How to Keep a 1,500-Foot Skyscraper From Falling Over

By Sophia Chen

The Chengdu Greenland Tower, currently under construction, is rising to conquer the Chengdu skyline. The expected completion date of the tower, which began construction last November, is sometime in 2018, the ten-year anniversary of a devastating earthquake that killed almost 70,000 people and ravaged the southwestern Chinese city's infrastructure. At 1,535 feet tall, the skyscraper will be the fourth tallest building in China—and a giant exhibit of engineering's ability to make tall things stand up.

The Chengdu Tower, in particular, stands up because of a new twist on an old technique that marries design and engineering. In addition to the concrete core and steel frames that make up the interior skeleton of many modern skyscrapers, the Chengdu Tower has an exoskeleton—a weight-bearing structure constructed on the outside of the building.

Techniques like the exoskeleton offer a creative solution to skyscraper engineers' ongoing challenge: how to reduce building costs while staying true to an architect's vision. To save money, engineers are always trying to use as little material as possible while keeping the building safe. It's helped that over the years scientists have developed better materials like stronger steel and concrete. But designing the exoskeleton is a problem that architects and engineers tackle together—how to make a structure that is both cost-efficient and beautiful.

"The ideal goal is for the exterior structure to reflect the shape of the building, almost like they're bound together," says Fei Xu, an architect who worked on the Chengdu Tower.

The basic engineering principle is simple. Exoskeletons are typically made up of triangles, which are the most structurally stable two dimensional shape. "You basically put a big 'X' on the building," says Dennis Poon, a structural engineer who led the engineering design behind the tower. "It's an efficient structural system because you use the entire width of the building to resist wind."

But in execution, the Chengdu Tower's exoskeleton is much more intricate than just some big X's. Because Chengdu is typically cloudy, the architects wanted the tower to face many different directions to reflect more natural light. Unlike older exoskeletons that lie flat on the facade of the building, such as the large triangles that support the Bank of China Tower in Hong Kong, finished in 1990, each adjacent triangle in the Chengdu tower's exoskeleton is on a different plane. The triangles weave in and out along the building's many faces, which make the tower look as though it is twisting in the air.

In addition to supporting the weight of the building, the 3-D exoskeleton also makes the building look better on the interior compared to a flat 2-D exoskeleton. "It makes the building more transparent by allowing you a bigger view on the inside," Xu says.

To be clear, an exoskeleton isn't necessarily better than other weight-bearing techniques—it's just another way to make skyscrapers stand up, while also simultaneously being material-efficient and coollooking. “Sometimes we use exoskeletons, and sometimes we don’t,” says Poon. “It depends on what drives the architectural design.”

With all these technical innovations, the structural principles that these engineers use are still basically the same as the ones used on the very first skyscrapers. To do their job, structural engineers like Poon track where all the forces go—how the concrete slab of the top floor transfers weight into steel beams that support it, how those beams shift that weight into larger beams, and how eventually all the weight gets transferred to the foundation of the entire building.

These days, computers make the planning process a lot faster. Engineers can build computer models to investigate the structural integrity of more creative geometry, which makes designs like the Chengdu Tower possible. By comparison, the Empire State Building, which is about 100 feet shorter than the Chengdu Tower, was designed “using a slide rule,” says John Shmerykowsky, a structural engineer has worked on many high-rises in New York City for over 50 years. “All the calculations were done by hand.”

So what keeps engineers from building even taller buildings? It’s not physics. “We can build twice as high as we can today,” says Shmerykowsky. “But it all comes back to the economics.” In other words, taller buildings aren’t worth the money to developers right now.

Plus, most cities have municipal codes that place restrictions on tall buildings to prevent them from interfering with air traffic or from disrupting the overall aesthetic of the city’s skyline. On the engineers’ part, as long as the soil around the foundation of the building can take the weight, even taller skyscrapers are possible.

“I look forward to designing a mile-high building,” Poon says. A nice pipe dream for now.