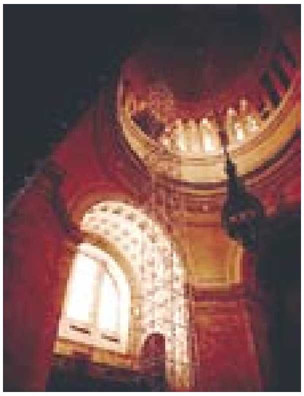
Washington State's Capitol Seismic Repair

by Marcus von der Hofen



Washington State's Capitol Seismic Upgrade will surely rank as one of the top restoration projects of this decade and shotcrete proved to be essential to its success. As with most complex rehabilitations, many of the hurdles faced arose after the project had begun. The ability of the contractors, engineers, and architects working together to overcome these issues proved once again to be the crucial factor in the success of the project.

Background of Project

A consummation of 7 years of construction, Washington State's Legislative Building, completed in 1928, serves as both a working governmental center and a symbol of Washington's free and democratic government. It is the centerpiece of the five historic capitol buildings designed by New York architects Walter Wilder and Harry White. Conceived in an architectural competition of 1911 and selected by the State Capitol Commission, Wilder and White's designs for the Legislative Building were completed and set into motion in 1922.

Arguably the most impressive structure in the state, the legislative building is comprised of more than 173 million lb (78 million kg) of stone, brick, concrete, and steel. The fourth tallest masonry dome in the world, rising over 270 ft (82 m), tops this magnificent edifice. The Legislative Building was a remarkable achievement founded in the era of "American Renaissance" and still stands as a symbol of American ideals and architectural grandeur.

Although the idea of significantly renovating the Legislative Building had been considered for over a decade, it was not until an analysis of the failing infrastructure was completed in 1996 by the architectural firm Merritt-Pardini, that serious dialogue about rehabilitation was considered. The report laid out an initial scope of work and was the foundation for the legislature's appropriation of funds for General Administration to complete a predesign.

General Administration contracted with the team of PB Architects and Barnett Schorr Architects (PBA+BSA) and Leavengood Architects to complete the predesign.

The predesign report confirmed the grim picture of the building's aging and ailing infrastructure, exterior stonework, and space-use needs. It also identified needs for increased safety requirements, accessibility, and security measures. According to the study, the structure was in need of major rehabilitation to rectify these far-reaching ailments.

To remedy these extensive aesthetic and operational problems, the predesign recommended a two-pronged approach. Separate designs, budgets, and timelines for infrastructure repair and exterior restoration were developed and recommended. The total project including both infrastructure improvements and exterior restoration would cost $114.5 million and take 8 years to complete. This predesign was forwarded to the Legislature for approval in 1999.

The engineering firm Swenson Say Faget and architects NBBJ made the final calls in the design. The project's remedial construction officially began on June 3, 2002, when General Administration issued the notice to proceed to Mortensen, the General Contractor/Construction Manager for the project. The ceremonial event, featuring special speakers, tenants, and the media, marked the transition from a period of preparation to a construction phase slated to be completed by November 2004—in time for the tenants to move back in for the 2005 legislative session.

Shotcrete

Wet-mix shotcrete was used to reinforce the masonry dome, catacombs, and create new ring beams in what was referred to as the upper structure. This was achieved by pumping 8000 psi (55 MPa) wet-mix shotcrete over 200 ft (60 m) vertically and through nearly 700 ft (213 m) of a twisting and turning pump line system. Placing shotcrete around highly congested reinforcing in extremely tight working quarters was a major challenge. However, because of careful pre-job planning followed by exceptional execution in the field, this extremely difficult shotcrete placement was completed without a flaw and to the satisfaction of the architect and engineer.

The difficulty of the project led the team to analyze most of the common questions in any seismic upgrade, or, for that matter, any structural shotcrete/concrete job. Because this job was designed for shotcrete in many areas, it was not as difficult to convert other areas for construction using the shotcrete process. Still, I found that this job's design team, as good as it was, had many misconceptions or misinterpretations of what you can or cannot do with shotcrete. During the preconstruction meetings, questions such as the following arose:

Reinforcement

Can you shoot bars larger than No. 5 (15 m)? Can you shoot through two layers of steel? What about noncontact lap splices?

When I read Chapter 5.4 of ACI 506R, there is one sentence that stands out to me that all designers, inspectors, specification writers, etc., should keep in mind. It reads, "In any case, reinforcement should be sized, spaced, and arranged to facilitate the placement of shotcrete and minimize the development of sand pockets and voids." Today we shotcrete far more difficult reinforcing configurations than was imagined when this chapter was written. This particular project had reinforcing as large as No. 11 (35 mm) with contact lap splicing (by choice). Designing around a one-size-fits-all configuration or spacing standard would hardly be a correct methodology.

Typically, standard concrete designs with multiple reinforcing faces can be constructed with shotcrete. The necessity of boundary elements or integral columns and beams complicates the issue, but construction can still be done with shotcrete, given the right design configurations. The key to success is good communication between the shotcrete contractor and the engineer and architect. Good communication can result in a field situation that meets the design requirements and is also suitable for the shotcrete applicator. Sometimes the question of constructability can only be answered with preconstruction testing. Preconstruction testing for this project proved that very complex reinforcing steel configurations can be satisfactorily placed using shotcrete.

Test Panels

Sometimes preconstruction test panels are not needed for a project. If a company and its personnel have many recent jobs that are similar to the project at hand, then it should be considered in the review of requirements. Preconstruction mockup panel production and testing should be done if documentation from previous testing or job experience is not available. In this case, the distance of the pump

Capitol front with exterior scaffold, not chosen as route for shotcrete hose

from the point of shooting, the complexity of the reinforcing, and the tight placing quarters were not situations that were encountered every day. Thus, preconstruction test panels were created in the building, using the same pumping setup used for the actual job. This was very beneficial for the contractor and designer in assessing the product's potential performance. For some reinforcing configurations, it could be shown through documentation of previous work performed by the shotcrete contractor that suitable results would be achieved, thus eliminating the need for preconstruction test panels.

Shotcrete Strength

At the beginning of this project, many of the design team members did not think that the production of high-strength (8000 psi [55 MPa]) wet-mix shotcrete was achievable. The fact is that materials available to concrete suppliers vary greatly throughout the world. Local ready mix services can help greatly in providing information on products available. In this case, previous testing done by the shotcrete contractor and supplier provided results that proved it was possible to produce such high-strength shotcrete with the materials available in Washington.

Conclusions

Communication and planning can overcome many job issues that can hinder a project. Always consult with a proven shotcrete professional before making your job decisions. This project has demonstrated that high-strength shotcrete can be successfully placed to construct complex reinforced structural elements, with large-diameter reinforcing bars, when there is proper communication between the architect, engineer, and shotcrete contractor.

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