Outstanding Projects and Leaders - Continued from Page 1

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This month's second outstanding project:
Globe Mills

Figure 1 - Globe Mills at the Completion of Rehabilitation
photo by Cathy Kelley

Synopsis

The historic and distinctive Globe Mills building complex, located in Sacramento, California, was chosen for seismic evaluation and rehabilitation as part of the city's seismic safety and downtown revitalization program. This evaluation provided a unique opportunity to examine new seismic systems and perform benefit-cost analyses. The Globe Mills complex, comprised of seven buildings, was originally constructed in the late 19th century. Several of the buildings suffered from fires contributing to the abandonment of the entire complex. However, the tall concrete grain silos and some of the historic features were intact. Hence, the complex is listed on the city's register of historic places and required preservation. The fire-damaged Mill Building was retrofitted using concrete shear walls, while the South Silo structure was found to be adequate without major retrofit measures. The remaining units were demolished due to irreparable damage/decay or project program requirements. Two new buildings were constructed using a unique structural system to provide open living spaces. The project provides 146 housing units and a recreation center. This rehabilitation project has provided a prime example of public-private partnerships and has received several awards. A recent photograph of the complex is shown in Figure 1.

Historical background

The construction of the Globe Mills complex began in the late 1880's and was completed in the 1920's. After completion, the complex consisted of seven adjacent structures, including the North and South Silos, the five-story main Mill Building with a water tower, the Barley Mill structure, and several smaller units. The complex footprint measures approximately 52 x 46 m (170 x 150 ft). The silos, Mill Building, and a smaller building were constructed with cast-in-place reinforced concrete. Some of the other buildings used wood framing. A historic photograph of the site from the 1930's is shown in Figure 2. In this figure, the northeast elevation of the Mill Building and its water tower are shown.

Figure 2 - Globe Mills (formerly Phoenix Mills), 1933
historic photo

The Globe Mills complex served as a grain and cereal mill processing center and operated until the 1970's. The sporadic use of the site since 1970 had left the complex in a severely decrepit condition. In addition, a large fire in 1995 struck the wood framing of the mill building, leaving much of the structure compromised and unstable as seen in Figure 3. As a result, the City of Sacramento considered razing the complex in the late 1990's. Until the current rehabilitation was planned, the complex remained vacant. A photograph of the complex taken in 2004 is shown in Figure 4. The poor condition of the site, and the fire-damage to the Mill Building at the time is evident in the picture.

Figure 3 - Mill Building Fire Destruction
courtesy of Michael Malinowski, AIA

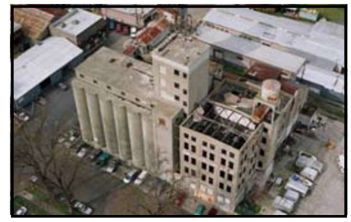

Figure 4 - Arial View of Globe Mills, 2004
courtesy of Michael Malinowski, AIA

Renovation program

In the 2000's, as part of the City of Sacramento's rehabilitation plan, an adaptive reuse and development plan for the Globe Mills site was initiated. The two primary goals of the project were: (1) to preserve the historic character of the complex, and (2) to provide affordable housing for seniors.

The project included preserving the South Silos, converting the head house above these silos into an activity center, and restoring and retrofitting the Mill building to be used to house new market-rate lofts. The site for the Barley Building was converted into an open space community area. In the place of the other razed buildings, two new five-story buildings were constructed to provide 100 units for senior housing. The project also includes tenant-serving retail and common area facilities. The new site plan is shown in Figure 5.

Figure 5 - New Site Plan
courtesy of Michael Malinowski, AIA

The construction cost for this project was approximately $40 million, making this renovation one of the largest rehabilitation and reuse projects in the greater downtown Sacramento area. A description of the rehabilitation and re-construction for the major units is provided in the following section.

Structural rehabilitation

The structural rehabilitation used both conventional code procedures and performance-based design methodologies for the analysis and design of various units in the complex.

South Silos

This unit consists of 24 interconnected annular silos, a rectangular silo, a stairway, and a head house at the top. The silos are 22 m (73 ft) tall and are constructed of reinforced concrete walls with a diameter of 4.6 m (15 ft). The silos are supported on a concrete slab, which in turn, rests on a series of concrete walls. At the top,

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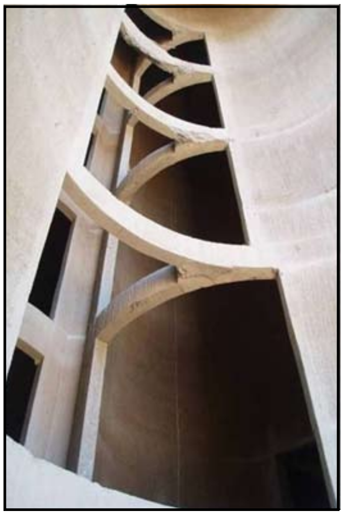

Figure 6 - Openings in Silo

a head house is situated. Above this level, a portion of the rectangular silo structure extends for an additional three levels.

