UNIVERSITY OF TORONTO SHEAR WALLS

Background

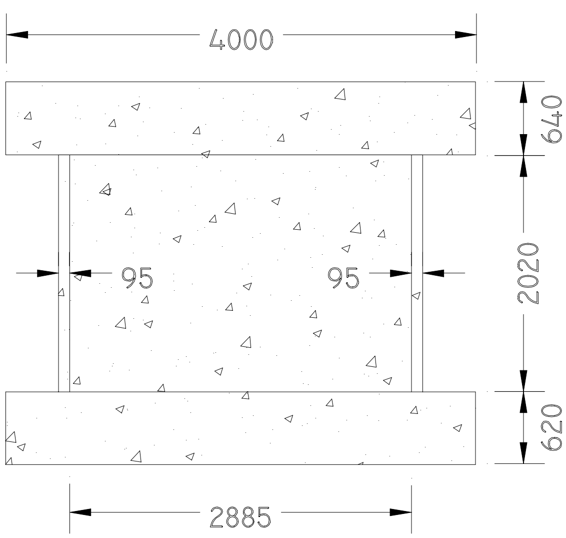
The results of the Seismic Shear Wall International Standard Problem (SSWISP) conducted by NUPEC (Nuclear Power Engineering Corporation of Japan) indicated that the ability to predict peak strength of shear walls under seismic excitations is not well established. More importantly, however, is the apparent inability of leading researchers to accurately predict structure ductility.

For the finite element static models, the analytical maximum load results varied between 65 to 115 % of the experimental value. A greater variation was evident in the calculated displacement at peak load. The range was from 35 to 180 % of the displacement recorded by NUPEC. The majority of the results underestimated the peak strength and ductility of the shear wall.

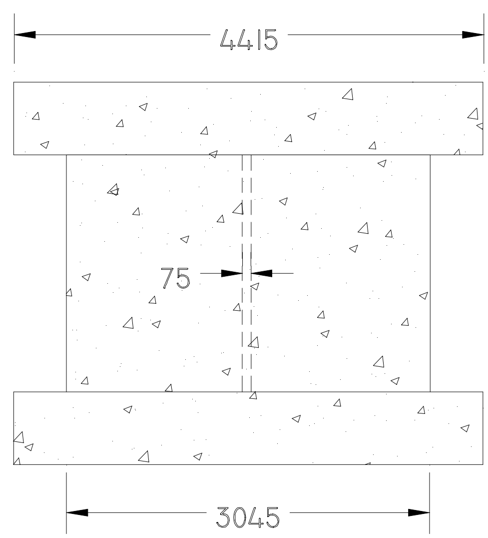
The difficulties with predicting ductility led to large scale testing of 3-D shear walls at the University of Toronto. Presented here are the details of the shear wall specimens DP1 and DP2.

Geometry

The two test specimens had identical geometrical properties. All dimensions are in mm. Specimen DP2, however, had a flange thickness of 100 mm.



