# Trimming the FAT

BY NINA KRISTEVA, P.E.


**This page:** At the center of a $2.5-billion multi-use development in downtown Los Angeles, the 56-story L.A. Live Hotel & Residences incorporates a steel plate shear wall system that returned 20,000 sq. ft of floor area to the developer.

AEG and Gensler

Changing from concrete to steel plate shear walls saved time, reduced weight, and reclaimed usable space.

**THE FIRST STEEL-PLATE** shear wall high-rise building in the high-seismicity land of California is redefining not only the Los Angeles skyline but the skyline for the structural engineering and steel construction industries as well.

The new L.A. Live Hotel & Residences building is the centerpiece of L.A. Live development, a 4-million-sq.-ft, $2.5 billion downtown Los Angeles sports, residential and entertainment district development adjacent to Staples Center and the Los Angeles Convention Center. The 55-story structure will include 1,001 hotel rooms and 224 luxury condominiums. Its total development cost is estimated at $1.0 billion for the two million sq. ft of space.

## A Better Way

It was March 2006 when the structural engineering firm Nabih Youssef Associates (NYA), Los Angeles, started reviewing the conceptual design for the L.A. Live Hotel & Residences and a new idea was born—an idea to replace heavy 30-in.-thick concrete shear walls with much lighter ¼-in. to ⅜-in.-thick steel plate shear walls. Making that change, the review showed, would free valuable real estate space, reduce seismic design forces and foundation sizes by eliminating a significant part of the weight of the structure, compress the construction schedule and budget, and allow for simplified and more efficient construction.

The concept was intriguing enough that NYA was asked by the developing group to convert the 56-story concrete shear wall design to steel-plate shear wall design.

## Details of the System

Steel plate shear walls (SPSW) resist lateral forces primarily through diagonal tension in the web-plates and overturning forces in the adjoining columns. Typical SPSW web plates (¼ in. to 1 in. thick) have negligible compression strength and thus, shear buckling occurs at low levels of lateral loading. Lateral loads are then resisted through diagonal tension in the web plate rather than through shear.

Vertical and horizontal boundary elements (VBE and HBE) are designed to permit the web plates to develop significant diagonal tension and reach their expected yield stress across the entire panel while dissipating energy. The ductility of the SPSW web plates also results in unparalleled performance under moderate and severe seismic loading.

"The 55-story steel-framed SPSW takes full advantage of many of the performance based design approaches and philosophies," said Nabih Youssef, NYA principal. "It is a seamlessly integrated, highly efficient seismic energy dissipating structural system using unstiffened thin steel plates as shear walls coupled with buckling-restrained braces."

The narrow aspect ratio (10:1 for the tower and 20:1 for the walls), sloping column, and T-shaped floor plate presented additional design challenges. Modeling methods were developed for the expected model system behavior that correlated well with observations from independent research tests. The behavior of this "first in California" single wall-frame system under extreme earthquake motions was computer simulated through complex engineering concepts. The acceptance of this performance-based design was extensively discussed through the peer review process. It relied on an unwavering confidence in the fundamental principals as supported by intense collaboration with a peer review panel that provided in-depth scrutiny into the design criteria, applicability of relevant research, and analysis modeling techniques, through to the final detailing for construction.

The innovative design was fueled by a high level of collaboration between all project members established at the early stages of the design. "The first real horse out of the gate was the steel erection," said Greg LeBon, developer AEG's director of design. "It went like clockwork and established a 'keep up with those guys'

**Peer Review Panel**

- Stephen A. Mahin, University of California, Berkeley
- Jack Moehle, University of California, Berkeley
- James O. Malley, S.E., Degenkolb Engineers, San Francisco
- Paul G. Somerville, URS Corporation, Pasadena, Calif.