As part of the rehabilitation, large openings were cut into several silos to provide new hallways, stair openings and elevator shafts and openings at each of the floor levels to serve occupants to both adjacent structures (Mill Building and New Building 2). Figure 6 depicts some of these openings. To characterize the seismic response of the silos, and to assess the effect of these openings, a comprehensive investigation was undertaken to assess the structural performance of the silos in the new configuration. This investigation encompassed condition assessment, including a detailed material testing and inspections program, site-specific seismic hazard development, and state of the art dynamic analysis of the structure. Analysis showed that the South Silos had a satisfactory response and that the cuts introduced during the rehabilitation did not compromise the structural integrity of the structure. A new floor level was provided near grade, and converted into a public space, including a mailroom in one of the former grain silos and an elevator that was also placed inside one of the former grain silos; see Figure 7.

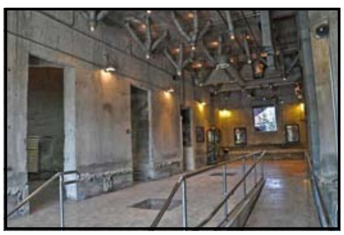

Figure 7 - New Ground Floor Lobby in South Silos
courtesy of Michael Malinowski, AIA

Mill Building

The five-story Mill Building has a footprint of 15 x 30 m (50 x 100 ft), and was constructed using cast-in-place reinforced concrete perimeter walls and wood floors. The floors were destroyed in past fires (see Figure 4). In addition, the building had rotated on its foundation and had a permanent tilt and skew. The existing water tower on the Mill building is one of the historically significant features of this building complex (see Figure 2) and hence required preservation. However, its framing was structurally deficient and required major retrofitting. The structural upgrade for the water tower consisted of adding 25-mm (1-in.) diameter rod bracing and copious concrete patching and reconstruction.

Seismic assessment showed that the perimeter walls were adequate in the short (East-West) direction. However, the building had insufficient lateral load capacity in the long (North-South) direction. To mitigate this problem, full-height interior reinforced concrete shear walls were added in the long direction. The new structural walls were supported on concrete footings. To alleviate concerns regarding soil stability, footings for the new shear walls were underpinned with new helical mini piles at each end, and were connected to the existing foundations using epoxy dowels. The new gravity framing for the building consisted of concrete filled steel decking supported by a system of steel beams and columns – the existing concrete walls were not utilized to support new gravity loads. Figure 8 shows a photograph of one of the lofts in the Mill Building after completion of the renovation.

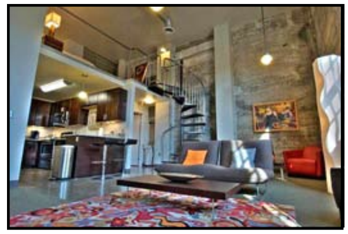

Figure 8 - Mill Building Loft, 2008
photo by Rich Baum

Barley Building

This is the oldest building in the complex, originally constructed in the 1880's. Initially, attempts were made to save this building, given its vintage. However, the extent of this building's rot and deterioration was so severe and pervasive that its preservation was not economically feasible, and as such, it had to be deconstructed. However, much of the century-old wood framing from the building was salvaged and incorporated into the community garden that now stands in its place; see Figure 9.

Figure 9 - Community Garden Center
photo by Cathy Kelley

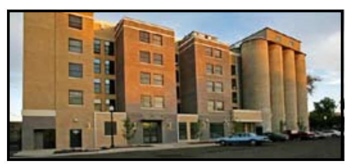

Figure 10 - Completed New Building 2, 2008
photo by Cathy Kelley

New Buildings

Two new five-story structures were designed and constructed to replace the existing units on the complex that were demolished; see Figure 10. Building 1 (NB1) is rectangular and has a footprint of approximately 25 x 45 m (82 x 156 ft), whereas Building 2 (NB2) is nearly square and measures approximately 24 x27 m (80 x 90 ft).

For both buildings, because of architectural constraints, the columns on the ground floor were not aligned with the columns at stories above. This lack of direct continuity in the load path necessitated careful analysis of these buildings and required designing a system for the transfer of upper level gravity and seismic forces to the lower story columns at the podium level. The building codes required amplification of forces at the discontinuous members by the overstrength (Σ_O) factor. Performance-based and innovative designs were examined. In particular, three distinct design alternatives were examined and the one that was the most cost-effective and simplest to construct was selected. The three alternatives all used a system of concrete/steel podium with steel ordinary moment resisting frames (OMRF) in one direction, and concrete shear walls in the orthogonal direction.

The following three alternatives for the four stories above the podium were investigated:

1. Metal stud bearing/shear walls;

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2. Steel ordinary concentric braced frames (OCBFs);
3. Truss moment frames with Hambro joists.

