Welded Reinforcement Grids

Rising to Meet the Demands of a New Millennium

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Reinforced concrete structures are rising, like California's tallest such building in San Francisco, The Millennium Tower, at 58 stories (*Figure 1; SER: DeSimone Consulting Engineers*). As the upsurge in tall building construction along the West Coast reflects a global trend, California in particular faces the additional challenge of being a highly seismic region. The parameters of safe and efficient design of concrete structures vulnerable to earthquakes are a source of ongoing research and development by design and construction engineers, which involves large-scale testing, as described by Steven McCabe in the December issue of STRUCTURE® (*The Promise of NEES*), as well as individual component testing. The objective is to gain a better understanding of the expected overall system performance and validate new design ideas and construction products.

Bend but Don't Break

Designers of concrete structures that need to provide resistance to strong earth motions, hurricane winds and blasts are looking to the cornerstone of concrete design – the balance of strength and ductility. Increasingly engineers are specifying higher strength concrete while the ductility, the property that allows the structure to bend but not break, is maintained through careful detailing of the reinforcing, particularly in plastic hinge regions. When properly designed and detailed, it is the transverse reinforcement that provides the concrete with ductility during an earthquake by keeping the critical core strength of members intact and the longitudinal reinforcing steel in place. Since early last century, this has been achieved by using closely spaced hoops and crossties. These structures, designed in accordance with the more stringent code requirements for this century, require bends, hooks, and hook extensions in their transverse assemblies that, quite often, result in labor-intensive construction, reinforcement congestion and concrete placement problems.

First conceived in 1987 to overcome these obstacles in narrow shear walls of a 17-story building in San Francisco, welded reinforcement grids were tested in shear wall boundary elements at the University of California at Berkeley (UCB). The grids are now manufactured with high-strength, cold-drawn wire, up to ¾-inch diameter, placed in two layers, and fuse-welded at every intersection using modern proprietary welding techniques and strict quality assurance procedures developed by the authors in conjunction with researchers. During manufacture, the welds are rigorously tested per ASTM A185 and additional proprietary tests based upon findings of many tests of near and full-size concrete specimens reinforced with the patented welded reinforcement grid. These tests were performed at accredited national and international laboratories where the concrete specimens reinforced with proprietary welded reinforcement grids were subjected

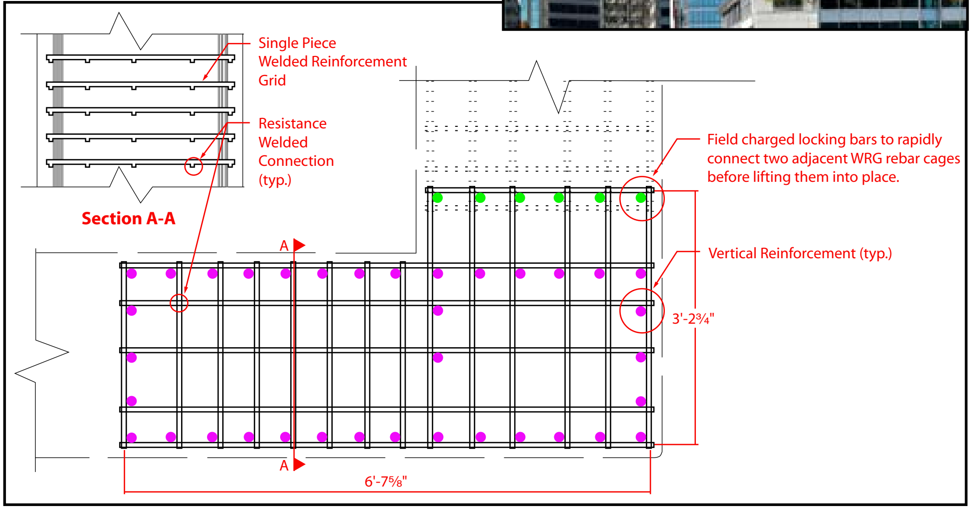

Figure 1: Partial plan of Millennium Tower shear core reinforced with BauGrid WRG™ (below) Under construction in 2007 (above).

to simulated loading of the most severe seismic conditions. As a result of this extensive testing, a patented, proprietary one-piece welded reinforcement grid (WRG™) was developed to replace the many pieces of conventional transverse reinforcement. The resistance-welded intersections replace cumbersome end hooks and provide a more exact and efficient system for placement of longitudinal and confinement reinforcement. The initial component testing at University of California, Berkeley validated performance by means of cyclic compression and tension testing, and provided data for design that allowed the shear walls to be reduced to 7 inches (178 mm) in thickness. Subsequent component testing showed exceptional ductile performance in cantilevered columns with lateral drift at high axial loads.

Welded reinforcement grids have also been used to reduce the congestion of hybrid precast beam-column connections of the Precast Seismic Structural Systems (PRESSS) test structure constructed as a scaled 5-story building at the University of California, San Diego (UCSD) in 1999. One of the largest-ever earthquake tests was conducted in 2005, subjecting a full-scale, seven-story test structure to the ground motions of the 1994 Northridge earthquake at the NEES shake table facility at UCSD. The test building was confined with welded reinforcement grids in the boundary elements of the shear walls and performed very well under the 0.82G acceleration that duplicated the motion and forces recorded close to the epicenter of this historic earthquake, proving the theory that ductility is the key to a building's superior seismic performance and validating the approach used in the design.

Raising the Bar

While experimental system and component tests conducted on concrete columns, beams and shear walls indicate that welded reinforcement grids provide equal or better confinement, another aspect of this research comes from actual field reports. Modern economic pressures are driving design-build teams to find new construction technology that allows a more efficient use of materials and methods to provide earlier use of their projects. Engineers are trending towards more modular designs, optimizing constructability to reduce costly on-site time and thus speed up completion.

Traditional transverse reinforcement represents a small proportion of the volume of reinforcing steel and a very large proportion of the time for fabrication of the reinforcing cages. Welded reinforcement grids, manufactured from engineer-approved shop drawings, remove the need for fabrication and site supervision of the tie assembly by arriving on site or in the yard as a custom-fabricated, dimensionally accurate, single-piece grid. By eliminating the lengthy end hooks, these grids weigh less than their conventional tie assembly counterparts and provide a uniform product that can be quickly assembled with the longitudinal steel to form rigid and stable cages. The improved rigidity and reduced weight of the grids allow for easier handling, thereby reducing crane and labor time for installation, further reducing costs by speeding construction. The consistently rigid cage also provides a perfect facade for rapid formwork installation, and the reduced cage congestion speeds concrete placement and improves consolidation.

Industry innovations such as welded reinforcement grids, combined with performance-based design approaches, continue to make concrete the material of choice for owners and help design and construction engineers to find new ways, means and materials to meet the demands of this new millennium.▪

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