report format
5. Give a presentation on these results

Timetable

January	Project Timetable
9	Proposal Corrections and Basic Research
16	In-depth Research Into Levels of Moment Restraint
23	Determine Calculation Method and Begin Calculations
30	Finish Calculation of All Moment Connection Types
February	
6	Layout of Moment Connections for RAM Steel
13	Determination and Check of New Members
20	SAP2000 Model Creation and Story Drift Check
27	General Comparison of New System to the Old
March	
6	**SPRING BREAK**
13	Determine Construction Management Breadth Findings
20	Complete Architecture Breadth Analysis
27	Final Presentation Preparations
April	
3	Final Presentation Cleanup
10	Thesis Presentation