



OZ Saferoom Team

OZ SAFEROOMS

Sponsor: Zagorski Forms Specialists, Inc.



Project Sponsor

Mission Statement: To structurally analyze and determine the survivability of OZ Saferoom structures

Project Information: OZ Saferooms are continuously poured steel-reinforced concrete structures designed to withstand natural disasters (Tornados). This project will assist Zagorski Forms Specialists, Inc. by providing them with structural analysis and experimental impact testing data to help validate the structural integrity of the OZ Saferoom product. The company, headquartered in Rochester, NY has installed 53 safe rooms during the time period from 2000 to 2004. These structures have been built in New York, Oklahoma, and Texas.

Project Goals:

- Structural analysis of steel-reinforced concrete structure
- Finite element analysis on four OZ Saferoom structures
- Determine the mechanical properties of the concrete following ASTM C 78-02 and C 39 concrete sample testing standards
- Impact testing on an existing OZ Saferoom in Macedon, NY
- Design of a sensor package for analyzing future OZ Saferoom structures subjected to an impact test

Sample Testing

Two factors that directly influence the performance of concrete are the bending and compressive strength. ASTM standards C 78-02 and C-39, were used for conducting three-point bending and compression testing respectively. From the sample testing experimentation, the Modulus of Elasticity and mass density of the concrete were determined.



14 in. x 4 in. x 4 in. specimen	W (lb)	Load _{max} (lb)	σ _{break} (psi)
AVG	19.07	2527.5	710.9
STDDEV	0.121	500.6	140.8

3-point bending testing results

6 in. diam. x 12 in. length specimen	W (lb)	Load _{max} (lb)	f _c (psi)
AVG	27.65	227157	8034.0
STDDEV	0.137	8868.0	313.6

Compression testing results

$$E_c = 57,000 \sqrt{f'_c} = 5.11 \times 10^6 \text{ psi}$$

$$\rho = 141 \frac{\text{lbm}}{\text{ft}^3}$$



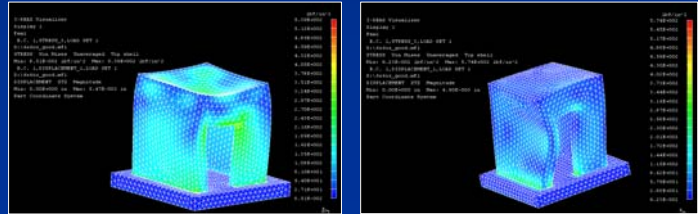
Failed compression specimen

Properties of concrete determined

Finite Element Analysis

In order to determine the survivability of each structure, the finite element models were loaded until failure. By comparing the stresses observed to the yield strength of the structure, one can determine the load which causes the structure to fail.

Analysis of 78 in. x 78 in. x 92 in. structure



Structure	Applied Pressure - Roof (psi)	Max Stress (psi)	Applied Pressure - Wall (psi)	Max Stress (psi)	250 mph Wind Pressure (psi)	Max Stress (psi)
78 in. x 78 in.	38	539	5.5	574	0.8125	54.9
102 in. x 102 in.	21.5	545	6	610	0.8125	33.3
126 in. x 126 in.	15.5	544	7	542	0.9097	34.5
240 in. x 360 in.	2.8	540	19	538	1.1597	32.1

Structure Failure: Max Stress > f_r

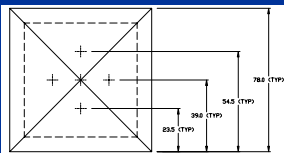
f_r = modulus of rupture
 $f_r = 6 \sqrt{f'_c} = 538 \text{ psi}$

Sensor Package Design

The sensor package will utilize anchor bolts (wire tied to rebar) for mounting the accelerometers inside the roof of the structure before the structure is constructed. Following yield line analysis, the accelerometers will be mounted at the locations below.

Description	QTY	Supplier
Accelerometer	5	PCB
Cable (100ft)	5	PCB
PC Interface Card	1	National Instruments
Signal Conditioner	1	National Instruments
SCXI Chassis	1	National Instruments
Labview Software	1	National Instruments
Computer	1	-
Anchor Bolt	5	McMaster-Carr
Wire Tie	-	-

Sensor Package Items



The Team



Project Mentor
Dr. Benjamin Varela

Left to Right: Rugved Phatak, Chris Moore, Matt Weaver, Matt Barton, Brett Kimball, Brian Conway

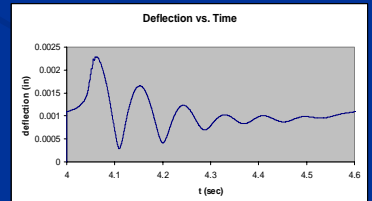
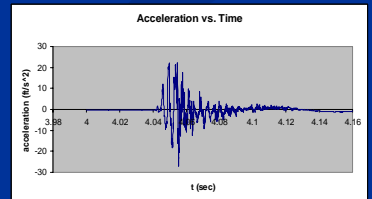
Impact Testing

Impact testing was performed on the existing 78 in. cubic structure in order to acquire its deflection and frequency response data. This data was then compared with finite element analysis to verify the models and results were correct.

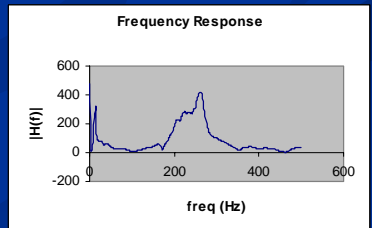


485 lb. load dropped from 20 ft.

Analysis of 485 lb. load dropped from 20 ft.



3,675 lb. Chevy Citation dropped from 15 ft.



Special Thanks to: Zagorski Forms Specialists, Inc., Dr. Benjamin Varela, Dr. Edward Hensel, Dr. Kevin Kochersberger, Dr. Abi Aghayere, Prof. John Wellin, and CME Associates, Inc.