High-Strength Rebar Expanding Options in Concrete Towers

By Cary Kopczynski, P.E., S.E, F.A.C.I.

As new technology boosts the strength of structural concrete in tall buildings, the correspondingly high quantities of reinforcing required for seismic confinement become a major obstacle. With concrete strengths reaching 15,000 psi and higher in some of today's high-rise towers, it becomes increasingly difficult to physically fit enough 60 ksi rebar ties into columns and shearwall boundaries to provide sufficient confinement.

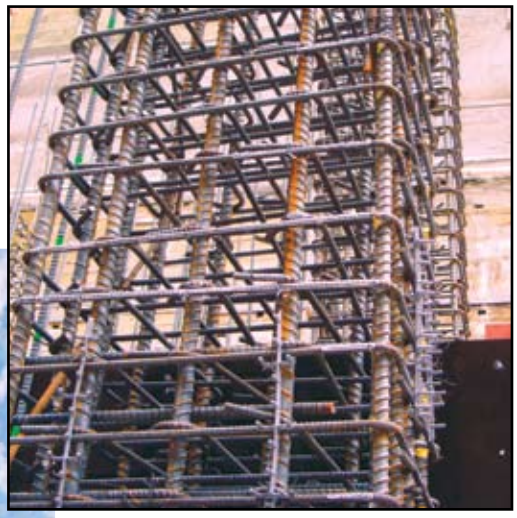
The upcoming approval of 100 ksi reinforcing steel for use in seismic applications will help alleviate such issues, reducing the quantity of confining steel by as much as 40 percent. It will reduce congestion in columns and shearwalls and lighten the work load for contractors, who typically find placing these ties time consuming and tedious.

Although this high-strength steel has not yet been included in the International Building Code (it was reviewed and approved by ACI 318 and is included in 318-08), it is currently being used – with special permission – in a downtown Seattle high-rise.

A column cage with 100 ksi ties (foreground) adjacent to a cage with Grade 60 ties in the fabricator's shop. Note the significant reduction in rebar congestion for the 100 ksi cage.

The Escala Example

Escala is an 820,000 square-foot condominium under construction in Seattle's downtown core. It is expected to be the largest residential tower in the city when construction completes in 2009. With 31 stories above grade and eight floors of subterranean parking below, it's not the city's tallest condominium project, but with each floor plate nearly 20,000 square feet, the tower will break previous records for total area. Already the project holds the distinction of having the deepest excavation in downtown Seattle since the construction of the 76-story Columbia Center office tower in 1985.



Jobsite column cages reflect the significant reduction in congestion achieved with 100 ksi ties.

Escala features a dual seismic system of concrete shearwalls and ductile frames, instead of a more conventional central core. The building's four small elevator cores – serving individual rooms – in the four quadrants of the building were insufficient without supplementation by ductile frames. With high axial loads on the end columns of each frame, structural engineers specified 14,000 psi concrete at Escala's lower levels.

