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Study of the Stability in the High Building: Case Study in Burj Dubai, UAE

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Abstract

Many people today live in urban cities and it is increasing every year, because of their need to live and work and This paper summarizes the solutions and the importance of stability in high-rise buildings and their tolerance of earthquakes and winds, and all that is needed for the stability of the building and to solve the problems that occur in particular and in detail Highlighted are the key connections of the tallest and ultra-slender buildings that have been designed and built for the world's tallest buildings. He talks about high-rise towers in general and about Burj Dubai in particular, and there will be what the engineers said and suggested before, and I will conclude in a simple way.

Keywords :
High - Rise Buildings, Stability, Urban Cities, Wind Loads

1. Introduction

The first tall buildings were built in the 1880s in the United States, took up less space and became staffed with steel structures and outdoor glass enclosures, and in the 20th, century became an important feature in most cities. High-rise towers are considered one of the most important components of the country's economic strength and a sign that distinguishes it from other countries. Many countries are now seeking to make progress in building high-rise investment projects. Countries are advancing in planning and scrutinizing architectural aspects. Architectural progress in the country encourages technological progress to take advantage of the latest systems according to the company's standards. In the stability of these buildings due to the different loads in tall buildings than in low buildings because they are exposed to the wind, the increase in the height of the building increases the impact of increased winds loads, causing safety concerns for the structure envelope and the integrity of the structural system. Tall buildings shook along the wind. The vibrations may be large to cause anxiety and discomfort for the people present, or by strong earthquakes. Strong earthquakes are rare, but they may occur once a year and cause huge disasters, as happened in the Sumatra earthquake in 2004 and led to the death of more than 230 thousand people and many Fatalities as a result of building collapse, there is a high probability that tall buildings will be exposed to these vibrations that may occur and The most important factor in the design of tall buildings is the need to withstand external forces through the use of cross walls to provide a rigid structural frame with greater strength to withstand wind pressures. Assessment of building movement is a prerequisite, stability under wind load is important for structural structures. Safety and Architectural Safety Hazards can be reduced in tall buildings, especially in active areas with earthquakes or prevailing wind loads.

2. Literature Review

2.1. Historical Stages of the Construction of High-Rise Buildings

The construction of tall buildings passed through several historical stages and economic changes, and the first stage was the nucleus of building tall buildings or gigantic skyscrapers. The first, which consists of a block and a clapboard-like shape that results in a very repetitive pattern and buildings in this phase were constructed exclusively for commercial purposes and commercial activities required to be close to each other and to the city center and then the second architectural phase of tall buildings was more evident in New York buildings. This new architectural style is known as Art Deco. The third stage represents the entrance to high-rise building planning for marketing experts, resulting in tall buildings being a profitable symbol rather than a work of art. tall buildings began to have as many corner offices as possible. The fourth phase began in the 1980s and was an answer to the Cubism period by continuing the marketing trend in the skyscraper facade and maximizing the viewing angle by curves and retrogrades. Other major concerns around this style were creating amenities in the entrance foyer, avoiding the flat roof and declaring the building's small facade hence the fifth phase began in the 1990s. One of the most prominent features of this phase is the modification and improvement of building forms and energy efficiency. It deals with the passive phase in architecture, such as the effect of natural light and solar orientation, as well as the negative control of architecture and engineering, but energy efficiency can be achieved. With more comprehensive options such as improved insulation, use of building thermal mass and wind energy, energy could be the future of sustainability for tall buildings.

2.2. Needs for High-Rise Buildings for Stability

Most high-rise buildings contain steel frames, and concrete frames consist of columns (vertical support and horizontal support) and to provide a structural frame with greater rigidity, cross walls or shear walls are used to better withstand wind pressures When designing tall structures, basic requirements such as loads, resistance, stability and durability must be considered.

2.2.1. Loads

Vertical loads, i.e., dead and live, do not cause any design problems as they are mostly deterministic in nature. However, lateral forces from wind or earthquakes make the design unpleasant. These lateral forces can generate significant tensile stresses in the structure, cause unwanted vibrations, or cause excessive lateral tilts and deflections of the structure, and thus require unique and important considerations.

