Reinforced Concrete Reaction Wall

Jessica Gonzalez

The University of Texas at San Antonio, San Antonio TX, 78249

Name: *Jessica Gonzalez*
Status: *Senior*
Department: *Civil Engineering*
Area of Study: *Structural Engineering*
USDA/UTSA Mentor(s): *Wassim Ghannoum*

WeARE Research Area

This research project focuses on applying engineering concepts, such as, reinforced concrete design and structural analysis to design a 30-foot concrete reaction wall for testing full-scale structural components and systems. The design will be finalized using computer-aided design software.

Motivation or Background

The University of Texas at San Antonio (UTSA) recently opened up a Large-Scale Testing Laboratory (LST) for students and researchers in UTSA's Department of Civil and Environmental Engineering (Figure 1). This 15,000 square foot and 50-foot tall facility provides a space where civil engineering students can build and test structural systems in a large and realistic setting. The laboratory is equipped with a 40x80 foot reaction floor that provides researchers the ability to apply vertical forces to real-size structural systems and components. In order to further support research projects, a reaction wall was needed to apply lateral forces to structural systems and components (e.g., columns, shear walls, etc.). With the reaction wall, the LST will be equipped to allow students and researchers to test specimens using both vertical and lateral forces.

Fig. 1 - Large Scale Testing Laboratory

Objectives

Develop an optimal design for a reinforced concrete reaction wall with the following criteria and design tasks:

- Criteria
  - Versatile modular built-in blocks to be attached at different locations
  - Modular components shall not exceed crane lifting capacity of 60,000lbs
  - Resist a maximum lateral load of 400,000lbs at an elevation of 30 feet from the base of the wall
  - Each floor anchor has a 400,000lbs axial force limit
- Design Tasks
  - Check bending, shear, and sliding capacities
  - Determine steel reinforcement design in each modular component
  - Produce reinforcement schedule for fabricators use

Methodology

Through trial error we developed wall design that would maximize the amount of lateral force the reaction wall would be able to withstand while meeting all criteria. Various computer software programs were used (e.g., Microsoft Excel, MathCad, AutoCad, and Revit) to run intensive calculations along with designated structural codes and to develop layout and design of the reaction wall.

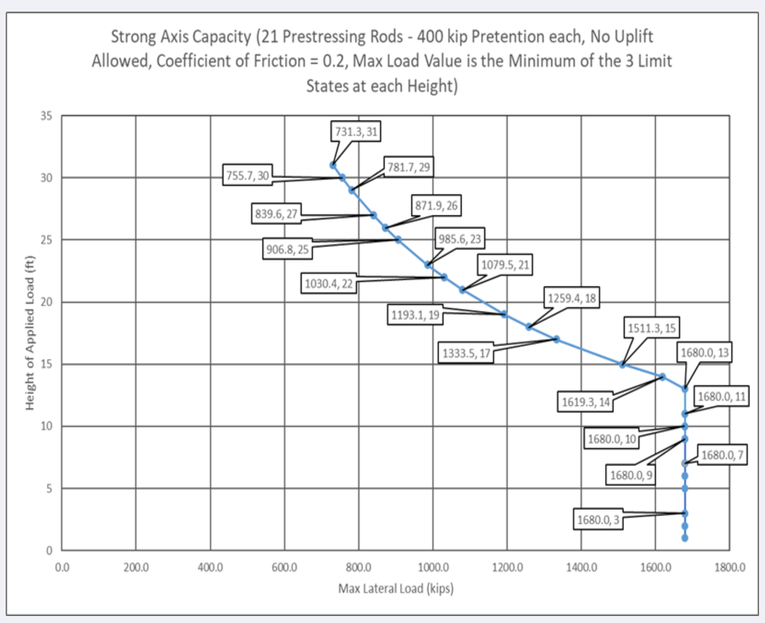

Fig 2 - Flexural, Shear, and Sliding Capacity Analysis

Results

An optimum design was chosen that would provide maximum strength while still being modular, simple to set up, and adaptable to the layout of the LST. The wall will consist of eight stacked up concrete blocks that are each 14'L X 9'W X 4'H. The blocks will be anchored to the floor by post stressing rods that will run through pre-positioned vertical conduits down to the LST reaction floor. Hydraulic actuators will be attached to the sides of a block using horizontal conduits within the block walls (Figure 3).

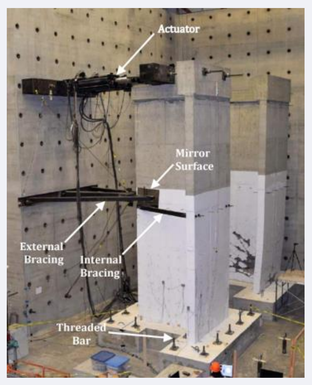

Fig 3 – Actuators Attached to Reaction Wall. Taken from Sajedul Huq, M. et al. (2017)

In order to develop higher flexural strength, an increase in the blocks moments of inertia about the x and y axes was needed (i.e., increase the footprint of the blocks to make them wider and longer). This was approached without adding extra weight by designing four voids in the modular blocks in order to meet crane limit criteria (Figure 4). Each block will weigh in at approximately 53,300lbs which is well within the LST crane's capabilities.

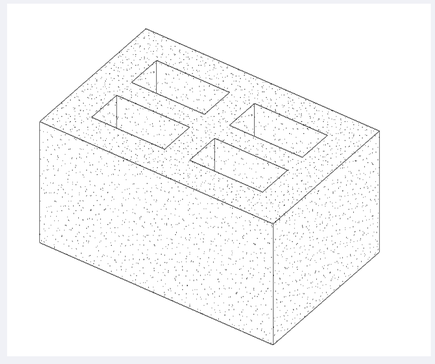

Fig 4 – Preliminary Modular Concrete Block

Skills and Experience

The skills and experience acquired throughout the duration of the research project consist of the following:

- Non conventional design from first principles
- Data organization and representation
- Learning new engineering design software
- Communication skills
- Teamwork

What I Learned

This project allowed me to practice the engineering concepts learned in class and apply them in a very unique way. I also learned how to keep a pragmatic point of view when designing. It was definitely a fun learning experience.

Future Plans

The reaction wall will allow UTSA's Department of Civil and Environmental Engineering gain more research opportunities by having the ability to test specimens using multiple load case scenarios. The research that will be done with this wall will expand our knowledge of how structures behave when they are suject to extreme lateral loading. The data collected from these experiments will lead to safer and more efficiently engineered structures in the future.

Acknowledgments

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References

Sajedul Huq, M., Weber-Kamin, A.S., Ameen, S., Lequesne, R.D., Lepage, A., "High-Strength Steel Bars in Reinforced Concrete Walls: Influence of Steel Mechanical Properties on Deformation Capacity," (06-14), Charles Pankow Foundation, pp. 318, December 2017.