SHEAR REQUIREMENTS FOR LOAD REVERSALS ON REINFORCED CONCRETE MEMBERS

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The ductility of structures subjected to load reversals is dependent on hinging regions in the members maintaining both flexural and shear capacity. Generally, shear stresses in such members do not produce distress under unidirectional loading to failure. However, under repeated and reversed loads producing large deformations, shear distress may become evident and limit the ductility of the members. With the expansion of research into the behavior of structures under seismic loading, a number of experimental investigations have been conducted to evaluate the shear requirements at flexural hinges. Because the load histories imposed on test specimens were not the same in all investigations, it is difficult to compare results and to determine shear requirements for members subjected to load reversals. In order to make comparisons between tests reported in the literature on members under cyclic loadings, a means of evaluating the severity of loading on different test specimens is needed.

The difficulty in evaluating the test results lies primarily in the different loading histories used by various investigators. In order to make comparisons between specimens subjected to widely varying load histories, a work index was defined. The work index is a measure of the energy absorbed at the hinging region during the loading history. Modifications were made to the index to account for the influence of the shear span and axial compression on the shear and energy absorbing capacity of the hinging region.

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Results from seven different investigations were considered and a total of 65 tests was included. In all cases the specimens reached flexural capacity and under continued cycling failed in a shear mode. Using the work index as a basis for comparing load histories, it was concluded that:

(a) Where hinging regions are subjected to reversal of loading, ultimate shear stresses imposed on the section (enclosed within the transverse reinforcement) should be limited to values of 6 to $7\sqrt{f'_c}$. This is considerably less than the maximum of $11.5\sqrt{f'_c}$ allowed by the ACI Code.

(b) If the section is proportioned to limit shear stress to 6 or $7\sqrt{f'_c}$, the transverse reinforcement should be designed to carry a shear equal to the maximum shear imposed on the section. If the section is designed using lower limiting values of shear stress, it may be possible to relax the requirements for transverse reinforcement; however, additional data are needed to clarify this point.

(c) The test results show that limits on the spacing of the transverse reinforcement (spacing less than one-fourth the effective depth of the member, or 4 to 6 times the diameter of the longitudinal bar) are needed to prevent buckling of the longitudinal reinforcement.