Warren J. Baker Endowment
for Excellence in Project-Based Learning
Robert D. Koob Endowment *for Student Success*

FINAL REPORT

Final reports will be published on the Cal Poly Digital Commons website (http://digitalcommons.calpoly.edu).

I. Project Title

Experimental Building Demonstration Model with Viscous Dampers

II. Project Completion Date

6/10/2016

III. Students, Departments, and Majors

Student Applicants	**Cal Poly Email**	**Department**
Blake Thomas Reeve	reeve@calpoly.edu	ARCE
Brianna Kufa	bkufa@calpoly.edu	ARCE
Aden Malek Stepanians	amalekst@calpoly.edu	ME
Sophie Ratkovich	sratkovi@calpoly.edu	ME

IV. Faculty Advisor and Department

Faculty Advisors:

Peter Laursen, ARCE department, *email:* plaursen@calpoly.edu, *phone:* 805-756-6303
Andrew Davol, ME department, *email:* adavol@calpoly.edu, *phone: 805-756-1388*

V. Cooperating Industry, Agency, Non-Profit, or University Organization(s)--None

VI. Executive Summary

At the end of spring quarter, 2016, we were able to meet most of the objectives and complete basic testing of the structure, as described in the proposal. However, we were unable to complete a few things. Firstly, we were unable to fabricate supplemental beams and columns to be ready in the case a member needed to be replaced. Drawings will be provided so that future students or faculty can fabricate the members. Secondly, we were unable to run earthquake ground motions through the structure due to time constraints with the students graduating. Future graduate students in the ARCE department will be testing the structure next year by running various ground motions through the shake table and analyzing the performance to confirm the adequacy of the structure. Those experimental results will be compared with the calculations performed to see how accurate the analysis was.

We were able to shake the model at its first mode of vibration during the spring quarter of 2016 and we were able to determine that the structure was constructed adequately. A complete report detailing the design and calculations has been uploaded to the digital commons.

The list for future projects that can be tested on the model can be seen below. It should be noted that these are just project suggestions and this model was designed to give students creative freedom to experiment with the model and to create other experiments as well

Suggested future testing includes

- Damper arrangement effectiveness
- Actual base shear distribution per floor using strain gauges
- Design base isolator systems for the model
- Damage simulation by loosening bolts
- Mass irregularities and their effect on the building lateral forces
- Testing of various bracing systems

VII. Major Accomplishments

1. Construct a versatile building demonstration model
2. Leave the ARCE and ME departments with a lasting model that can be utilized by future students and integrate its use into ARCE courses
3. Predict structural behavior of buildings using supplemental damping devices
4. Determine critical variables in damper efficiency
5. Compare the actual behavior of the model under seismic loading with predicted behavior by common analysis techniques

VIII. Expenditure of Funds

Aluminum Tubing:	$ 563.72
Fasteners and hardware:	$ 698.35
Steel for Connections:	$ 694.02
Steel Weights:	$ 1197.55
Dampers:	$ 1292.38

Total: **$ 4446.02**

IX. Impact on Student Learning

Because of the hands on nature of the project, students learned far more than the initial goal of learning the design and analysis of structures with supplemental damping devices. In the field of structural engineering more and more essential structures such as hospitals or fire stations are turning towards energy dissipating devices to help reduce the demands of earthquakes like viscous dampers. The design knowledge gained from this project will be extremely beneficial in the workforce and will put the students one step ahead of the curve.

The greatest unintended outcome was developing connection design skills and the corresponding detailing of them. The size constraints, and unconventional design of the connections meant the students had to think critically of what was required of each connection and how to achieve the required strength. Designing with aluminum was a new challenge for the ARCE students, and they learned the specific design criteria for it. ARCE students also sharpened their computer modeling and numerical analysis techniques when solving problems. ME students learned more in depth about fatigue stresses and cyclic loading on materials.

Another outcome was learning fabrication and mass productions techniques. The ME students gained machining skills. The ARCE students developed jigs to enable the quick production of dozens of parts and assemblies.

All of the skills the students learned will help them to be an integrated engineer in the future.