Lateral System Analysis and Confirmation Design

Executive Summary

The building that I am doing my thesis project is the UMCP Student Housing – Building B at the University of Maryland. In the previous assignments, I have looked into the existing structure and alternative floor systems. The structural system that was used in the building is load-bearing masonry facade with some tube steel columns that help in the transfer of gravity loads in the lower two floors. The floor system consists of composite Hambro joists that bear directly on the masonry facade, tube steel columns, and light gauge metal walls. Some floor systems may be viable for my building were the staggered truss, long span metal deck, and 2-way concrete floor system.

The lateral system for my building consists of light gauge metal shear walls with X-patterned strap metal bracing. The shear walls span in both the longitudinal and the transverse direction of the building. Drift and strength are the critical calculations that must be performed in doing lateral analysis. It was found that all the story drifts and overall building drift fall within the limits of the industry standard of h/400. In addition, the critical light gauge metal members perform well against resisting the load, except the shear wall header plates. Therefore, the lateral system performs well in my building.

Description of Existing Lateral System

The lateral system of the building consists of shear walls with X-bracing in both the longitudinal and transverse directions. The shear walls themselves consist of light gauge metal studs that have a minimum strength of $f_y = 50,000$ psi. To see the framing layout of the shear walls, please refer to page 4 for the West End of the Second Floor Framing Plan. The end posts of the shear wall are made up of built-up light gauge metal studs. This is done by welding multiple studs together to get added strength from the individual members. X-bracing consists of strap metal that is attached to the outside of the building. The X-bracing is used to help in the transfer of load to the shear wall below or the foundation. To see the X-bracing configuration, please refer to page 5 for the shear wall elevations and details. The end posts of the shear walls rest directly on foundation piers that are adequately attached to the footing by dowel reinforcement. Therefore, the load and overturning moment are distributed directly to the soil. To see the foundation detail, please refer to page 6.

Determination of Critical Load

The most critical load for my building is the wind load. To find the most critical load, all of the loads must be calculated in order to determine this. Loads were calculated based on equations and factors obtained from BOCA 1999. For the lateral loads, the loads that needed to be
compared were the wind load and the seismic load. To see the design load calculations, please refer to page 7-9 for all of the load calculations.

**Determination of Load Distribution**

The lateral load in my building is distributed to each shear wall by tributary area. Loads are distributed in this fashion because all of the shear walls are of the same size and strength. The shear walls are spaced at 44’-5” on center throughout the entire building in the longitudinal direction and 13’-0” in the transverse directions.

**Confirmation of Load Path**

The wind load that is applied to my building follows a certain load path. The load first follows the concrete floor slab to the shear walls. This means that the concrete slab acts as a horizontal diaphragm. Then, the load is transferred from the concrete slab by shear wall action to the shear wall. The shear wall action is a uniform distributed shear that then produces a force in the end posts and an overturning moment. These forces are then transferred to the shear walls below. Once the load reaches the bottom shear wall, the force and overturning moment are transferred to the concrete footing in the foundation, which in turn pass these to the earth’s soil.

**Lateral System Calculations**

The analysis of a lateral system involves a series of drift, overturning, and strength calculations. To obtain these calculations, the wind load must calculated. The wind load is calculated based on the equations and factors in BOCA 1999. To see the wind load calculation, please refer to pages 7-8. The load is then distributed to each floor, so that the concrete slab (horizontal diaphragm) can pass the load to the shear wall. To see the calculation of the story forces, please refer to page 12 for the longitudinal direction and page 13 for the transverse direction. With the story forces, the drift and strength calculations can be performed. These calculations will be described in greater detail in the next sections, please refer to Spot Checking of Strength in Critical Members and Comparison of Lateral Drift for these calculations.

**Spot Checking of Strength in Critical Members**

The most critical shear walls in my building are the ones on the fourth floor. These are the most critical because only half the wind load is applied to the top of the fifth floor. The members that were spot-checked are the end post and the header plate of the shear wall. At the fourth floor in the longitudinal direction, a force of 3.75k is applied in the end posts by the wind load. Checking the axial capacity of a light gauge metal stud, it was found that 1-6”x1 5/8” 12 gauge stud is good enough to carry the load when compared against $f_y = 50,000$ psi. For the header plate, a combination of axial and bending capacities needed to be included. When checking the member, it was found that 10-6”x1 5/8” 12 gauge studs were needed to adequately carry the
load. The calculation is the same in the transverse direction, except the load has changed. To see the spot-checking calculations, please refer to page 22-23.

**Comparison of Lateral Drift**

There are two drift calculations that are very important; these are story drift and overall building drift. Both of these drift calculations must be less than the industry standard of h/400. This standard is used because many studies have been done to determine what an exceptible movement could occur before the occupants could start feeling it. For my building, the maximum story drift allowed by h/400 is 0.30”. The maximum overall building drift allowed by h/400 is 1.48”. When these values are compared to the actual deflection of the shear walls under the applied load, all of the deflections are well within the limits of the standard. Take for example; the shear wall on the second floor in the longitudinal direction has a story drift of 0.07”, which is less than 0.30”. For the calculations of the story and overall drift, please refer to page 19-21.

**Building Torsion**

Building torsion is the action of twist that the building under goes when the load is applied to the building. This effect can be magnified when the center of rigidity is off the geometric center of the building. I am not sure how to go about this calculation; I will research into this area more so that in the resubmission, it will then be included.

**Discussion of Overall Lateral System Performance**

The overall lateral performance of the shear walls with X-bracing performs rather well in resisting the lateral loads applied to my building. This system also is great because it does not interfere with the living spaces because the act as walls between adjoining apartments, which need to be separated. Drift is one reason why the lateral system performs really well. All of the story drifts and overall building drift fall within the limits of the industry standard of h/400. In addition, the light gauge metal studs perform well in this condition as well. The only place were light gauge metal studs are a problem are in the shear wall header plates. Using a built-up 10-6”x1 5/8” 12 gauge stud is expensive and inefficient. However, this lateral system performs very well for this building.