

# Seismic Evaluation of a Green Building Structural System: ICF Grid Walls

Investigators, PI: Peter Dusicka, PhD  
 Students: Thomas Kay, Carl Werner and Max Stephens

## Need for Green Building Systems

The demand for green building construction is growing from commercial multi-story buildings to condominiums and single family homes. However, traditional methods of construction and conventional materials continue to dominate the structural systems of most buildings, including those aimed for green building recognition. The lack of rational design criteria for more sustainable alternatives to traditional structural systems makes their implementation difficult in new building construction, particularly in regions subject to significant seismic risk such as the Pacific Northwest.

## ICF Grid Walls – A Sustainable Alternative to Conventional Shear Walls

Insulated Concrete Form (ICF) grid walls consist of stay-in-place prefabricated blocks that when stacked form an internal lattice of hollow cores (Figure 1A). The cores are filled with rebar and concrete (Figure 1B) resulting in a reinforced concrete grid responsible for the wall's structural integrity for both vertical and horizontal loads. ICF grid walls are intended to serve as a building's shear wall system and offer a more sustainable alternative to traditional reinforced concrete shear walls. A typical building built using ICF grid walls is shown in Figure 1C.



(A) Erection of ICF grid wall form (B) Concrete placement in cores



(C) Building constructed with ICF grid walls

Figure 1 – ICF Grid Wall Construction

ICF Grid Wall Advantages:

- 1) ICF blocks can be manufactured from a variety of recycled materials, such as post-consumer polystyrene and recycled wood products
- 2) ICF grid walls require virtually no formwork to construct, thereby reducing the labor costs and material waste associated with construction
- 3) ICF grid walls use up to 40% less concrete than conventional reinforced concrete walls
- 4) ICF material is an excellent thermal insulator and produces a wall that can save the building occupant up to 40% in heating and cooling costs.