Advances in the design of multi-store structures have emphasized the importance of restricting lateral impact (displacement) as well as the activity of lateral loads. The provision of a shear wall, in contrast to conventional inflexible frames, reduces the side effect of the structure. A well- designed shear wall provides structural integrity and security for non-structural elements such as suspended ceilings, architectural walls of various types, and so on from seismic disturbances.

2.2.2. Resistance

One of the most important aspects of a tall structure is to withstand and stabilize the worst possible range of loads that may occur throughout the life of the structure, including the construction period. In addition, strains from differential activities such as creep, shrinkage or temperature must be included in the structural strength parameters.

2.2.3. Stability or Balance

High structures must have bases and foundations that ensure stability under the influence of a combination of vertical and lateral forces. Thus, foundations and structures must be designed and implemented so that the easy rule of net force flow is applied and passed through the middle third of the base, thus ensuring that the stresses under the foundations are compressive stresses and prevent the generation of extreme stresses. They cause the entire structure to tip over due to the movement of the rigid body around one edge of the base. Similarly, the resistance torque of the dead weight of the structure must be greater than the overturning torque of a suitable safety factor.

2.2.4. Durability

Structures built with the right materials and methods will be more robust and resilient than a building built without building codes and codes and using untrained labor even if it is a small or short building The longevity of reinforced concrete depends on the following factors in addition to the quality of materials and construction

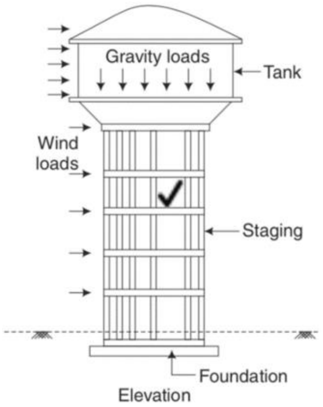

Figure 1. Group Loads on Structures

2.3. Needs for High-Rise Buildings for Stability

The force of the wind affects tall buildings of More than 6 floors or the shelters of mosques, high tanks and other high buildings because it adds an additional load (moment) on columns and foundations to increase the design stresses of structural and other elements and the depth of foundations under the soil. Therefore, wind and earthquake resistance must be taken into consideration structures when designing It is calculated from the following law: - F = A*P P= Ce*Cq*Qs*lw.

The impact of the wind in high towers is resisted by reducing the area exposed to the wind as we rise vertically, and this also gives greater stability to the tower, as the weight of the structure is greater at the base and first floors and gradually decreases as we go vertically upward. It is important to design tall buildings to resist wind and earthquake forces, especially in tall and slender buildings, because they are more sensitive and exposed to them. High altitudes from vibrations caused by wind and earthquakes, absorbing vibrations to reduce horizontal displacement of floors before they travel to upper floors. One of its applications is the tuned block damper, which consists of a block, spring, and damper attached to the facility and act as pendulums to reduce the dynamic response of the buildings and resist movement caused by wind or earthquake, in the event that an earthquake or wind causes the building to sway, the block moves in the opposite direction to restrict the movement of the building and the block absorbs energy kinetics to eventually dissipate through the dampers. This system is usually placed on the upper floors to control the lateral movement of the facility.