Alternative 1 required very heavy (14-gage) studs and built-up sections to support the design loads. Furthermore, heavy gage metal deck was needed to span between the stud demising walls. Heavy shear and hold-down connections were needed for the walls to account for the code's overstrength (Σ_O) factor. At the time of design, the cost of light-gage framing was growing exponentially, driving up costs dramatically, and pricing out this alternative.

Alternative 2 utilized heavy wide flange transfer girders at the podium. To optimize this alternative, performance based design was investigated. Finite element mathematical models of buildings were prepared. A three-step analysis procedure was used.

- The steel members were first sized using site-specific response spectrum loading, but without application of the overstrength factor.
- Pushover analyses were performed to assess the response of the structure at the performance point.
- Response history analyses were conducted for verification.

This analysis regime showed that the seismic performance of the buildings would be essentially linear; therefore, in lieu of using the code's overstrength factor, performance-based engineering was used to ensure that members supporting discontinuous columns remained elastic.

Although a reasonable design was achieved, there were several challenges that made this design undesirable. These included:

- Space design was extremely aggressive, making it difficult to make room for braces. At these locations, fitting of braces would have required major architectural compromise.
- Although member sizes were optimized, large steel members were nonetheless required at the podium. The size of these members supporting the braced frame columns and the complexity of the connections drove the project cost significantly upward. This was primarily because the space and architectural design necessitated using narrow braced frame bays, resulting in high vertical forces.
- Due to the presence of many transfer beams at the podium, gravity load deflections of these beams resulted in complex loading to the braced frames. This created large pre-loads in braces that were difficult to predict and could potentially lead to overstressing of these braces under combinations of gravity and earthquake loading.

Alternative 3 consisted of a system of truss moment frames, steel joists, and Hambro framing at the upper four floors, supported by a concrete/steel podium structure at the base of the second floor. The truss moment frames consisted of small tubular columns and light truss frame elements. Figure 10 shows the west elevation of NB2 after completion.

Summary

Conventional and performance-based engineering was used to assess the seismic performance of the historic Globe Mills complex in Sacramento, California. For this complex, the first priority was preservation, for which innovative engineering techniques were employed, allowing for the conservation of some of the most significant units on the site. The use of an integral approach using both the code procedures and performance-based engineering was critical for realistic evaluation of the complex. Examination of various alternatives and selection of the optimal structural framing resulted in a solution that was also economically feasible for the new buildings at the site.

Globe Mills received the Sacramento Section's Structural Project of the Year (2009) Award. - Ed.

ASCE Region 9 Lesiglative Affairs

by Rich Haller, Secretary
ASCE Region 9

In March the State Senate Committee on Business, Professions and Economic Development passed ASCE supported AB 1431(Jerry Hill – D-South San Francisco) which amended the makeup of the Board of Registration for Engineers and Land Surveyors. AB 1431 updates the name and expands membership to include one licensed geologist or geophysicist. In deciding to support the bill, ASCE Region 9 Governors felt it important that geologists and geophysicists be represented on the board. In an interesting development, the Association of Environmental and Engineering Geologists (AEG) has taken an "oppose unless amended" position on the bill, urging that the bill be amended to: (1) maintain the number of Board members at 13 members, the current level; (2) add one geophysicist to the Board; (3) add "Geophysicist" to the name of the Board. The bill in its current form only adds one member who is a geologist or geophysicist and does not include geophysicist in the name of the board. AEG wants to remove the Structural Engineer and the title act engineer from the board to keep the membership at 13. The bill will be on hold while conversations take place with the administration and among the engineering societies.

ASCE Region 9 has joined the Alliance for Clean Water and Jobs to help convince the public of the merits of spending on water infrastructure and to support the Water Bond at the general election in November. The Alliance website http://www.waterforca.com/ has information on the Water Bond and talking points.

The Region 9 Water and Environment Committee has been reviewing more than 40 bills that were introduced this year dealing with water related matters. Based upon recommendations of the Committee, Region 9 will be recommending amendments to AB 1793 that prohibits the governing board of a common interest development from banning artificial turf. While supporting the use of technologies like grass replacements to encourage water conservation, Region 9 believes it is important that these replacements maintain the permeability of the native material so as not to reduce groundwater recharge or increase stormwater runoff. Region 9 is also supporting AB 1978 that requires new multi-unit construction include provisions for individual water meters as a water use efficiency promoting technology. Region 9 will oppose AB 2049 that would ban any water transfers from an agricultural user to a municipal user and will "oppose unless amended", AB 2092, which allows the Delta Stewardship Council (DSC) to charge a fee on water supply contractors of the State Water Project (SWP) or Central Valley Project (CVP). The Committee recognized the need for funding for the DSC but will encourage a broader application of fees to include the beneficiaries of the water controlled by the DSC. For more information on the Water Committee's activities, contact Mark Norton [MNorton@sawpa.org] or Richard Markuson [Richard@pacificadvocacygroup.com].