# Reducing Steel, Increasing Profits

## Ways to Design Smarter Amidst Rising Steel Costs

*By Sheila Bacon*

Ever since America's earliest builders turned the first shovelful of dirt, developers, designers and contractors have been looking for ways to build structures in the most effective and efficient ways possible. Today, with the cost of steel rising faster than a self-climbing forming system, engineers are attempting to reduce the amount of steel in their high-rise concrete projects while still designing a building that meets code and exceeds the owner's expectations.

A tall order, indeed.

Steel shortages and price increases have left virtually no one in the U.S. construction industry unscathed. Most economists blame China and its booming economy for the United States' steel woes. China's steel consumption is up 110 percent over a six-year period and is rising, according a report on China's role in the steel market by Global Insight, an economic consulting firm based in Boston, Mass. The country saw 300,000,000 metric tons of output this year, said John Anton, Global Insight's director of steel service, triple the amount in 1996. The raw materials and finished steel that were typically exported to the United States a few years ago are now being used up by the Chinese to fuel their thriving economy. Previously abundant raw materials are now in scarce supply, adding to the rising costs.

And China isn't the only country competing with the U.S. for steel and its components. Japan, India and other smaller economies are also posting favorable growth rates, consequently creating an even tighter market.

This new market presence is throwing a wrench into steel buyers' procurement budgets and heavily taxing their margins. The high steel costs have burdened companies, emerging from the recession that had hoped to shore up profits by keeping material budgets tight.

### Steel Reduction Ideas

The price of plate steel has increased from a steady $300 a ton for the past several years to around $740 a ton today, according to Anton, making the product "by far the most expensive of non-alloy steel products." Rebar prices are up significantly from approximately $270 during 2003 through 2004. Its cost had jumped to around $470 a ton in early 2005, said Anton, and recently crept to around $485 a ton, where it has hovered since September.

While steel prices continue to climb, the demand for steel in buildings has not changed; adding significantly to the cost of a building's foundation and frame. Engineers at Bellevue, Wash. - based structural engineering firm Cary Kopczynski and Company (CKC) have derived a number of ways to reduce the amount of steel in their projects and, as a result, help soften the blow to the owner's pocketbook.

*75 ksi rebar in place of conventional 650 ksi bar in the foundation of downtown Seattle's Cosmopolitan Tower*

*Eliminating rebar splices and reducing rebar weight at Westlake Tower, Seattle*

#### Reduce the Amount of Steel Used In Shear Walls

A significant amount of steel in high-rise projects is used in construction of the shear walls surrounding the building's elevators and stairwells. By eliminating columns around the core and placing more of the building's vertical load on the shearwalls, the walls are effectively prestressed in compression by gravity, which reduces steel requirements under wind and seismic forces. This technique sometimes requires that the wall concrete strength be increased to accommodate the additional gravity load. In most markets, however, the cost premium for higher concrete strength is more than offset by the steel savings.

CKC used this approach in the structural design of the 34-story Cosmopolitan Tower, currently under construction in downtown Seattle. The slab over the corridor around the core was thickened, allowing it to clear span from the core to the building's perimeter. This placed approximately 35 percent of the structure's gravity load on the core, and reduced the tensile forces that develop under wind and seismic forces. Lower tensile forces translate directly into a reduction in rebar.

According to Cary Kopczynski, CKC president and senior principal, this technique can ultimately reduce steel requirements in the shear walls by 10 to 20 percent.

#### Increase the Steel Strength

By using higher strength steel in a number of different applications, overall project costs can be further reduced. By specifying 75 ksi rebar instead of conventional 60 ksi rebar in foundation mats, for example, using the stronger steel at its full capacity, less steel is required. While the cost of the higher strength steel may be more than the weaker bar, the steel savings offset the additional cost while labor requirements remain the same. Furthermore, use of the larger rebar reduces congestion in the foundation mat. With fewer bars, space between bars is increased and fewer layers are required, making concrete pours faster, easier and ultimately less expensive.

Cosmopolitan Tower used this method as well in its foundation mat to further reduce steel costs. By substituting 75 ksi rebar for the more traditional grade 60 bar; CKC was able to reduce steel quantities by about 45 tons.

Another way of further reducing the amount of steel is to use 80 ksi welded-wire reinforcing steel — an application that involves welding multiple bars into a grid and placing the grid as a unit. This reduces tonnage and cuts labor costs, since rebar isn't being placed individually.

For those willing to tread into relatively uncharted territory, a new 100 ksi rebar — called MMFX2 steel and marketed by MMFX Steel Corporation of America, based in Charlotte, N.C. – may be appropriate. Although the steel is approved by the American Society for Testing and Materials for its use as a 100 ksi product in structural applications, the International Building Code has yet to recognize it for use beyond 80 ksi strength.

The steel offers a breaking strength of nearly double conventional 60 grade rebar, and its yield strength is nearly

70 percent higher than its weaker counterpart. The steel's stronger properties mean considerably less steel is required; lowering the project's cost substantially – most significantly for large projects.

Subject to approval by the Clark County building department, CKC hopes to use the steel in construction of a yet-to-be-built condominium tower in Las Vegas, appropriate because of its size: 1.2 million square feet in 51 stories. Of the approximately 6,000 tons of conventional 60 ksi rebar specified in the tower, the use of the new, stronger steel in the foundations and shear walls will eliminate in excess of 1,000 tons of rebar, said Kopczynski.

### *Reduce the Number of Lap Splices*

When engineers, contractors and suppliers don't pay close attention to rebar placement requirements up front, money is often left on the table. On the other hand, when designers coordinate rebar placement early on with contractors and placers to optimize rebar length and placement techniques, substantial savings can be realized.

When placing rebar in long columns, beams, slabs and walls, long sections of rebar are used. When more than one piece of rebar is joined with another to accommodate those longer applications, they typically overlap by several feet. Often, by analyzing rebar length requirements early on, some lap splices can be reduced or even eliminated. For example, lack of foresight may result in the use of 20-foot-long bars in a 200-foot long slab, resulting in numerous splices. By working with a contractor before construction starts, an engineer can specify longer individual units – up to 60 foot-long bars – that would eliminate many unnecessary splices.

"This is one of the areas where the ball gets dropped a lot between the designer and the contractor" said Kopczynski. "Instead, if we discuss this with the contractor right off the bat, they can plan ahead and reduce lap splice quantities significantly."

CKC recently utilized this technique in the design of columns for a large three-story parking structure in San Bruno, Calif. By using larger corner bars to stiffen the cages and allow them to stand higher, they were fabricated full height, eliminating lap splices altogether. To compensate for the increased weight of corner bars, intermediate bars were reduced in size. Kopczynski estimates that the lack of splices reduced column rebar weight by an average of 300 lbs. per column, which translated into a total savings of nearly 20 tons of steel over the full footprint of the structure.

The lack of splices also solved the rebar congestion problem that often occurs at splice locations, enhancing the buildability of the columns.

## Conclusion

While the monetary savings associated with the use of just one of these techniques on a project may seem inconsequential, the combination of several such efforts could result in substantial steel savings — and a noticeable reduction in the overall project's bottom line.▪

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All photos courtesy of Cary Kopczynski and Co.