The World's Tallest Building, Burj Dubai, U.A.E.

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Abstract

Burj Dubai will be the tallest structure ever built, exceeding 610 meters (2,000 ft.) in height. This residential tower required a highly integrated approach to the development of architectural and engineering systems. A primary concern was developing the architectural mass (shape) to meet structural engineering requirements. In this paper, the process of shaping the tower in order to mitigate wind effects and assist in resisting loads is discussed. In addition, the building's structural systems are presented and discussed.

Keywords: world's tallest building, residential building, high performance concrete, wind engineering.

The Burj Dubai structure represents the state-of-the-art in tall building design. Once completed, it will not only be the world's tallest building but the tallest man-made structure ever created. From the project's initial concept design through construction, the combination of several important technological innovations results in a building of unprecedented height. The following is a description of some of the innovative structural design methods which enable the creation of a superstructure that is both efficient and robust.

Designing the Wind

The primary concern in the engineering of tall buildings is the effect of the wind on the building's structure. The shape of the Burj Dubai is the result of collaboration between SOM's architects and engineers to vary the shape of the building along its height, thereby minimizing wind forces on the building. In effect, each uniquely-shaped section of the tower causes the wind to behave differently, preventing it from becoming organized and minimizing lateral movement of the structure.

The modular, Y-shaped structure, with setbacks along each of the three wings, was part of the original concept design entered in an invited design competition at the beginning of the project. From this starting point, the SOM team refined the tower's shape over several months of extensive wind tunnel tests. Through these tests, the team determined the harmonic frequency of wind gusts and eddies under various wind conditions. This information was used to set targets for the building's natural frequencies, thereby "tuning" it to minimize the effects of the wind.

Concurrent with the wind tunnel studies, the team performed a detailed climatic study which considered the unique meteorological conditions of the Dubai wind climate. These studies considered both frequently occurring and rare wind events to address occupant comfort and building strength. Together, the wind tunnel testing and climatic studies resulted in a highly engineered solution that is appropriate for the Dubai wind climate.

Buttressed Core System

As a residential tower, the Burj Dubai requires floor plates with shallow lease spans that maximize the amount of exterior window area (and therefore natural light) in the living spaces. As a very tall tower, it requires a wide footprint to provide sufficient stability to resist high wind loads. The Y-shaped arrangement of reinforced concrete shear walls around a central hexagonal reinforced concrete core satisfies both of these requirements. The resulting "buttressed core" is an extremely efficient solution to the potentially conflicting structural requirements of a supertall residential tower.

Core walls in each wing are arranged in a 9-meter module that matches the setbacks of the tower. This allows the building to be shaped without transfers; the columns in the nose of each setback sit directly on the walls below. The result is an easily constructed system

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that is significantly less expensive to build than one requiring transfers.

The perimeter columns on the sides of each wing match the width of the adjacent shear walls, thus permitting them to be engaged by infill walls at each mechanical level. This engagement of the perimeter columns leads to high levels of structural efficiency in resisting loads as well as a high degree of redundancy.

High Performance Concrete

The specified material and the configuration of the structural elements utilize the high performance concrete and formwork systems readily available in Dubai. Very strong, high density concrete composed of Portland cement in combination with silica fume, fly ash, and ground granulated slag is available and results in a structure which is stiff, strong and highly constructible.

The mat utilizes C60 self-compacting self-consolidating concrete (SCC). Advantages of this type of concrete include the high uniformity of placed concrete, ease of placement, elimination of vibration, reduced bleed water and reduced labor. The mat was placed in four sections in order to minimize thermal effects.

The superstructure uses concrete strengths that vary between C80 to C60 for the lateral system. Lower concrete strengths are specified for the horizontal framing. Higher strength concretes were considered but since the structural system distributes the loads so effectively, higher strength concrete was not required.

Foundations

The superstructure is supported by a large 3.7 meter thick reinforced concrete mat, which is in turn supported by 1.5 meter diameter bored reinforced concrete piles. The design of these elements is based on extensive geotechnical and seismic investigations and analysis. The high density and low permeability of the concrete used for the foundations minimize the detrimental effects of high chlorides and sulphate content in the local ground water. The foundations are further protected by waterproofing and cathodic protection systems.

Conclusion

The Burj Dubai structure represents the state-of-the-art in supertall buildings. It capitalizes on the latest advances in wind engineering, structural engineering, structural systems, construction materials and construction methods to result in a structure that goes beyond anything that has been achieved before. The tallest structure ever built, it realizes the aspirations of mankind to reach to the sky.

Figure 1: Burj Dubai Rendering