



A Unique Opportunity for a Conventional Tall Building Frame

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The Sichuan Airlines Center (SAC) Tower occupies a prominent site in the city center of Chengdu and has become a glittering symbol of the city's urban transformation. The distinctive 650-foot tall (200 meter) tower is a recognizable city landmark, occupying a pivotal location on the Chengdu skyline. The Tower form is a natural reconciliation of geometry, structure, and space made possible through a systematic approach to its construction. The tower's design is focused on the creation of flexible, high-quality office spaces and a thoughtful engagement of the public realm, inviting the life of the street into the site. The unique form of the tower folds open vertically, responding to the local climate, capturing light and views for occupants.

As the tower rises, its shape is organically transformed in response to the changing relationship of the interior spaces to their elevation; each floor slab changes slightly in shape from the one below at a consistent rate. The perimeter columns follow the building's changing shape, shifting slightly from one level to the next. To achieve this unique building form, surfaces of the tower skin gently twist as the building rises. This subtle movement is achieved by precisely bending each glazing panel onto the building using adjustable exterior wall anchors. Overall, the result is a single, continuous form that accommodates both the required footprint and setbacks, while extending the southeast corner of the building as a large gentle arc, visually unifying the building's relationship with the corner of the site and the surrounding civic space.

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Sustainability

The Sichuan Airlines Centre has achieved LEED® Gold Pre-certification for its commitment to energy efficiency, water conservation, increased ventilation, and improved indoor air quality. The project incorporates a number of sustainability measures which are integral to the building's overall design intent. Energy use is extensively metered for actual energy consumption monitoring and verification efforts.

The project additionally integrates a water efficient landscaping concept where storm water and air conditioning condensation are collected and treated for landscape and irrigation uses. SAC has achieved the highest standard of stormwater design within the project as the landscape irrigation does not utilize any potable water on site.

Similar to the design of the structure itself, the development of the site maximizes open space and access to nearby public spaces. The site's connectivity is positioned near a number of existing public transit opportunities including metro train and bus networks; it is situated just one block from a subway interchange station. This contributes to the building's high Walk Score rating of 94 – where daily errands do not require a car. A new, extensive public transit system has also been proposed for the Central Chengdu region, which will further increase alternative transportation options for building occupants.

Form and Structure Creating Quality Spaces

Building forms which are highly responsive to energy performance, quality views, and aesthetics often create complex geometric interior spaces. This frequently results in poor office layouts and irrational relationships of building structure and exterior wall. Even in cases where the structural geometry is responsive to the exterior wall, the quality of the interior office space is often left lacking.

The exterior wall of SAC is highly respectful of solar exposure and expansive views. A traditional moment frame would have approximately 30-foot (9-meter) bays with columns extruded vertically through the space. Since the exterior wall changes dramatically from the base of the building to the roof, the column relationship to the exterior wall would result in varying and often very poor office space conditions, dramatically diminishing views and adversely affecting energy performance by blocking too much sun in the cold winters prevalent in Chengdu.

A simple, but novel change to traditional frame geometry was incorporated which gradually reduced the spacing of columns from 30 feet at the building's base to 20 feet (6 meters) at the top, and shifted in their plan location slightly at each floor. Buildings with extruded rectangular geometries typically have the columns and exterior wall mullions aligned. This creates a natural place for

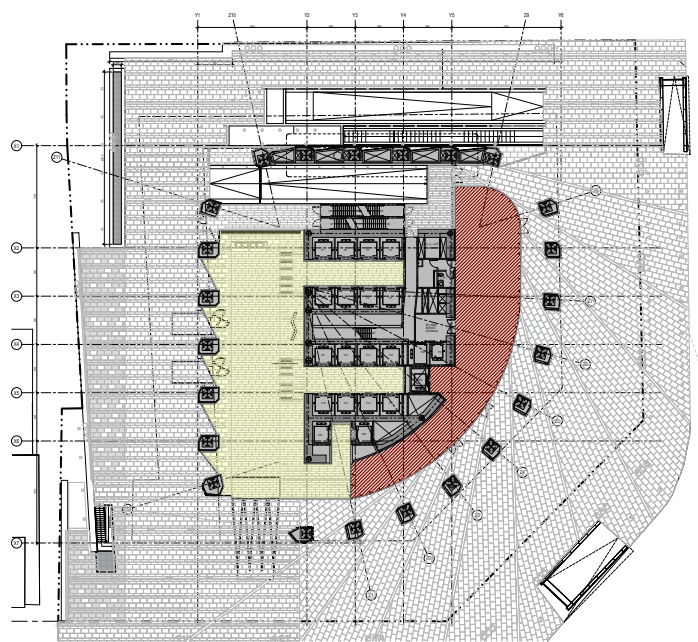
interior partition walls to meet the exterior wall. Buildings with complex and varying perimeter geometries often lose this organization of the column and exterior wall mullions. Thus, when an interior partition meets the exterior wall, it often ends up being located between mullions and columns. This greatly diminishes the usability and quality of the interior spaces. For the SAC tower, this condition was minimized by shifting the columns slightly on each floor and following the mullions. Thus, an innovative and integrated building form was achieved without compromising the quality of the interior spaces.

The shift in column location from floor to floor was small enough that conventional reinforcement detailing could be used and significant eccentricities were avoided. Since the frame column spacing was tighter towards the top of the building, it could be designed more efficiently and could have higher participation in seismic events, alleviating some of the demands on the central core. At the corners of the floor plans, much longer spans, up to 42 feet (13 meters), were introduced to provide expansive, uninterrupted views.

Safety in Seismic Zones

The city of Chengdu is the capital of Sichuan province in China and was tragically struck by a magnitude 8.0 earthquake in 2008, only three years before the start of the SAC Tower design. With nearly 70,000 deaths, 15,000 missing, and 375,000 injuries, safety was of paramount importance to both the developer and the city of Chengdu. In recent decades, the Chinese building codes have significantly evolved and have been shown to yield safe buildings in seismic zones. The issues encountered in the Sichuan earthquake of 2008 were due to much older buildings which pre-dated many of the current Chinese code provisions pertaining to seismic safety and poor construction.

The seismic force resisting system of the SAC tower is a dual system composed of a centrally reinforced concrete floor supplemented by a perimeter reinforced concrete moment frame. The combined behavior of the two systems results in a building period of 5.3 seconds with satisfactory inter-story drift behavior.



Typical floor plan.



The site unifies the building's relationship with the corner of the site and the surrounding civic space.

The Chinese regulations require buildings that exceed code provisions to undergo “expert panel reviews” (EPR). The level of review depends on a building’s code-exceeding characteristics such as structural height, the uniqueness of the lateral force resisting system, building complexity, inherent torsion, etc. Due particularly to the height of the building, which exceeded code limits for the structure type, a regional level EPR was required, as opposed to a more stringent national level EPR. The regional EPR process is

a general review of all aspects of the lateral force resisting system. Under the provisions of the Chinese building code, in addition to other special design checks, a nonlinear time-history analysis was conducted by China Southwest Architectural Design and Research Institute and presented to the EPR panel. Although different than the performance-based design process established in select cities of the West Coast of the United States, the EPR process serves as a highly valuable component of the Chinese building code review process in producing buildings of high seismic safety.

Conclusion

The Sichuan Airlines Center tower is an example of transformative urban architecture, quality office space, integrated design, and seismic safety. Its construction in a rapidly evolving Chengdu city skyline will provide a quality precedent for future construction in Sichuan Province. ■



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