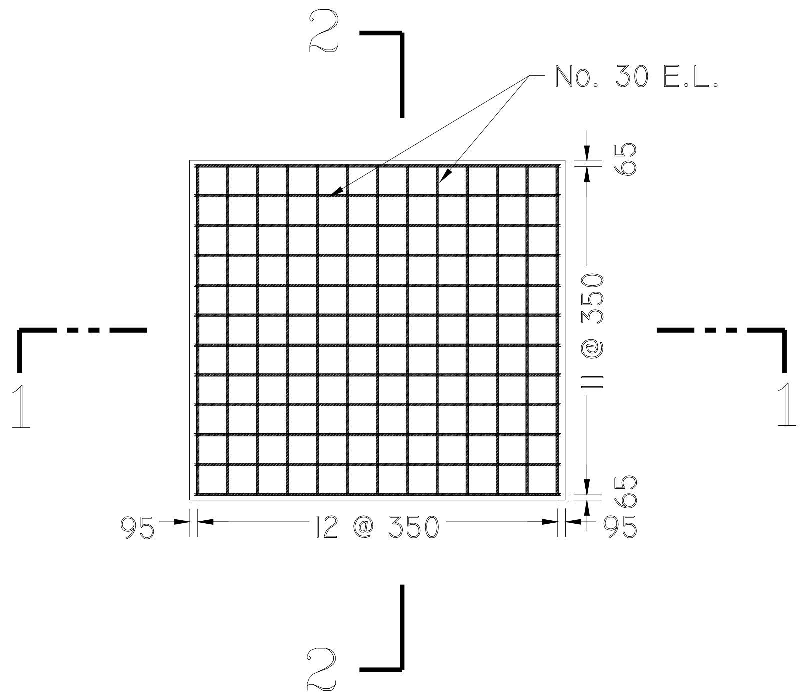
Web View



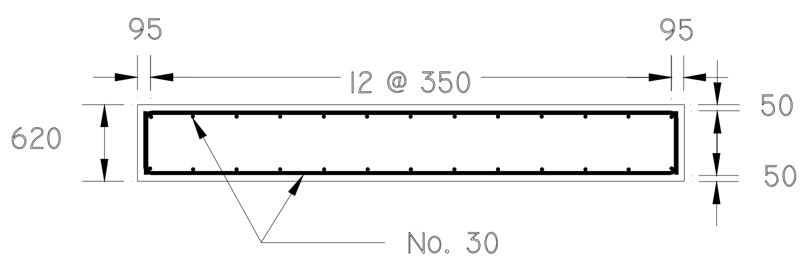
Flange View

Reinforcement

The top and bottom slabs were reinforced with No. 30 deformed reinforcing bars at a spacing of 350 mm in two perpendicular directions, with a top and bottom layer. A 500 mm hook was provided at the ends of the bars.

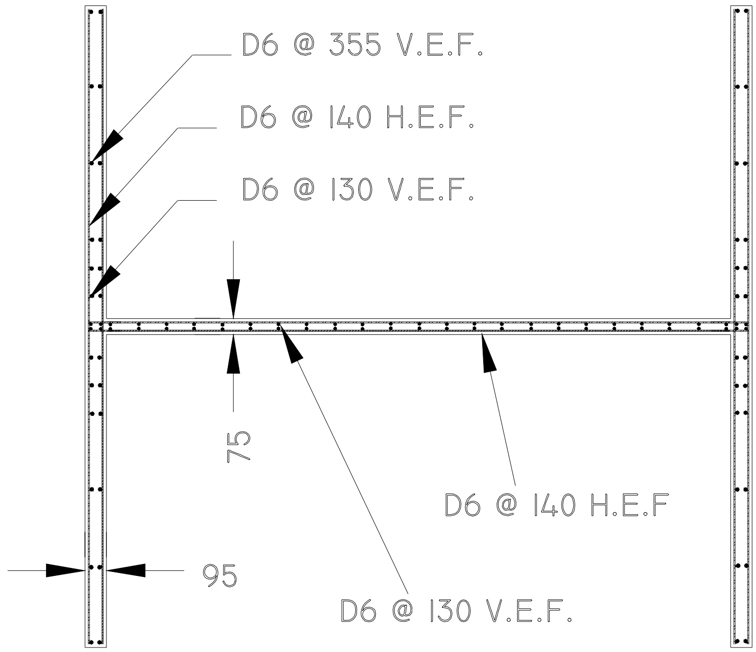


Top View of Slab Reinforcement

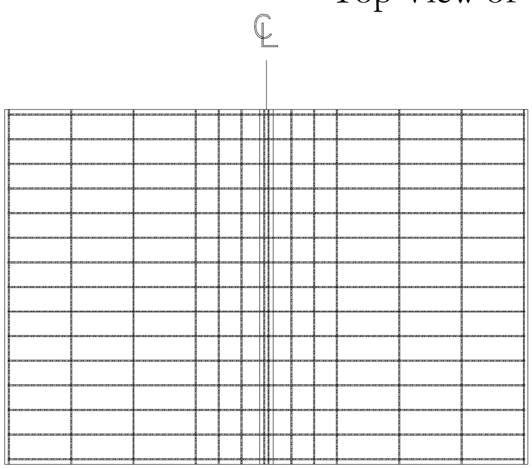


Section 1-1

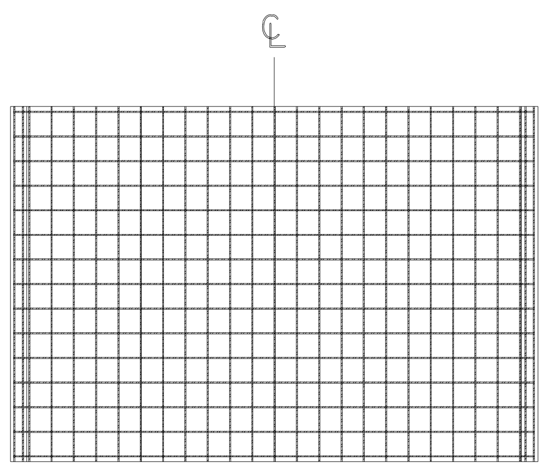
The web and flanges walls were reinforced with D6 reinforcing bars. The bars were spaced 140 mm horizontally and 130 mm vertically in the web. In the flanges, the horizontal reinforcement was spaced 140 mm, and the vertical bars were spaced 130 mm near the web wall and 355 mm near the flange tips. The horizontal bars in the web were hooked for a length of 500 mm and anchored into the flange walls. The web vertical bars extended to the ends of the top and bottom slab and were also hooked for a length of 500 mm.



