Overcoming Seismic Challenges in the Tallest Building West of Mississippi

A Customer Success Story

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Design Excellence

The Wilshire Grand is California's tallest skyscraper, and the tallest building west of Mississippi standing at 1,100 feet tall.

With architectural details including its 100-foot crown sail designed to emulate the Half Dome in Yosemite National Park and a 30-foot tall LED-laced spire, it dramatically redefines the Los Angeles skyline as the city's only building without a flat-top roof.

The large-scale build stands at approximately 2,000,000 square feet with 73-stories housing 5 levels of underground parking, 900 hotel rooms, 400,000 square feet of office space and 45,000 square feet of retail space.

Suited with hi-tech, computerized double-deck elevator cabs, the building's design delivers a unique top down experience for its guests. Elevators bring guests to the 70th floor in just 50 seconds where its panoramic "sky lobby" is located beneath a restaurant and infinity pool. Hotel rooms are further located below the lobby.

1,100
feet tall

2,000,000
square feet

73
stories

900
hotel rooms

400,000
square feet
of office space

44,000
square feet
of retail space

Project Details

The Wilshire Grand was built in California just 46 miles a way from the San Andreas Fault and needed to withstand earthquakes up to a magnitude of 7.4, as well as handle strong winds. That meant the structure needed to be dynamic enough to handle environmental forces, but rigid enough to make the building comfortable for its visitors.

As a result, the project included a concrete core wall with outriggers and belt trusses for added support. The core's function was to stabilize the building against both seismic and wind force, as well as anchor structural elements of the build.

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It was built into a thick foundation made from the largest continuous concrete pour in history dumping 82 million pounds. It was then supplemented with buckle-resistant braces (BRBs) at levels 70-73, that would act as shock absorbers in the case of an earthquake or strong winds.

The structure was built with 18,963 tons of structural steel, 900 tons of steel was used in the sail-like crown, and 124 tons in the architectural spire topping the roof.

Project facts

- » 18,514 Drawings
- » 40,976 Assemblies
- » 18,963 Tons of steel
- » 320 BRB's
- » 2.1M Square feet
- » Peak construction: approximately 90 men

Innovative steel erection on complex projects

When it comes to efficient and innovative steel erection, Schuff Steel is an industry leader. Every project we work with is planned and designed with constructability in mind.

Erecting the Wilshire Grand project to accommodate the seismic activity in the region was a priority from the early design stages.

Potential solutions were put to the test using computer simulations of the structure. The result was a rectangular core comprised of thick walls to anchor structural elements to the outer walls. The Schuff Steel team also helped to integrate (120) single floor BRB's into a 6-story truss system and (50) 3-story tall 2,200 kip braces from the core wall to the perimeter belt truss framing for further shock absorption. This included groundbreaking design of the jacking system for pre-compressing (10) BRB's at level 73. As well, the Wilshire Grand project is the first to implement Narrow Gap Electroslag Welding Process in the field that met D1.8 code requirements, which enabled both a time and cost savings.

Resistance to Seismic Activity and Strong Winds

Located in a seismically active zone, the tall slender design of the Wilshire Grand needed to withstand earthquakes up to 7.4 in magnitude. This made resistance to seismic activity challenging for the Schuff Steel team.

In order to make the design work with the environmental forces the structure might face, we had to balance stiffness, strength and mass. It was in the early stages of design, that we collaborated alongside the contractor and architect to determine the best solution for the project. We considered steel braced frames in the core, steel plate shear walls, a concrete core wall, or a concrete core wall with outriggers and belt trusses.

Finding the right solution

Based on cost, constructability and the schedule of the project, it was decided that a concrete central core paired with outriggers and belt trusses was the best option for the build.

The wall of the concrete core was up to four feet thick and reached five levels underground, and 850 feet into the air. It was built into a thick foundation comprised of 82 million pounds of concrete.

Outside of the core wall, steel box columns filled with concrete helped to improve the rigidity of the structure, along with steel floor beams and girders with lightweight concrete over the metal deck.