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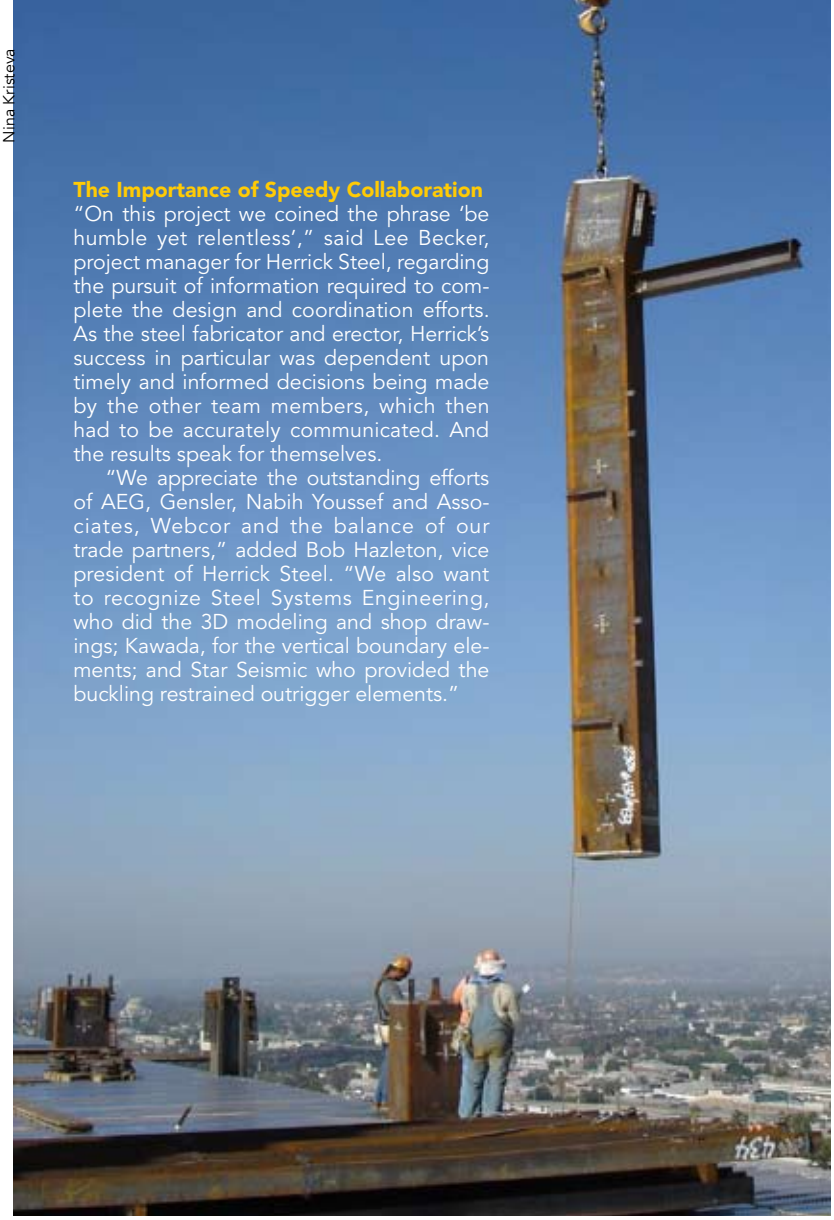
Nina Kristeva



### The Importance of Speedy Collaboration

"On this project we coined the phrase 'be humble yet relentless'," said Lee Becker, project manager for Herrick Steel, regarding the pursuit of information required to complete the design and coordination efforts. As the steel fabricator and erector, Herrick's success in particular was dependent upon timely and informed decisions being made by the other team members, which then had to be accurately communicated. And the results speak for themselves.

"We appreciate the outstanding efforts of AEG, Gensler, Nabih Youssef and Associates, Webcor and the balance of our trade partners," added Bob Hazleton, vice president of Herrick Steel. "We also want to recognize Steel Systems Engineering, who did the 3D modeling and shop drawings; Kawada, for the vertical boundary elements; and Star Seismic who provided the buckling restrained outrigger elements."

energy that led to a project that was two months ahead of schedule and on budget—almost unheard of in today's development community," LeBon said.

"To meet the rigorous demands of the project schedule and make the steel structure for this project happen in time, we had to get all of the main parties working together as a unified team, to execute the design of the steel structure" said Warwick Wicksman, principal with the project architect, Los Angeles-based Gensler. That included not only AEG, NYA and Gensler, but also general contractor Webcor Builders, steel fabricator and erector Herrick Corporation, the city of Los Angeles and the city's peer review panel.

"We had daily work sessions with NYA and Herrick," Wicksman said, "working together to determine which size steel members would be available, at each point during the erection sequence, to meet the demands of the engineering of the building, and to work with the schedule, for 'just-in-time' delivery of the primary structure."

All parties committed to mitigating risk on behalf of the team rather than passing it from one partner to another. Gensler, NYA and Herrick abandoned the traditional flow of documents to establish a streamlined procedure for managing requests for information (RFIs) and submittals. They met two to three times per week to review submittals and RFIs and coordinate new design issues so they could be resolved quickly in order to avoid revisions and resubmittals. The process allowed all to influence the process, providing value engineering and workable details prior to issuance of updated designs. Keeping open channels of communication was essential to overcoming the challenges on this 18,000-ton structural steel project and turning it into a success by achieving:

By using a steel-plate shear wall system (visible below and in the inset) in place of concrete, the structure's weight was reduced by 35% which also reduced and simplified foundation requirements.

Nina Kristeva

AEG and Gensler

Herrick Corporation

Situated in the heart of Los Angeles, the new L.A. Live Hotel & Residence is the first use of a steel plate shear wall system in the high-seismicity area of California.

- Increased building efficiency by adopting the structure to the building program
- Improved building design and seismic performance
- Uncompromised architectural views by eliminating perimeter moment frames
- Reclaiming 20,000 sq. ft of real estate floor area through the elimination of the 30-in.-thick concrete shear walls, which equates to an extra $20 million in real estate value
- Replacement of a heavy and complex deep foundation system with a mat foundation, made possible by replacing the concrete walls with steel-plate walls thus eliminating 35% of the building weight
- Overall cost savings of nearly $8 million
- A time savings of two months

L.A. Live Hotel & Residences broke ground on November 2007 and the structural steel erection was completed on January 25, 2009, two months ahead of schedule. A temporary certificate of occupancy was scheduled for December 2009 and the projected opening was February 2010. MSC

**Owner**
AEG Worldwide, Los Angeles

**Structural Engineer**
Nabih Youssef Associates, Los Angeles

**Architect**
Gensler, Santa Monica, Calif.

**General Contractor**
Webcor Builders, Los Angeles

**Steel Fabricator and Erector**
Herrick Steel Corporation, Stockton, Calif. (AISC and IMPACT Member)

**Steel Detailer**
Steel Systems Engineering, Inc., Sherman Oaks, Calif. (AISC and NISD Member)