Highway Technology Bridges Gap in Office Construction

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What do you do when your team is well into a construction project and reality fails to align with what was planned? Is it possible to change course and salvage a project, thus avoiding a teardown and starting over?

These are big, important questions, and exploring each of them could constitute a thoughtful academic exercise. But when a concrete producer contacted our firm, CTL|Thompson, about a snag in construction, we didn't have time for academics. The producer was well into a large, high-profile high-rise in downtown Denver, and the second-floor parking deck was unable to meet the required loads. The project was 16M, a 340,000-square-foot, mixed-use building on the southeast corner of the 16th Street Mall and Market Street in downtown Denver. The vision was a 10-story development including luxury apartments, five floors of office space and a full floor of restaurant space – all of which was threatened because of concrete that wasn't meeting compressive strength. The structural engineer of record had carefully analyzed the slab using the lesser strength achieved and found a small area that would not provide adequate support as built.

No one on the project had anticipated this problem, as so many steps had been taken to ensure a smooth build. Early tests had shown that the concrete should make the required design strength. Yet the material wasn't performing as expected. The project team now faced practical (and potentially costly) concerns as to whether the existing slab would need to be torn out and replaced, a cumbersome, disruptive decision that would have delayed work on this building.

When we received the call, most of the on-the-ground project team, with years and years of experience in high-rise construction, saw slab replacement as the presumptive option. However, I knew from 40-plus years of experience in materials testing that this choice came with a very high price.

Another option included beam placement below the problematic area. This option was also expensive and potentially unacceptable, as it would limit clearance in the main drive location of the below-ground parking lot.

Luckily, our materials testing team has years of experience that spans many sectors of development and construction. Relying on our work with departments of transportation and road/bridge developers, we were able to see a solution to the problem that had eluded 16M's project team. Commercial construction rarely needs this "fix," as it is primarily used to reinforce roads and bridges, but we believed it would work, and careful study bore us out.

The answer was this: Use carbon fiber to improve the strength of the section in question. This could be done with concrete as placed, preventing the need for a teardown. The carbon fiber material has been used for more than two decades and possesses incredible strength compared

to steel. In our state, the Colorado Department of Transportation uses it occasionally on bridge repair and highway construction projects. The strong, thin layer of carbon fibers, encapsulated in a resin film, can be adhered with epoxy to the surface of concrete, akin to putting a cast on a broken arm. Proceeding with reinforced post-tension concrete in this case would place tensile reinforcement on the bottom of the slab, providing a structurally sound repair while also serving as a new application of a unique solution.

Most importantly, the application would compensate for the lesser compressive strength, thus allowing the concrete to stay in place. In addition, external tensile reinforcement uses strong, flexible fibers that are not subject to weathering – a key consideration for structures such as parking garages, which take a lot of wear and tear and are exposed to aggressive levels of sand and salt drippings over different seasons.

Other advantages to pursuing this approach:

- There was no compromise in the floor-to-ceiling clearance in the area of repair.
- The repair would be nearly invisible to passing occupants or visitors. Anyone looking closely at the underside of the slab in the area of the understrength concrete would see only a slight difference in texture and color as compared with the rest of the underside of the slab.
- Where other repair methods would include a risk of damaging steel during concrete excavation, this repair required no cutting or chipping into the concrete that encases the existing strands.

As expected when an atypical approach is suggested to solve a problem, questions arose. Yet the contractor initially accepted this solution, and as soon as the structural engineer evaluated its feasibility and endorsed it, it was smooth sailing. However “outside the box” the solution appeared, the developer recognized it as the best possible scenario – one that was safe, efficient and kept construction moving on schedule.

Today the building is a vibrant, LEED-certified, mixed-use commercial site, able to withstand its daily traffic levels and house 115,000 square feet of office space, 13,000 square feet of retail space and 36 apartments on the top four floors.

The developers of 16M will implement a similar design for Pivot Denver, a mixed-use development at 17th and Wewatta streets to be completed in April 2018. This project, previously called 17|W, will feature four levels of parking, three above grade; three 10-story apartment towers housing 580 apartment units; and a 56,000-square-foot Whole Foods Market.

As Denver’s density grows, and the number of parcels available for development in the downtown area continues to shrink, issues like those seen at 16M may become more commonplace. Most developable land in Denver today is brownfield and requires some level of remediation. In fact, according to the City and County of Denver’s Open Data, only about 3

percent of the parcels within the City and County of Denver are vacant land, so developers are seeing opportunities where, in the past, they might have seen only problems.

But, as in the case of 16M, solutions exist – even if they are borrowed from other trades. What is critical is a strong coalition between the contractor, the supplier, specialty repair contractors and the engineer of record. This healthy working relationship among all the parties involved – not any single entity – was the reason for the successful outcome at 16M, one that minimizes the expense of repair and retains the structure's value.

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Orville "Bud" Werner II, P.E., is Principal of CTL|Thompson & President of its division, CTL|Thompson Materials Engineers Inc. Established in 1971, the full-service geotechnical, structural, environmental and materials engineering firm currently employs 200 technical and non-technical employees and provides expertise in small and large-scale projects in all areas of construction. CTL|Thompson is headquartered in Denver and has offices in Colorado Springs, Fort Collins, Glenwood Springs, Pueblo, and Summit County, Colorado, and Cheyenne, Wyoming. For more information, please visit www.ctlt.com.