# Cyclic Behavior of Concrete Shear Walls: A Rational Approach

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**Abstract**

Evidence from structural failure in past earthquakes clearly shows that shear walls offer excellent protection to buildings in seismic regions. The behavior of large reinforced concrete shear walls can be visualized as assemblies of membrane elements. Understanding the behavior of reinforced concrete elements under cyclic loading makes it possible to predict the behavior of shear walls under an earthquake. To date three reinforced concrete panels were subjected to reversed cyclic pure shear conditions at the University of Houston using the Universal Panel Tester. The strains and forces of the test panels in the principal directions were measured to understand the behavior of concrete and steel bars under reversed cyclic loading. The test results indicated that if shear reinforcements are arranged in the applied principal stress directions, the energy dissipation of the panel is remarkably large. New constitutive models for concrete and steel reinforcing bars embedded in reinforced concrete under cyclic loading are being proposed.

## 1. Introduction

In the past, the behavior of low-rise shear walls have been studied by directly testing scale-down models of the whole structures. Although these studies yielded valuable information, they were inadequate for establishing a rational model for the prediction of wall behavior based on the element level. In recent years, a rational two step approach was initiated. In the first step, a structure is visualized as assemblage of membrane elements (panels) which are subjected to laboratory studies. The static behavior of individual concrete panels has been studied under the condition of shear and normal stresses, and the analytical models are developed to predict the stress-strain relationships of the elements 1,2,3. In the second step, the behavior of membrane elements is integrated by finite element method to obtain the behavior of the whole structures. As far as cyclic behavior of the elements is concerned, previous tests provided very limited information before the yield point because they were performed under load-control conditions. Such tests could not demonstrate the important hysteresis characteristics, such as cyclic shear deformation, the degradation in strength and stiffness of concrete.

To study the cyclic behavior of panels beyond the yield point, tests must be performed using strain-control procedures. Such tests were carried out using Universal Panel Tester at the University of Houston, which is equipped with a servo-control system that allows mode switches from load-control to strain-control during the testing of the reinforced concrete panels.

## 2. Specimens and Experimental procedures

To date, three reinforced concrete panels have tested using the Universal Panel Tester under pure cyclic shear. The dimension of each panel is 55 in. square and the thickness varied between 7 and 8 inches depending on the size of the reinforcing bars being used. The diameters of the reinforcing steel bars were as followed: 1/2 in., 3/4 in. and 1 in. The steel bars was set parallel to the direction of the principal stresses. The strength of the concrete was designed to be 6000 psi. The Universal Panel Tester consists of 40 in-plane jacks of 100-tons capacity and 20 out-of-plane jacks of 60-tons capacity. The loads were applied such that a state of pure shear prevailed throughout the loading history.

## 3. Experimental Results

According to the test results of the three panels, the following observations were made:

1. When the steel bars are oriented in the direction of principal stresses, the panels can be subjected to reversed cyclic loading up to ten times the yield load without any pinching effect or strength degradation.

2. Stiffness degradation was observed with increasing strain magnitude of reversed cyclic loading

Also, constitutive models are being prepared which describes the cyclic behavior of a steel bar embedded in concrete as well as the cyclic behavior of concrete under cyclic loading.

## 4. Acknowledgment

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## 5. References

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