Top View of Wall Reinforcement



Flange Reinforcement



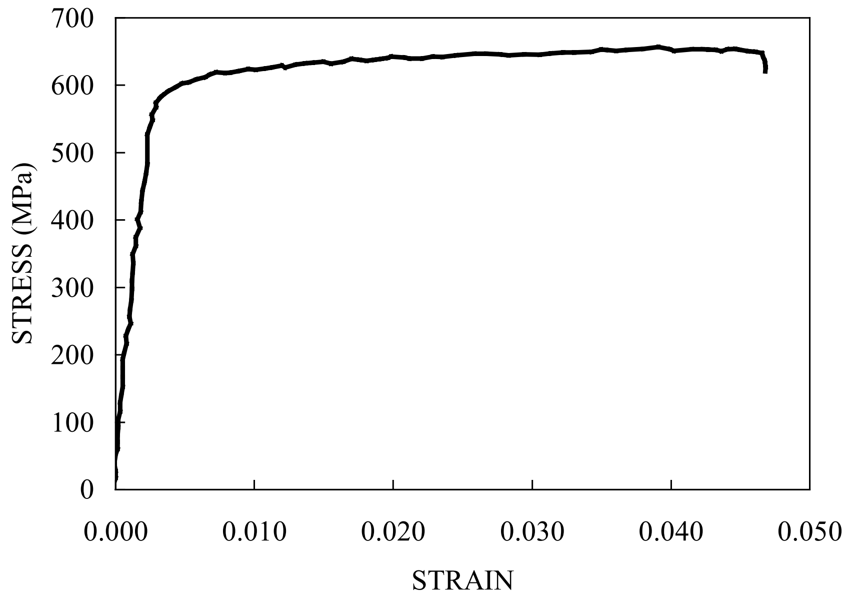
Web Reinforcement

Material Properties

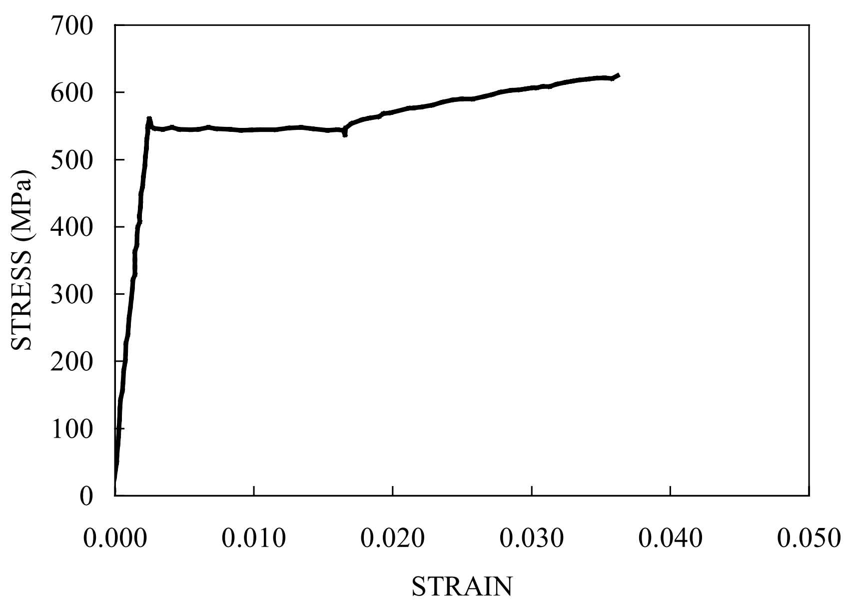
Reinforcement Properties

The values given in the table to follow represent an average of the coupon tests on samples of each reinforcement type. Note that the plot shows that the bar ruptured at a lower strain. This was the result of rupturing of the bar outside of the gauge length. The rupture strain was determined from a coupon test where the bar area was reduced within the gauge length.

