# Good Seats

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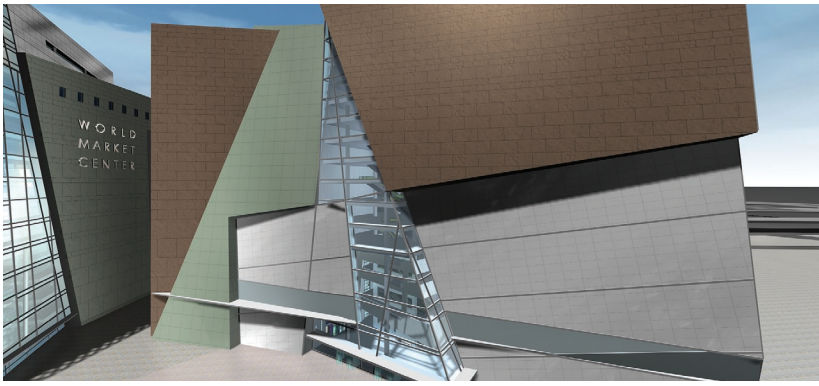


## The third phase of the ever-expanding World Furniture Mart sits well with its neighbors thanks to buckling-restrained braced frames.

**LAS VEGAS, WELL KNOWN AS THE CONVENTION CAPITAL OF THE WORLD, IS ALSO HOME TO THE FASTEST GROWING FURNISHINGS MARKET IN THE COUNTRY.** Orchestrating this development is the World Market Center (WMC), a dynamic new showcase for the home furnishings industry in downtown Las Vegas. When completed in 2012, the $3 billion World Market Center Las Vegas campus is expected to have more than 12 million sq. ft of state-of-the-art exhibit space in eight buildings on 57 contiguous acres.

Building One is a 10-story structure, completed in 2005 at a cost of approximately $230 million, comprised of 230 showrooms in 1.3 million sq. ft of space. The 16-story Building Two ($345 million) opened last year and added 1.6 million sq. ft and 300 showrooms to the complex. The two buildings are connected via a bridge on levels two through ten.

The construction work on Building Three, with a total cost of about $550 million, began during the fourth quarter of 2006 and was scheduled to open in time for WMC's July 2008 trade show. This third building continues the trend of each phase being bigger than the last and consists of 400 showrooms on 16 floors—2.1 million sq. ft—and is connected to Building Two with a sky bridge.

With the completion of the third phase, WMC has invested more than $1.1 billion, showcasing 5 million sq. ft of permanent showrooms. This exceeds the size of any wholesale merchandise mart in the United States. (The city of Las Vegas has already granted approval for the construction of Building Four, which will scale back from Building Three with a total floor space of "only" one million sq. ft. It will be connected seamlessly to Building Three, eliminating the need for a sky bridge in this case.)

### New Phase, New Lateral Resisting System

Building Three is a 16-story steel-framed structure measuring approximately 250 ft wide by 700 ft long, with approximately 130,000 sq. ft on each floor, using 17,500 tons of structural steel. The main gravity system consists of concrete-filled metal deck over composite steel beams and girders supported by steel columns. A typical column spacing of 32 ft × 32 ft was used for efficient space planning.

While the first two buildings of WMC used concrete shear walls as the primary lateral resisting system, a buckling-restrained braced frame (BRBF) system was selected as the primary lateral system for Building Three thanks to its superior seismic performance and speed of construction. These frames were placed in the perimeter bays and selected interior bays in a two-story "X" configuration for maximum efficiency.

The project is notable as the first in Las Vegas to use BRBFs. Furthermore, according to CoreBrace, who provided the buckling-restrained braces, this is the largest U.S. structure to date to be constructed with a BRBF system; almost 600 braces were used in the building. The bolted connections used with the BRBF system shortened the erection schedule, eliminated field welding, and reduced construction cost. According to the steel fabricator/erector, SME Steel, using the BRBF system with bolted connections saved approximately $10 million over a concrete shear wall system. The structural steel was erected in approximately eight months.

### Buckling-Restrained Brace Frames

The BRBF system is a relatively new type of concentrically braced frame (CBF) system and was first introduced to the United States in 1999. Traditionally, CBFs have been treated as high-

**Above left:** The structure is the third phase of the World Market Center Las Vegas campus, which will eventually include more than 12 million sq. ft of exhibit space in all.

**Above right:** A completed rendering of Building Three.

strength, low-ductility systems, because the steel braces show significant strength in tension, yet usually buckle in compression and deliver only a fraction of the strength that they can deliver in tension. The main concept for the BRBF system is to simply enable the use of brace members that yield in both tension and compression.

To achieve this fully balanced hysteretic behavior, the main steel brace is encased in a concrete-filled steel tube that provides the core with the required buckling resistance. Since the steel core of the brace member is confined, the unbonded brace members deliver as much compression capacity as their tension capacity. The BRBF design procedure requires the columns to have the strength to resist the vertical component of the expected yield strength of each brace in the frame. This design philosophy allows the column to remain elastic during a seismic event while the BRBFs are yielding and absorbing seismic energy.

The braces are also required to be designed for deformations corresponding to two times the design story drift. Therefore, the BRBF system performs with a higher degree of ductility than conventional braced frames. This high ductility and level of performance result in a larger response modification factor, and therefore lower seismic design force in comparison to conventional concentrically braced frames and concrete shear wall systems. *(For more information on BRBFs, read "Design of Buckling-Restrained Braced Frames" in the March 2004 issue of MSC.)*

## Code Challenges

The structural design for Building Three started in early 2006, when the enforced building code was IBC 2003. That code did not include design guidelines for the BRBF system. Luckily, DeSimone Consulting Engineers managed to get approval from the Las Vegas buildings department to design the structure in accordance with IBC 2003 and in conjunction with the *Seismic Provisions for Structural Steel Buildings*, ANSI/AISC 341-05, and ASCE 7-05, which addressed the design procedures for BRBFs for the first time; they were later referenced in IBC 2006. MSC

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World Market Center Building Three is the first in Las Vegas to use BRBFs.