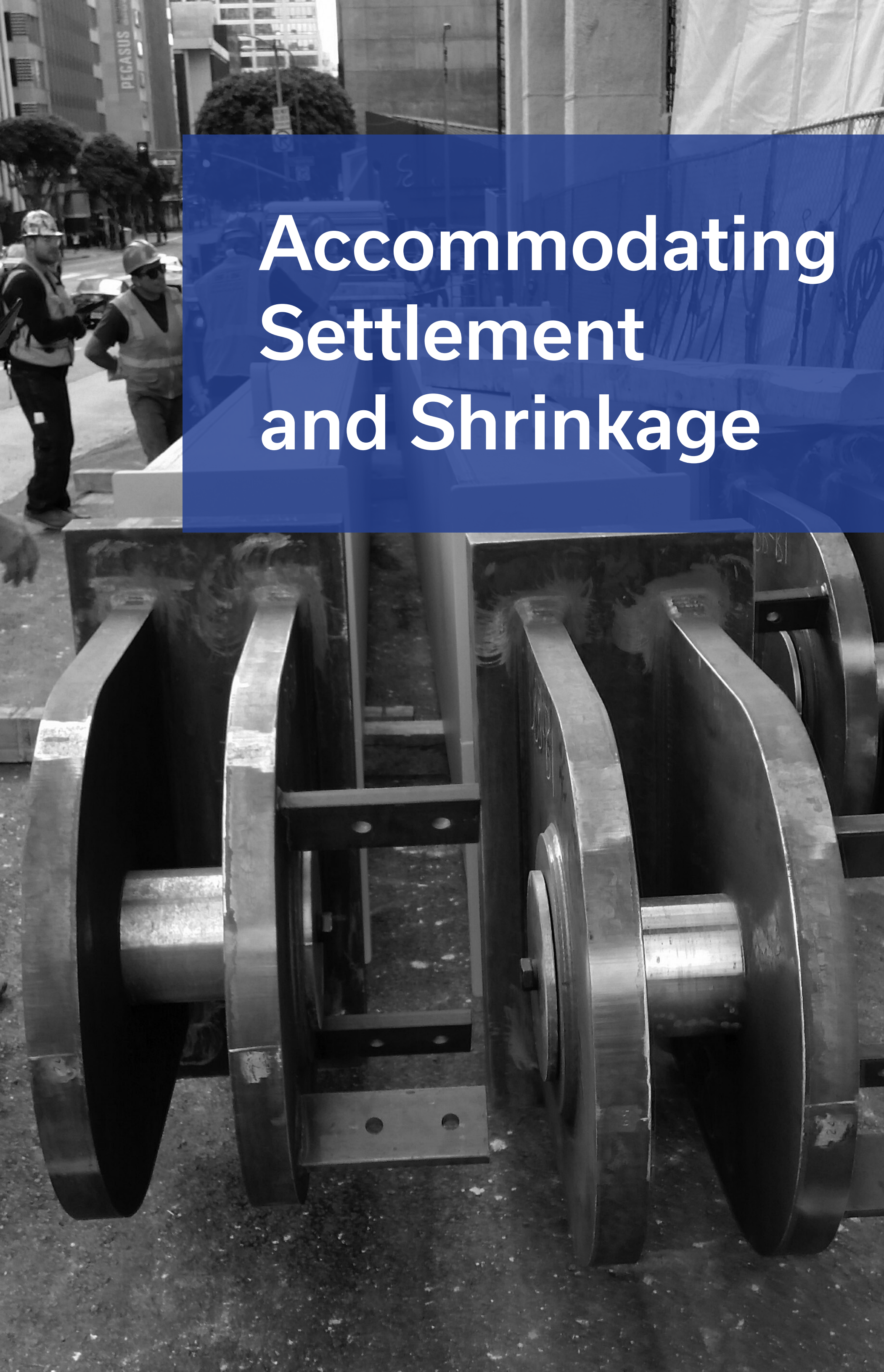
The height and geometry posed many complex connections at both the steel box columns and the concrete core wall in certain areas of the building (L28-L31, L53-L59 and L70-L73). Once each tier of columns was set, they were surveyed for elevation. Considering the results of the survey we either increased or decreased the box column elevation at each grid.