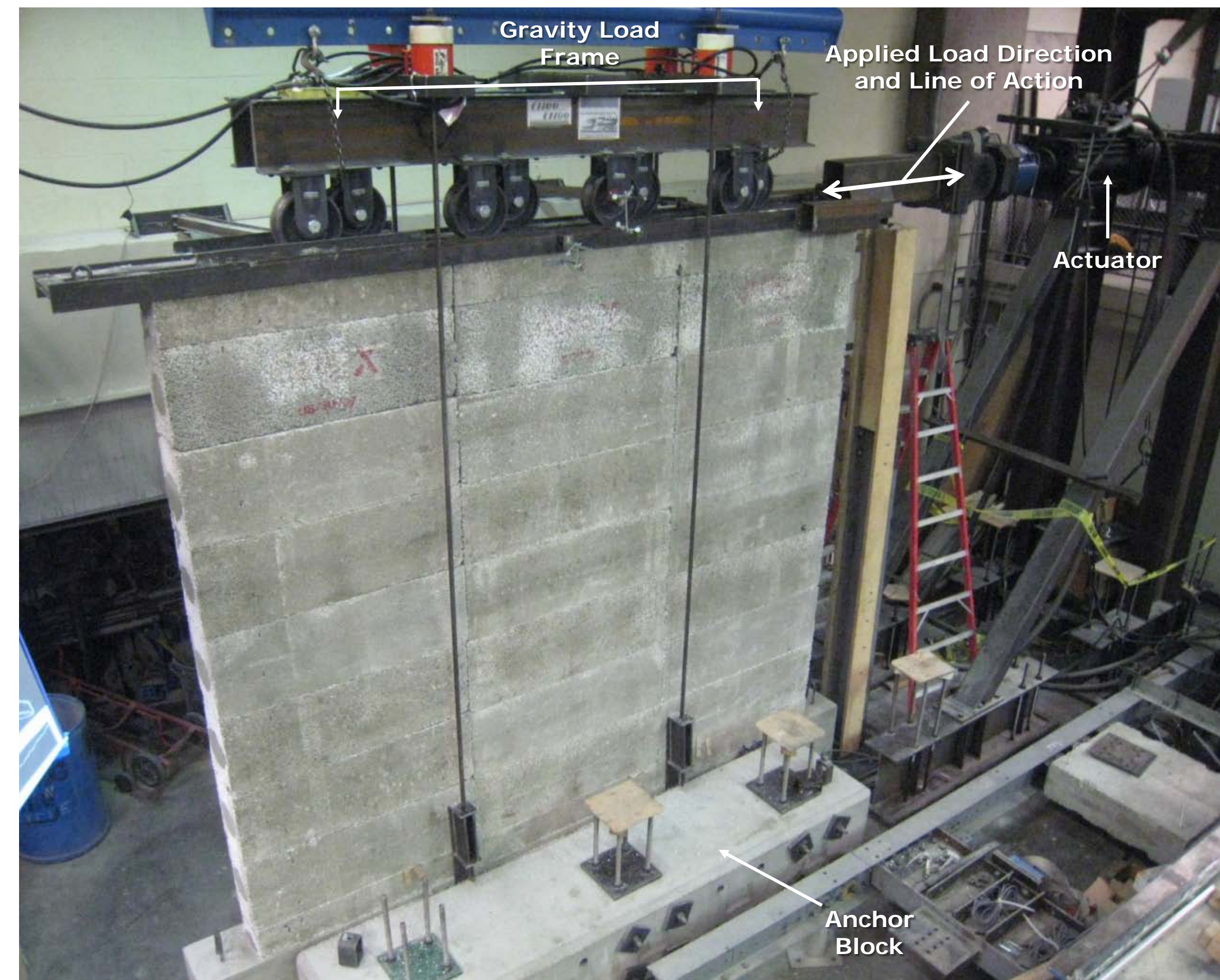


Figure 2 – Load Frame for Cyclic Load Tests of Shear Walls

## Objectives

Limited data is available on the seismic performance of ICF grid walls and existing design guidelines have not been verified experimentally. This study's objectives are to

- 1) Evaluate shear resistance and drift capacity of ICF grid walls subject to cyclic loading and generate data that would serve as a basis for future design procedure development,
- 2) Characterize failure modes in ICF grid wall subject to cyclic loading,
- 3) Verify that the current design procedures for ICF grid walls are capable of reliably predicting shear wall resistance,
- 4) Investigate the role of the ICF material's contribution to wall performance – which is assumed to be negligible in existing design procedures.

Displacement-controlled reversed cyclic loading tests were conducted on a series of sample ICF grid walls and conventional reinforced concrete walls. Sample walls were tested to failure using the load frame shown in Figure 2 which consists of a 220 kip capacity actuator with a 20 inch stroke mounted to a lateral reaction frame and two anchor blocks secured to the lab floor. Load was applied such to produce a series of cycle sets – where each cycle set comprised of three fully reversed cycles of increasing amplitude 1.4 times greater than the previous cycle set (Figure 3). Pseudo-static application of the load allowed for the capture of high-resolution load and displacement data.

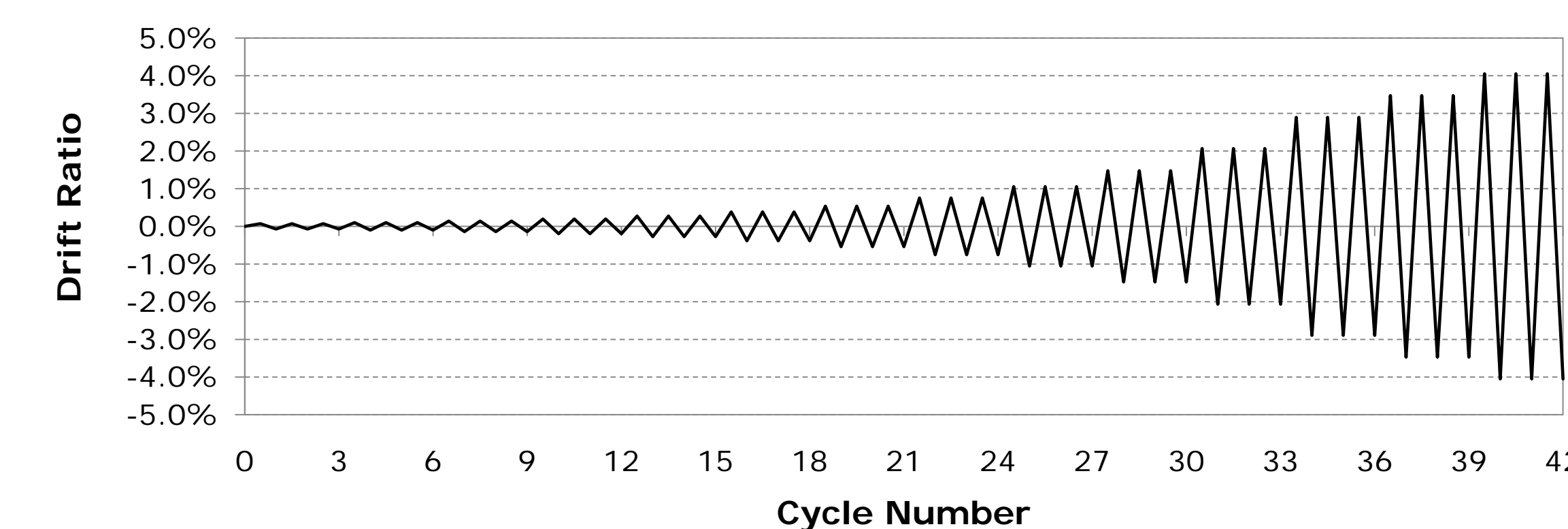


Figure 3 – Displacement History for Cyclic Load Tests

## Results

Several wall samples were prepared according to the test matrix described in Table 1 and tested to failure. This project is still ongoing, but preliminary test results shown in Figure 4 plot the hysteretic behavior and response envelope for a 4 ft and 12 ft ICF grid wall under nominal gravity loads. Failure occurred near the bottom of the wall at the point where the foundation rebar splices into the wall reinforcement. The 4 ft wall exhibited ductile behavior where strength degradation did not occur until drift cycles beyond 2%. The 12 ft wall showed a peak strength at 0.5% drift and significant strength degradation beyond 1% drift.

