



ERRATA SP-206

Concrete: Material Science to Application - A Tribute to Surendra P. Shah

In the printing of SP-206, page 11 of “Failure Mechanism of Reinforced Concrete Under Cyclic Loading” by T. C. Hsu and M. Y. Mansour was omitted. This page should be inserted between pages 10 and 11. The missing text appears below:

Panel CE3 ($\alpha_2 = 90^\circ$) - Fig. 7 shows the various Mohr circles at the four points, A, B, C, and D, chosen on Fig. 5(b). Notice that the smeared steel stresses of the longitudinal and transverse steel are now plotted on the horizontal axis, because these steel stresses are oriented in the direction of the applied principal stresses.

At point A in the first post-yield cycle, Fig. 7, the maximum applied shear stress, τ_{45° , of 4.79 MPa produces a large shear strain, γ_{45° , of 0.00374. To resist this applied shear stress, the concrete is subjected to a maximum vertical compressive stress, σ_V^C , of 4.58 MPa, and a maximum smeared steel stresses, $\rho_\ell f_\ell$, of 4.47 MPa in the longitudinal directions. The compressive steel stress of -0.21 MPa in the transverse direction is small.

When the panel is unloaded from point A to point B, the applied shear stress of 4.79 MPa is reduced to virtually zero. From equilibrium, the compressive stress in the concrete and the tensile stress in the steel are also approaching zero. Correspondingly, the shear strain is reduced from 0.00374 at point A to a value of 0.00182 at point B. This unloading process produces an almost linear shear stiffness due to the normal relaxation of steel and concrete. These nearly proportional reductions of stresses in the concrete and steel are also related to the closing of cracks in the vertical direction. The horizontal strain, ε_H , decreases from 0.00724 at point A to 0.00362 at point B, but remains in tension with significant size of crack width. The compressive strain in the vertical direction, ε_V , also decreases from -0.00012 at point A to nearly zero at point B.

When the positive shear strain of 0.00182 at point B is reversed to become a negative shear strain of -0.00178 at point C, the vertical strain increases to a tensile strain of 0.00192, while the horizontal strain further decreases to a small tensile value of 0.00014 (not in compression). This large change of shear strain through the origin is accompanied by a large increase of the applied

shear stress, τ_{45° , from 0.09 MPa at point B to 4.76 MPa at point C, meaning that the shear stiffness in the BC region is large. This large shear stress is supplied by a simple internal mechanism as follows: Although the vertical cracks at point C do not fully close to form the compression struts and the Mohr circle for concrete is very small, the principal compressive stress is actually resisted by the longitudinal steel. It is clear that the large shear stress is resisted primarily by the transverse steel with a smeared stress of 4.24 MPa in the principal tension direction, and by the longitudinal steel with a smeared compressive stress of -3.43 MPa in the principal compression direction.

After yielding of steel at point C, the applied shear stress and the stresses in the concrete and steel all remain essentially constant up to point D. The