ABSTRACT

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The potential use of high-strength steel reinforcement (HSSR) with yield stress (f_y) larger than 80 ksi requires reconsideration of design criteria and limits used to avoid sudden failure because they were conceived for elements with Gr. 60 and 80 (f_y=60 and 80 ksi) reinforcement. The objective of this study is to investigate the feasibility of using HSSR for applications not related to seismic demands, with a focus on three topics: (i) minimum flexural reinforcement in slabs and walls, (ii) maximum flexural reinforcement in beams, and (iii) crack widths and deflections. Nine slabs with gross longitudinal reinforcement ratio (ρ_g) between 0.07% and 0.18%, four walls with ρ_g between 0.07% and 0.24%, and six continuous beams with longitudinal reinforcement ratio between 0.8% and 2.5% and a net tensile strain of approximately 0.005 were tested to study the strength, toughness, and serviceability of elements with HSSR.

The test data indicated that it is feasible to use HSSR for applications not related to seismic demands. The following conclusions are made in relation to the three specific topics investigated:

1) Minimum longitudinal reinforcement ratio for slabs can be reduced in inverse proportion to increase in yield stress. Test slabs with HSSR and ρ_g as small as 0.09% had rotational capacities larger than 4%. Nevertheless, prudence is due because brittle failure at small displacements may occur in lightly reinforced elements in which cracking moment exceeds yield moment (M_{cr}>M_y).

2) In walls with products of gross reinforcement ratio and yield stress smaller than approximately 100 psi, failure took place just after first cracking and at loads lower than that at first cracking suggesting that flexural elements in this range should be avoided in all structures no matter how low the probability of cracking is estimated to be. This is especially critical for ordinary structural walls without confined boundary elements in seismic regions.

3) In the tests conducted, sections with HSSR designed to have net tensile strain (ε_t) of 0.005 had sufficient rotational capacity for moment redistribution. In design, detailing to accommodate increases in shear and bond demands caused by load redistribution is needed and may be as critical as controlling maximum reinforcement ratio through ε_t to avoid brittle failure.

4) Test data suggest that extrapolation of minimum thickness for one-way slabs with HSSR as the thickness required for an element with working stress of 40 ksi multiplied by a factor related to service stress in the reinforcing bars (f_s), $0.4 + \frac{3 f_s(ksi)}{200 ksi}$, would lead to acceptable immediate and long-term deflections.

5) According to the measurements made, reduction in bar spacing (s) with increase in working stress in the reinforcing bars (f_s), determined as $s = 15\left(\frac{40{,}000}{f_s(psi)}\right) - 2.5 * cover$, would be sufficient to avoid intolerable crack widths even in elements with working stresses up to 80 ksi.