The Creeping of the Burj Khalifa

Duke University

Fifty or so years from now, the world’s tallest building could likely be about two feet shorter.

That may not seem like much for a structure that is 2,717 feet tall – more than nine football fields -- but it could wreak havoc on all sorts of conduits and lines within the building, such as those for water, electricity, communications, cooling and heating.

The skyscraper Burj Khalifa, which cost $1.5 billion to build, officially opened earlier this month in Dubai, United Arab Emirates. The building, home to a mixture of residences, hotel rooms, restaurants, offices and the world’s highest mosque, opened to much fanfare and international news coverage.

In the early planning stages of this massive structure, a Pratt School of Engineering alum tried to figure out the effect of all that concrete on the structural integrity of the building. Shane McCormick,E ’98, was a member of the team that analyzed the plans for the skyscraper and quantified the likely stresses that the 110,000 tons of concrete used in its construction would place on the building. The year was 2004, and McCormick was then working at Skidmore, Owings, and Merrill (SOM), a Chicago-based architectural and engineering firm.

As it turns out, concrete undergoes subtle, almost imperceptible, changes over time as a result of the pressures placed upon it – the taller the structure, the more stress on the concrete below.

“Concrete has unique characteristics as a material,” said McCormick, a structural engineer. “Over time, the concrete tends to shrink and creep. The creeping is the tendency of the concrete to deform over time as a result of the loads on it. The shrinkage occurs as the liquid in the concrete evaporates. Over the course of 50 years, the concrete may deform as much as one-eighth of an inch per floor.”

For most buildings, this is usually not a significant problem. But for a structure that has 160 floors, this creeping must be understood and accounted for. McCormick said that in 50 to 100 years, the building could be two feet shorter than it is now.

“From a structural point of view, there is not much that can be done,” McCormick explained. “However, many of the services and systems within the building need to have special joints, and they need larger openings in walls to allow the mechanical services to accommodate the movement. As long as you know about it, you can plan accordingly.”

During his two-month stint on the Burj Khalid project, McCormick devised computer models to determine where the most stresses would likely occur, thereby helping the engineers and architects as they designed the building.

The design of the building itself is straightforward, McCormick said. It is basically three towers, or elements, located around a central core. The foot print of the building is that of the letter Y whose cross-section decreases at the tower reaches the sky.

“The unique aspect of the building is that almost every vertical element is connected together to form an integrated system,” McCormick said. “While the structure is fairly conventional, the challenges come from dealing with the sheer size of the project. When you have that many vertical elements, it’s important to come up with modeling techniques that can account for this unique situation.

“My job was to develop computer programs and techniques to create a model for the building,” he continued. “For normal tall buildings, creeping and shrinkage is not a big worry. However, for the height of this new building can have significant effects – we estimated that forces can be increased by as much as 50 percent, depending on the element involved.”

McCormick conducted similar studies on a much smaller scale during his studies at Duke’s Pratt School of Engineering while an advisee of Henri Gavin, W.H. Gardner Jr. Associate Professor of civil and environmental engineering.

“He and I worked on developing ways to conduct large computational tasks,” McCormick said. “We came up with matrix-structured analysis programs that we could use to optimize a given structure’s geometry and weight profile given different loading conditions.”

After graduating from Duke, McCormick headed north to Urbana-Champagne, where he earned a master’s degree in structural engineering from the University of Illinois. From there he traveled even farther north, where he worked for SOM. In 2005, he joined Martin/Martin Consulting Engineers, a full-service civil and structural engineering firm based in Lakewood, Colorado.

“Working on the Burj Khalid project was a lot of fun” said McCormick, who was also involved Chicago’s Trump Tower project at the time. “It was a once-in-a-lifetime opportunity. This type of experience is one of the big reasons I decided to go into this business.”

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