Bar Type	Diameter (mm)	Yield Stress (MPa)	Yield Strain ($x10^{-3}$)	Ultimate Stress (MPa)	Rupture Strain ($x10^{-3}$)
D6	7	605	3.18	652	88.3
No. 30	29.9	550	2.51	696	N.A.



Typical Stress-Strain Response For D6 Reinforcement



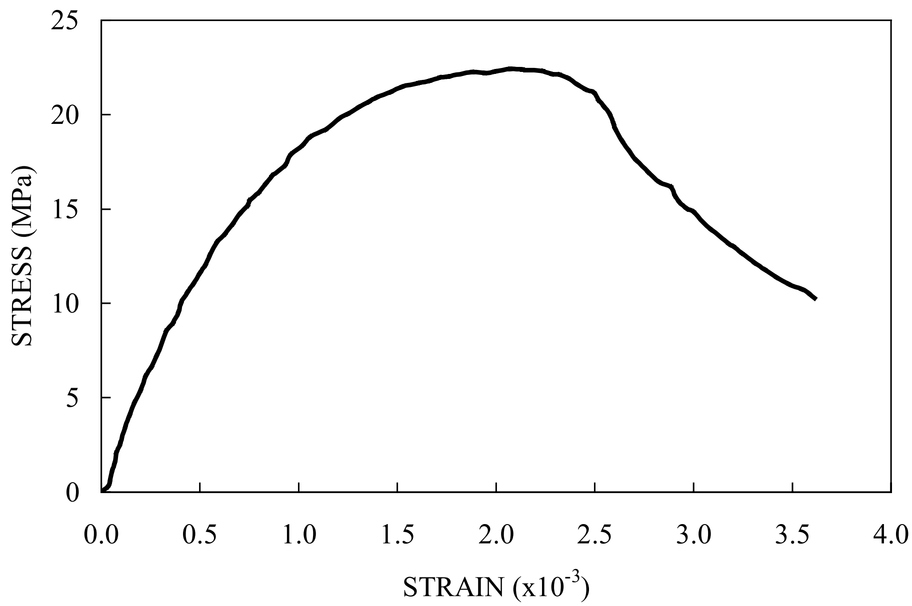
Typical Stress-Strain Response For No. 30 Reinforcement

Concrete Properties

The values given in the table below represent an average of the cylinders tested at the onset of testing.

	$f'c$ (MPa)		$\varepsilon'c$ ($x10^{-3}$)		amax (mm)
	DP1	DP2	DP1	DP2	
Web Walls	21.7	19.4	2.04	2.15	10
Flange Walls	21.7	19.4	2.04	2.15	10
Top Slab	43.9	39.3	1.93	1.88	10
Bottom Slab	34.7	34.7	1.66	1.66	10

$f'c$ is the peak cylinder stress, $\varepsilon'c$ is the strain at peak stress, and amax is the maximum aggregate size in the concrete mix.



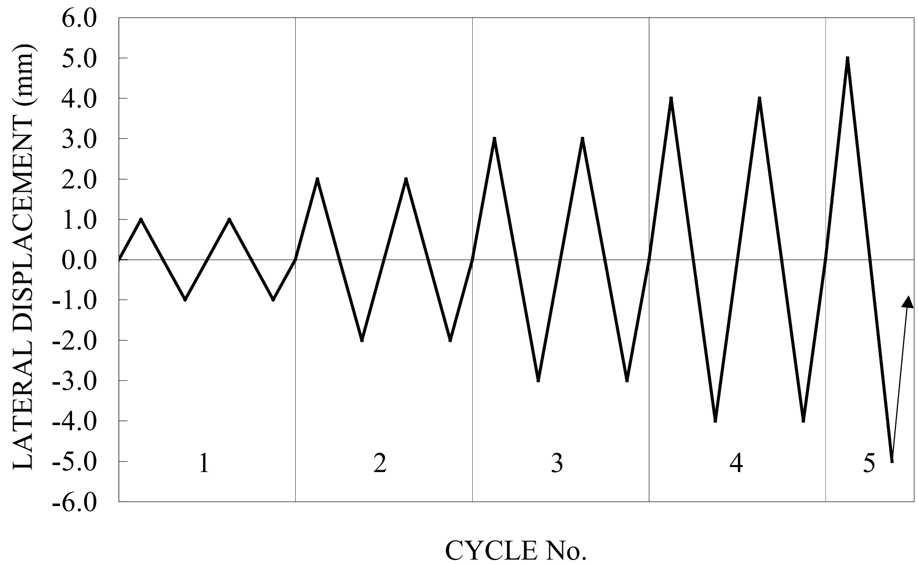
Typical Stress-Strain Response For DP1 Walls

Loading Application

The loading application was identical for the two tests, except for the exclusion of the applied axial load on test DP2.