Table 1 – Test Matrix

Wall Type	Length	Gravity Load	Top Wall Connection
4.5" Thick R/C Shear Wall	4'-0"	nominal	-
	12'-0"	nominal	-
APEX Wall	4'-0"	nominal	cores
		10,000 lb/ft	cores
	12'-0"	nominal	4" int. bond beam
		10,000 lb/ft	4" int. bond beam
APEX Wall - Cores Only	12'-0"	nominal	11" int. bond beam
		nominal	11" int. bond beam

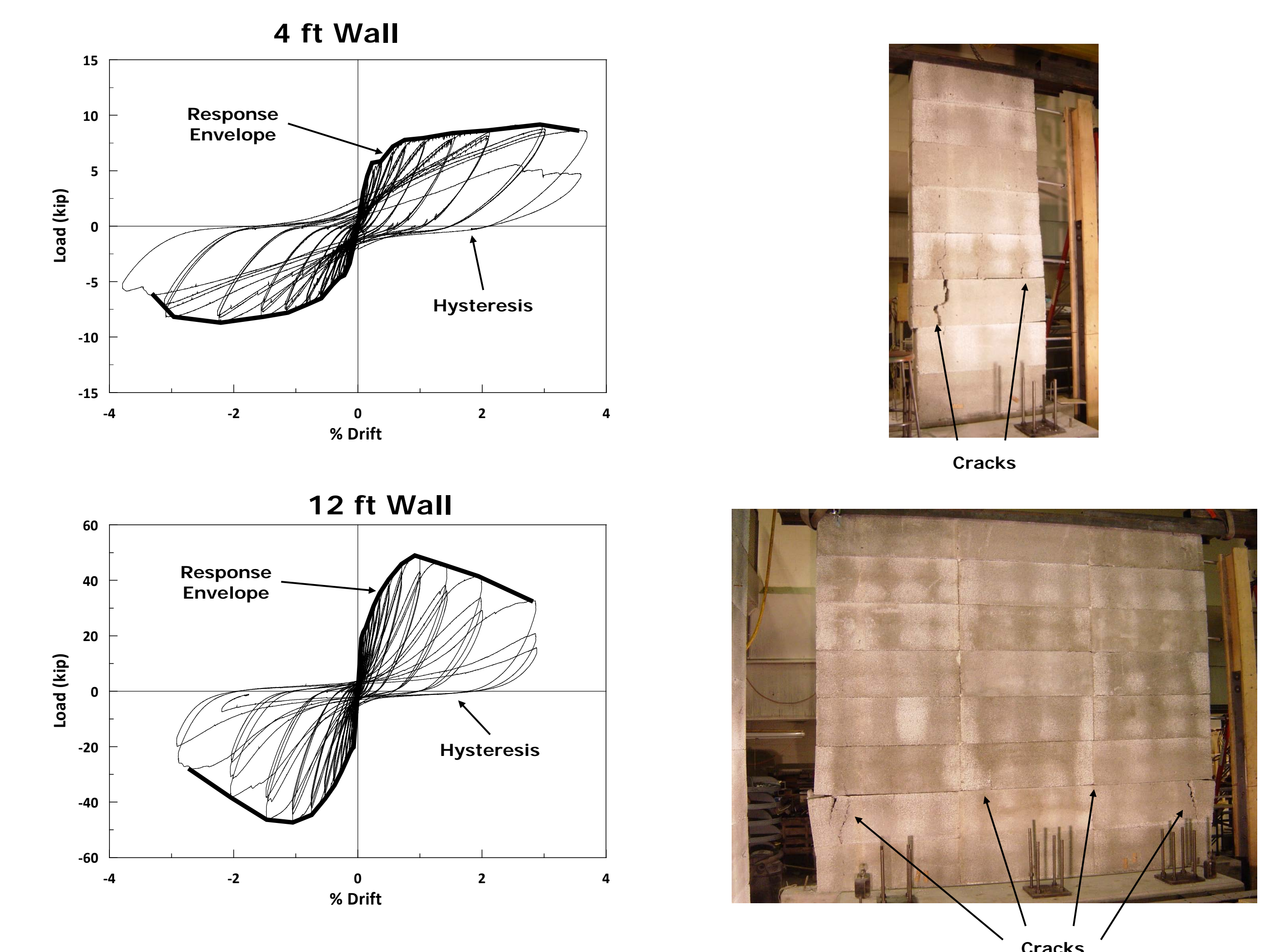


Figure 5 – Hysteresis, Response Envelope and Pictures at Failure

## Summary

The experimental program is ongoing, but preliminary results indicate that potential exists for the use of ICF grid walls in seismicly active regions. Additionally, the test plan used to evaluate this structural system is yielding data that suitable for the eventual development of future rational design criteria.