A Case Study in Emulative Design Success

Brigham Young University
Auditorium Shear Wall
Case Study CS001
Brigham Young University Shear Wall:
Connection Techniques Contribute to Emulative Design Success

Project Name: Brigham Young University Auditorium Shear Wall
Project Location: Rexburg, Idaho

Project Overview
The project consisted of a sixteen-inch thick precast concrete radiused shear wall nearly 96’-0” tall and over 400 linear feet long. In addition to providing the primary lateral resistance in a high seismic region, the wall provided the primary support for auditorium risers and the nearly 10-foot deep 106-foot long roof trusses. In response to the high seismic location, the wall’s initial design called for the use of cast-in-place. Using emulative design and over 5000 NMB Splice-Sleeves® the wall was converted from cast-in-place to precast concrete. Because of the thickness of the panels, a voided precast panel system with prestressed super columns was utilized. The massive wall was constructed in just ten weeks. The auditorium shear wall is the first wall of this magnitude and with this innovative design to be constructed in this region.

Architectural Design Success
The shear wall also served as an exterior wall that was clad with architectural precast panels reinforced with carbon fiber mesh. Coordination between the structural wall and the exterior cladding required connections to be made in difficult spaces with little or no visibility. The wall had a number of openings that required constant trade coordination between each of the specialty contractors.

Engineering Design Accomplishments
Single-piece prestressed super columns, 96’-0” in length, were designed to support 400+ kips of axial load from the king trusses and two cantilever raker systems for auditorium riser support, while serving as an integral component of the wet jointed lateral force resisting system. Wet joints accounted for a majority of the panel-to-panel connections, panel-to-column connections, and cord-reinforcement connections. Along with a rebar splice solution, the wet jointed system eliminated heavy welding, large embedded plates, and the final finish was a smooth wall with limited exposed connections. Pass-through voids cast into the columns permitted reinforcement continuity. Wall panels were designed with voids to reduce their weight, enabling larger panels to be shipped and erected.

Material Innovations
Wall panels were cast with voids created by capped Sonotube® forms. Columns were cast as I-shaped sections with voids through the web. These voids, formed by Styrofoam®, were used to create continuous bands of horizontal reinforcement. After construction the edges of the wall panels and the voids in the columns were
sandblasted to enhance shear transfer after they were grouted in the field. Foam was used during the casting of the panels and columns to facilitate the proper formation of unique key ways and cord steel key ways.

**Construction Innovations**

Wall panels were cast in a vertical battery mold to prevent movement of the voids. To allow placement of horizontal steel cord, teeth were formed at the ends of the walls and a trough was shaped along the top edges. Precasting the 300 panels and 23 columns accommodated factors that hindered cast-in place construction, the large number of openings, extreme winter weather conditions, and the placement of a large volume of concrete in potentially adverse winter weather conditions.

**Quality and Consistency Levels**

The precast panels and columns were fabricated in accordance to PCI MNL-116, and their installation followed PCI MNL-127.

**Owner Benefit**

Construction of the precast system was completed in ten weeks, a savings of over seven months as compared to the original cast-in-place schedule. In addition to its longer construction time, the cast-in-place design may have required an onsite concrete batch plant due to the project location and the need for a constant volume of material once the placement of the cast-in-place began. Utilizing a precast solution, the owner saved what could have been a major expense in dollars and time for this temporary plant mobilization.
90-foot long prestressed columns supported 220-foot roof trusses. Block outs at 18” on center allowed rebar from the adjacent wall panels to be tied and cast as part of a wet joint. The columns were transported in the same manner as prestressed bridge girders.

Erection required the use of two cranes to remove the columns from the trailer and lift them into an upright position. All twenty-three columns as well as the extensive bracing systems were erected in just over a week.

The bracing systems were designed to support the wall until the wet joints were completed and reached the required strength. Cables were used to restrain all in-plane forces on the wall during construction.
The wall panels were set on rebar cast into the footing by the contractor. These projecting bars were then set into the NMB Splice-Sleeves® in the bottom of the panel. Once in position, the base joint was grouted, and the sleeves were pumped with high-strength grout. This gave the bars continuity from the footing to the wall.

Once the columns were erected and braced, installation of the 16” thick precast voided wall system began. These unique wall pieces contained voids to reduce their weight, allowing larger pieces to be shipped and erected. The back wall was set to a radius of just over 266 feet.
After the rebar was tied, re-usable forms were installed, and the joint was poured. This phase followed the erection of the panels by one day. The coordination of rebar with both the inserts and the holes in the forms was essential for the process to be successful.

Corners were cast using special steel forms. In this instance, it was more cost-effective to use cast-in-place concrete rather than precast. The main reinforcing steel was tied to the walls, formed and poured; the process was unaffected by the change in material.
All of the openings were cast into the panels at the precast manufacturing facility. Panels with openings were designed as single units to reduce the number of pieces needed. Fewer walls decreased transportation and crane times, thus creating a more efficient structure.
Job site as seen from first floor.

Aerial view of job site.
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