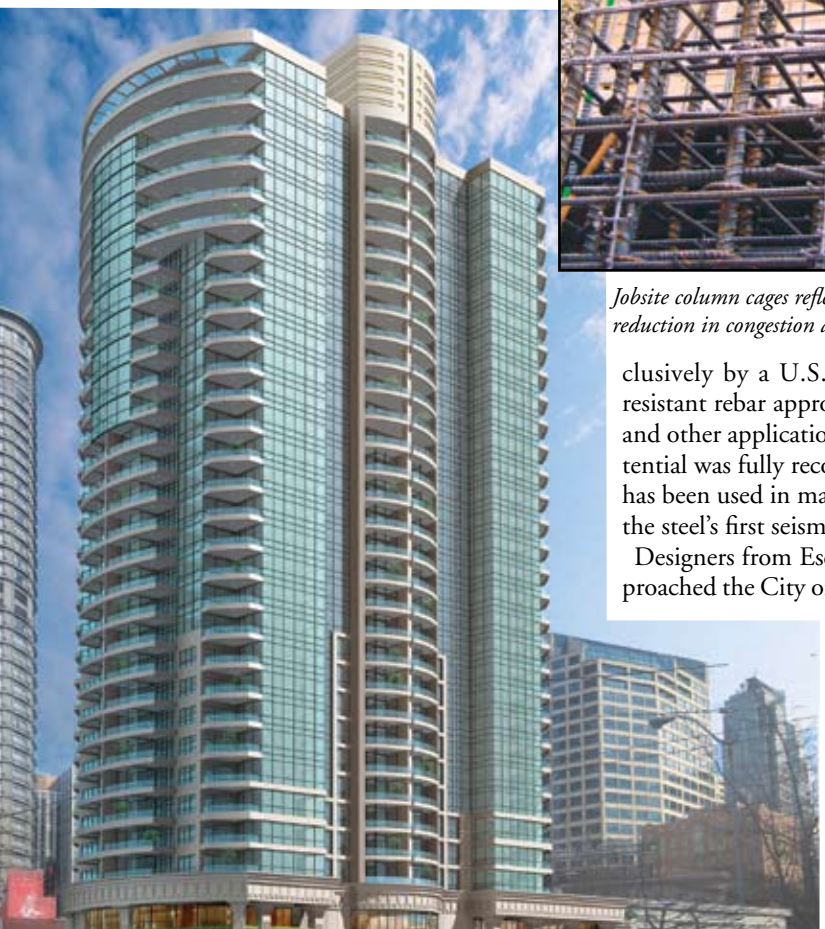
Concrete this high in compressive strength would have required copious amounts of 60 ksi column ties, making the frames very difficult to build. The large quantity and tight spacing of the ties would cause excessive congestion in the columns and shearwall boundary zones. The design team knew a higher strength steel would be ideal for use in Escala, but with formal IBC approval of the 100 ksi steel for use in seismic applications still more than two years away, it would take some extra legwork in order to make it happen.

Super Steel

The 100 ksi steel – currently offered exclusively by a U.S. manufacturer – was initially marketed to the industry as corrosion-resistant rebar appropriate for use in bridge decks, parking structures, industrial buildings and other applications in which water intrusion was a concern. Later, its high-strength potential was fully recognized, and use of the bar was explored for these properties. The steel has been used in mat foundations and bridge decks to add strength, but its use in Escala is the steel's first seismic application in North America.

Designers from Escala's structural engineering firm, Cary Kopczynski & Co. (CKC), approached the City of Seattle for permission to use the high-strength steel in the new condominium tower. The steel had been approved in 2006 by the American Concrete Institute's Committee 318 – the committee that writes the section used by the IBC – for reinforced concrete. However, it was still awaiting the public review and comment process.

Testing and research that had been reviewed by ACI 318, resulting in the steel's approval, was performed on relatively small columns. The



Escala will rise 31-stories above Seattle's downtown core.

After constructing eight subterranean parking levels, workmen prepare to roll out post-tensioning cable in Escala's street level slab.

City expressed concern about the steel's use in Escala, which featured considerably larger columns. The City questioned whether the research results for the smaller columns could extend to columns as large as those for Escala. Based on a review of the literature and other investigation, CKC designers argued that this difference was inconsequential. Letters from other concrete experts familiar with the steel and research, who agreed that confinement provided by the higher strength bar would be similar in large columns to the small column data, supported CKC's suppositions. The City approved the use of the high-strength steel in Escala, and construction began last summer.

Putting the Steel to Use

Practicing structural engineers will find the use of 100 ksi steel appropriate for use in columns and shearwall boundaries of tall structures in high seismic zones. A key benefit is the ability to use fewer ties at wider spacing, alleviating congestion and reducing the potential for field problems. With less seismic confining steel, the door opens to expanded design options. Higher strength concrete allows smaller columns, offering more usable floor space and improved building efficiency.

Structural engineers seeking to specify 100 ksi steel in an upcoming project should be aware that, although the steel has been approved by ACI 318-08, it will not be included in the IBC until 2009. To use the steel before then may require the approval of your local building department.

Aerial view of Escala's subterranean garage under construction.

Those who have received approval and are using the 100 ksi steel should provide astute oversight during field installation. Aside from the bar mark, the 100 ksi bars are visually indistinguishable from Grade 60 bars. If 100 ksi steel bars are being used on your project, it is wise to specify the bars throughout a given level to avoid unintentional mix-ups in the field.

Although the steel's proprietary nature has some designers holding back amidst fears of availability and its high price, its supplier is seeking ways to lower the steel's cost.

Nevertheless, the 100 ksi rebar is worth a look. For seismic confinement, the new high strength steel is simplifying construction and expanding the design options for high-rise concrete projects in high seismic areas.▪

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