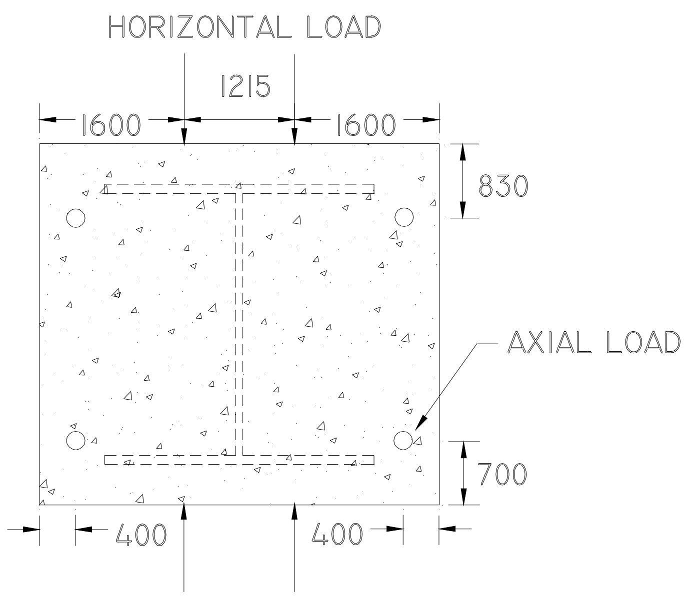
The total applied axial load for DP1, including weight of the top slab, was 1200 kN. It was introduced at the four corners of the top slab and distributed along two spreader beams, and remained constant throughout the test. No Axial load was applied with DP2.

The horizontal cyclic displacements were applied at the mid height of the top slab along two points of application. Displacements were incremented in steps of 1 mm with two repetitions per displacement level. Refer to sketch.

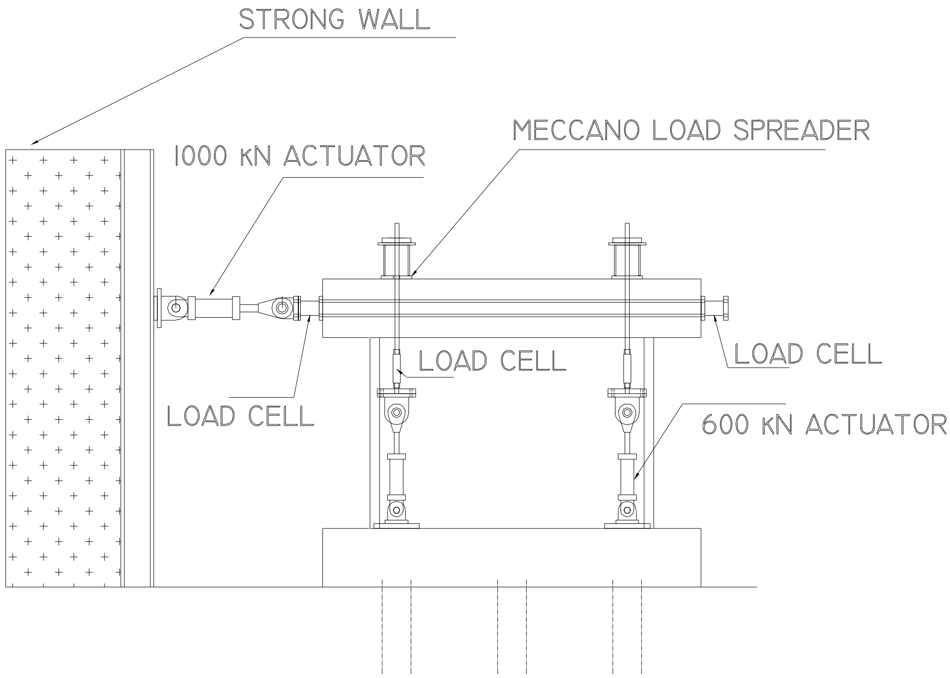


Lateral Loading History

Forty floor bolts were used to clamp the base slab to the laboratory strong floor to simulate a rigid foundation.



Top View of Loading Application



Testing Rig Setup

Other Details

Specimen	Age of Specimen at Loading (Days)	Time to Complete Testing (Days)
DP1	183	11
DP2	168	8