To improve shock absorption of the build, the core was supplemented with three rings of multi-story BRBs. There were (40) 2,200-kip BRB outriggers at lower levels (28-31), (120) 800-kip BRB outriggers in the middle levels (52-58) and (10) 2,200-kip BRB outriggers in the upper levels (71-71). Spanning 42 feet long at lower levels, the BRBs were fused between the exterior wall and the central core wall. Connections for each of the bottom BRBs consisted of 7 1/2 inch pinned clevis and 2 3/4 inch thick gusset plates. The top connections were 1 1/2 inch bolts through 1 1/2 inch thick splice plates over 2 inch gusset/core plates.

Prior to erection, Schuff Steel used plywood mockups of the BRBs and gusset plates to ensure bolting could be accommodated in tight quarters.

The structure also had two three-story belt trusses at both lower and upper outrigger levels stretching around the perimeter of the build. These belt trusses help to stiffen the structure and distribute resistance vertically.

Using this system in place of conventional steel outriggers allowed for more energy absorption and dynamic movement. Each outrigger holds the strength of 8.8 million pounds, making the Wilshire Grand the highest capacity system in the world with all four combined.



Accommodating Settlement and Shrinkage

The design of the Wilshire Grand presented unique settlement and shrinkage dimensions between the steel and concrete used in its construction. Over the next 100 years or so, the concrete core will sink by about 2 inches.

Planning a solution

Our approach was to stay one step ahead, planning for the inevitable changes. Settlement and shrinkage dimensions were added into shop drawings to account for increased lengths in vertical members and columns, while pre-compression was used to reduce the risk of deformation in the event of strong winds or an earthquake.

Accommodating shrinkage dimensions of the central core was essential for the support of the crown sail and spire. To do this, sail columns were designed with a 5-inch gap between the column and the floor to prevent them from pushing down into the steel framing once the concrete settled. The spire was reinforced with large steel pins with hinges to allow for downward movement.

To prevent permanent structural deformities after 50 years of shrinkage, a pre-compression force of 1,000 kips was used for each of the upper BRBs on alternate sides of the build to reduce tensile force between braces. Once the compressive strains reach approximately a 1/2 inch the BRB was bolted off.

A total of 500 tons of compression was jacked into all 10 braces creating tension in the exterior building columns with each brace pushing upwards on the building's perimeter. Each floor from the middle upwards lifted slightly vertically shifting tension to the middle outrigger level as planned.

Using the Right Welding Method

Welding elements of the Wilshire Grand project posed a challenge for both timeline and safety during erection.

Critical elements of the lower outrigger truss system required a great deal of welding that would consume both time and manpower. The method itself could pose safety hazards to the integrity the joint due to overheating created with multiple welding passes.

Finding the right method of application was critical to project efficiency, as well as effective erection.

Using Electro Slag Welding

Electro Slag Welding proved to be the most time efficient solution for the project with its ability to lay metal at a higher rate per hour than standard welding processes.

Having never been used in high-rise construction as a field application, various rounds of procedure qualification records and demonstrations were used to ensure it would work.

Its application was used to join 70mm gusset plates for the BRB's to a 10-meter tall steel embedment in the concrete core. The gusset plates were 12 feet tall and 2 1/2 inches thick, each welded just a few hours after they were installed.

Electro Slag Welding was also used to connect the chord and diagonal members of the belt trusses flanges to the face of the box columns. These welds were up to 49 inches long and up to 5 inches thick.

Unlike traditional welding methods, Electro Slag Welding does not require preheating and can be done in one single pass. This reduces the risk of overheating the critical joints of the build and creates safe and effective results.