1. Based on Zeeshan et al., (2018) The most important factor in the design of tall buildings is the building's need to withstand lateral forces imposed by wind and earthquake. Cross walls or shear walls can be used to provide a structural framework with greater rigidity to withstand wind pressure. Square column behavior is better than rectangular column in terms of floor wear and base and roof shear offset. Shear walls are used to eliminate lateral load and soft flooring effects in shear walls, they are kept centrally and are not much affected by the behavior of structures.
2. Based on Sharma et al. (2017) Tall buildings are subject to dynamic horizontal loads such as winds and earthquakes. These horizontal forces cause significant stresses, displacements and vibrations due to the height and flexibility inherent in the building. Wind displacement and vibration become critical as altitude increases.
3. Based on Malik & Muhammed (2017) The demand for tall buildings is increasing day by day due to population growth and land shortage in urban areas. It is the multi-storey high-rise buildings that are affected by lateral forces due to their height to the extent that they play an important role in the structural design. Lateral stability is most important for tall buildings.
4. Based on Ding & Kareem (2020) The increasing growth of tall buildings in urban areas around the world places new demands on their performance in the wind. This includes choosing a building form that minimizes wind loads and a structural topology that transfers loads efficiently. Aerodynamic form design consisting of modifying the building's exterior has shown great promise in reducing wind loads and associated structural movements as reflected in the design of Taipei 101 and Burj Khalifa. In these buildings, angle adjustments for cross-section and taper are introduced along the height. An attractive alternative is the design of a building that can adapt its shape to the complex, changing wind environment of urban areas with clusters of high-rise buildings, that is, by implementing a dynamic facade.
5. Based on Hickey et al., (2022) High- rise buildings are subject to wind-induced movement which can lead to serviceability and habitability issues associated with occupant discomfort. Modular construction, in which volumetric units are assembled around a reinforced concrete core, can be particularly susceptible to wind-induced acceleration due to the long slender shape of the core and the units' small and uncertain contribution to global lateral stiffness and damping. There are two approaches to mitigating excessive vibrations; Increase the basic dimensions or add additional damping.
6. Based on Al-Kodmany (2018) As cities adapt to rapid population growth—adding 2.5 billion people by 2050—and struggle with expansionary expansion, politicians, planners, and architects have become increasingly interested in the vertical city model. The three pillars of sustainability are simply: social, economic and environmental. The identification of "unsustainable" aspects forms the basis for addressing them in future research and development of tall buildings.
7. Based on Avini et al,. (2019) The design of low to mid- rise buildings is based on a quasi-static analysis of wind loading. These measures do not fully address issues such as interference from other structures, wind direction, cross-wind response, and dynamic effects including acceleration, structural rigidity and damping that affect occupant comfort parameters.
8. Based on Nizamani et al., (2018) Wind is a randomly changing dynamic phenomenon consisting of many eddies of different sizes and characteristics of rotation along a general stream of air moving relative to the Earth. These eddies give off their winds, which creates fluctuations and results in complex flow characteristics. The wind vector at any point can be thought of as the sum of the mean wind vector and oscillation components. These components vary not only with altitude, but also with terrain. Prevailing winds exert pressure on structural surfaces.
9. Based on Jamaludden & Banerjee (2021) Many tall structures, tall towers, and buildings are now being built around the world, around the effect of wind load on tall buildings. Usually there are two buildings in the form of a symmetrical building. Due to some engineering or architectural requirements, the symmetry between the wings is not properly maintained, and the height of the building varies. This study

is about building displacement, span, base shear, and fundamental moment coefficients for a different shape of tall building. By varying the height of the building between 16 to 20 floors.

10 Based on Zaborova et al.,(2018) Through experiments with different construction materials. The experiments were conducted in a thermal chamber with a temperature of 0 to 20 °C (cyclical and non-cyclic) without thermal insulation materials with sensors installed throughout the structure to check the temperature. Then, overlapping graphs were drawn in order to compare the obtained results; It shows the heterogeneity of heat transfer in different parts of the structure within clay bricks (full-bodied), lightweight concrete and reinforced concrete. Finally, the results indicated that clay bricks are more thermally stable.

3. Research Methodology

The design of superstructures is subject to interaction with lateral winds and gravitational loads, and the choice of building form and structural system can greatly influence the wind and gravity behavior of a structure. In This paper outlines the design process and philosophy used in the design of the Burj Dubai's superlative buildings The concrete structure to keep the structure in its simple form, enhance buildability and reduce wind forces on the tower, Burj Dubai has been designed with the letter "Y". The skeletal system can be described as the core. Each wing assists, with its concrete core and high-performance perimeter columns, via a hexagonal central core, or hexagonal axis. The result is an extremely rigid torsion tower.

The structural system of the tower consists of a walkway, hammerhead-reinforced concrete walls and a central hex, and the reinforced concrete core walls provide hexagonal resistance to resist torsion of the structure, similar to a closed tube or axle. To renitence wind shears and moments for piles in the mechanical floors of the surrounding columns allow interference to jointly resist the lateral load of the structure, and all vertical concrete is used as support for lateral and gravity loads, and for the strength of concrete in the wall ranges from C80 to C60 cu. And local aggregates were used to design the concrete mixture, and fly ash and Portland cement were used. the reinforced concrete structure and building code requirements for structural concrete are designed. According to the requirements of ACI 318-02 American Concrete Institute The upper side of the tower consists of a structural steel tower and uses an inclined side system. Also in accordance with the requirements of the American Institute of Structural Steel AISC, the structural steel tower is designed to specification for design factor of resistance, wind, earthquake, pressure and resistance of structural steel buildings and resistance to loads (1999). Also, the exposed outer steel surface is protected by a flame-applied aluminum finish. The foundations of this tower consist of a raft supported by piles. The thickness of the solid reinforced concrete raft is 3.7 m. then the raft was cast from the SCC using 12500 m3 of C50 cubic force. in four (4) separate estuaries the raft is built (central core and three wings).

