Reinforced Concrete Reaction Wall

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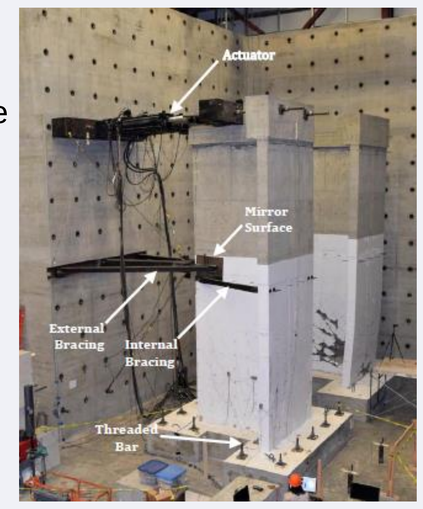
WeARE Research Area

This research project focuses on applying engineering concepts, such as, reinforced concrete design and structural analysis to design a 30-foot concrete reaction wall that will be used for the lateral load testing of full-scale structural components and systems.



Motivation or Background

The University of Texas at San Antonio (UTSA) recently opened up a Large-Scale Testing Laboratory (LST) that provides a space where researchers can build and test full size structural systems in a realistic setting. The laboratory's reaction floor provides researchers the ability to apply vertical loads of up to 1 million pounds. The faculty members in charge of the lab want to expand the capabilities of the LST to include lateral load testing of structural components (e.g., columns, shear walls, etc.).

Fig. 1 *UTSA LST Laboratory Exterior*

Fig. 2 *Strongwall at the University of Kansas*

Objectives

- Develop an optimal design for a reinforced concrete reaction wall
  1. Criteria
     - modular (built in blocks) to be attached in different locations and orientations
     - Each component could not exceed a weight of 60,000lbs to remain within crane capacity
     - Resist up to 400,000lbs applied at an elevation of 30 feet from the base of the wall
     - Floor anchors have a limit of 400,000lbs of axial force each
  2. Design Tasks
     - Verify shear, bending, and sliding strengths
     - Design the steel reinforcement in each concrete component
     - Produce a reinforcement schedule so each component of the wall can be constructed by a fabricator.

Methodology

- Assess the reaction floor to determine the locations of the anchorage points and the vertical support walls under the floor
- Optimize the block design to maximize anchorage points and moments of inertia, while still being able to anchor if rotated 90° and being kept under the 60,000lbs weight limit
- Calculate flexural, shear, and shear sliding capacities using Microsoft Excel and MathCAD to determine if the block design is sufficient
- Design the internal reinforcement using the ACI 318-19 design code to resist the localized forces that the individual blocks will be subject to during testing and finalize the reinforcement schedule

Fig. 3
LST Lab Interior and Visual of the Floor Anchor Points

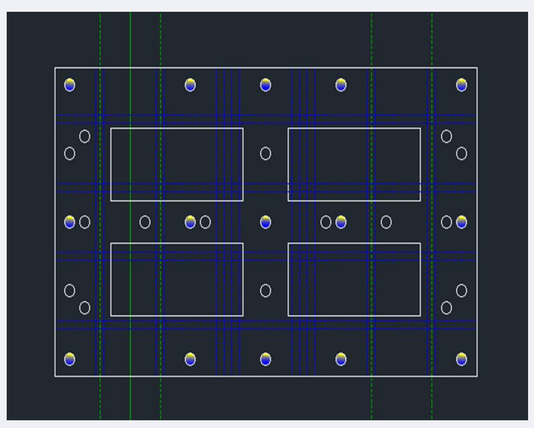


Fig. 4
Top view of the block showing the vertical conduits

Results

- The final dimensions of the reinforced concrete block are 14'L X 9'W X 4'H with four voids to reduce weight as seen in Fig. 5. Each block will weigh approximately 53,290lbs.
- The superstructure will consist of eight stacked blocks anchored to the floor by post stressing rods that will apply 400,000lbs of axial force each
- The post stressing rods will pass through each block in vertical conduits. Seen in Fig. 4
- When the reaction wall is in its strongest configuration, the superstructure will be able to resist lateral loads of up to 750,000lbs applied at an elevation of 30' from the base of the reaction wall. (Fig. 6) Loading will be reduced due to internal reinforcement capacities

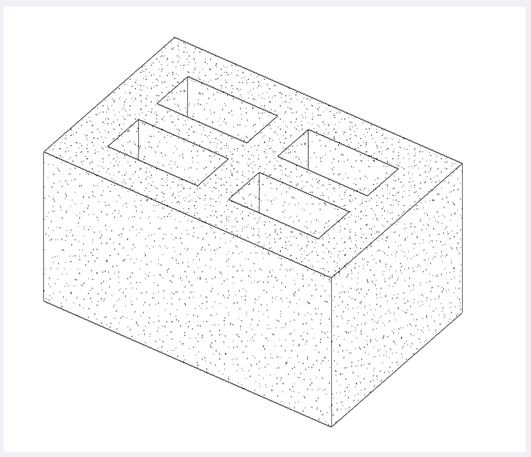


Fig. 5
Preliminary Wall Block Design using Revit

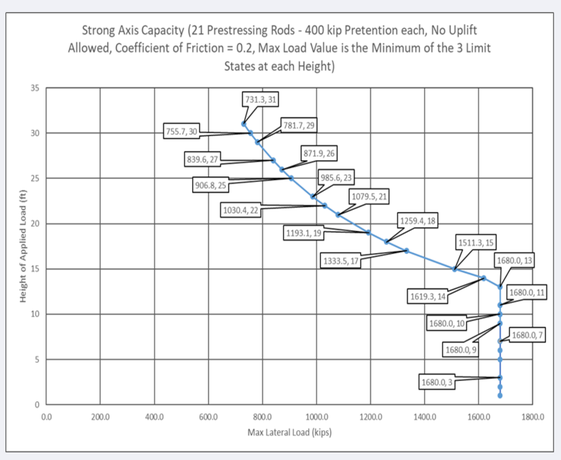


Fig. 6
Flexural, Shear, Shear Sliding Capacity Analysis

Skills and Experience

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

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

What I Learned

I started this project with a basic knowledge of reinforced concrete design and very little experience with engineering design software. I've gotten a lot of hands on experience with other engineering software programs and the concrete design aspect of the project has definitely thrown us a few curveballs as well. Hopefully I get to see it smash a shear wall in the future.

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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