Project Team

Owner
Hanjin Group

Contractor
Turner Construction Company

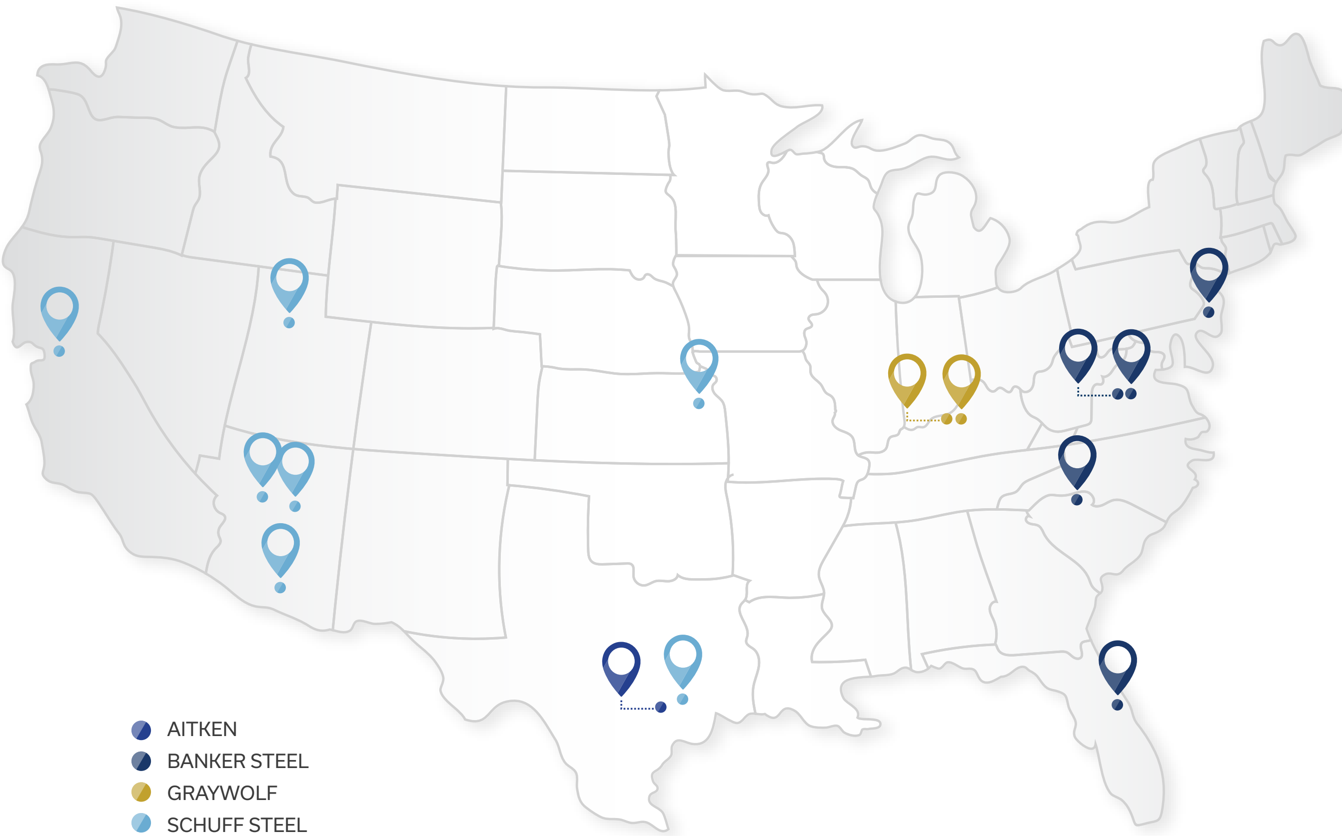
Architect
AC Martin Inc

Project Management
Martin Project Management

Steel Fabricator and Erector
Schuff Steel Company

Steel Detailers
DBM Vircon

Ironworkers
Local 433



Nationwide Footprint

With Schuff Steel's building expertise and nationwide footprint of fabrication shops and subfabricators, we are able to perform the largest, most complex projects from coast-to-coast. We have demonstrated time and again our ability to execute projects with the highest level of quality and performance, while bringing significant value to our customers through enhancing design, mitigating risk and saving time.

In addition to our 7 fabrication plant locations, we have access to another 8 within the DBM Global platform of companies, for a total of 2.2M square feet under roof.

Get in Touch

sales@schuff.com

7
Fabrication Plants

1.325M
Sqft Under Roof

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