A 3D model of reinforced concrete walls, piles, slabs and mats and conical structural steel was analyzed and this structure consisted of hinged beams. Dubai system as a seismic zone UBC97 zone 2a with seismic zone factor Z = 0.15 and soil shape was determined by Dubai Municipality to protect the foundation of the tower, cathodic and other protection was used for reinforcements. The buoy is supported by 194 piles cast in place, approximately 43 meters long and 1.5 meters in diameter, with a capacity of 3,000 tons each. The tonnage of these piles has been tested up to 6000 tons. Then C60 concrete (cubic strength) was laid using a polymer slurry by Trim method. The friction piles are supported in naturally occurring calcite formations / agglomerated calcite formations. The resulting motions and wind forces at higher levels become dominant factors in structural design. An extensive program with proportional parametric layers for wind tunnel tests and other wind tunnel studies was conducted, 2.4m x 1.9m in RWDI and 4.9m x 2.4m in Ontario, Guelph. To develop aerodynamic solutions aimed at reducing wind speeds in these studies, studies were used Pedestrian winds at scale greater than 1:250 and 1:500 scale models. High-frequency power balancing technology was also used, and wind tunnel tests were conducted early in the design. The dynamic characteristics of the tower were then combined in order to calculate the dynamic response of the tower with wind tunnel data and the overall effective wind force distributions on a large scale.

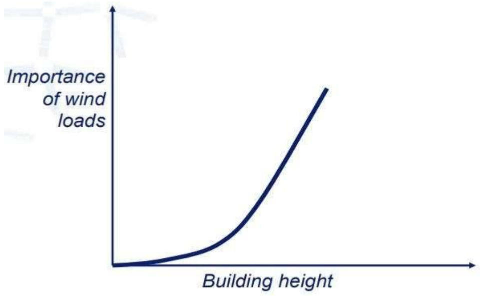

Figure 2. A curve showing the ascending relationship between the importance of increased wind force and the height of buildings.

The design used a technique that utilized in situ test data and pile installation data to determine the amount of construction control and performance monitoring of the supported structure during and after construction. ϕ_g may range from 0.4 for cautious designs involving little or no pile testing and unknown ground conditions to 0.8 for circumstances where substantial testing is done and the ground conditions and design parameters have been properly examined.

Table 1. Design test illustrative table

Situation	Purpose	Agent Applied to Geotechnical Force Parameters	Load Situation	Commentary
1	Structural design capacity	1.0	ULS	The maximum pile axial load and pile bending moment are calculated using unfactored geotechnical strength parameters and short-term pile modulus.
2	Geotechnical design ability	ϕg	ULS	The ϕg geotechnical reduction factor is used to strength measurements to determine the pile group's overall stability.
3	Serviceability	1.0	SLS	To evaluate pile head deflections and rotations, unfactored geotechnical strength parameters are used.

4. Discussion and Results

4.1. Foundation Design Analysis

A review of the hull foundations was conducted, and it was decided that the stacked foundations would be acceptable to both the tower and the platform. Final unit shaft resistance f_s = 0.25 (q_u) 0.5, 24 where f_s = uniaxial compressive strength in MN/m2 and q_u = final unit shaft resistance in kPa. The pontoon of this tower was built at -7.55 m DMD using tower piles 1.5 m in diameter and 47.45 m in length. The thickness of the raft was 3.7 meters. Loading, consisting of four wind loading scenarios and three seismic loading scenarios, the response of the more stable soil layer reduced the tower's stability to dead load, live load and wind load by 28%, from 85 to 61 mm. The load difference above or below the pile was looked at in order to better understand how cyclic loading affects the pile. It has happened sometimes to have dead load and live load. It was determined that the maximum load contrast of more than 10 MN was not sufficient.

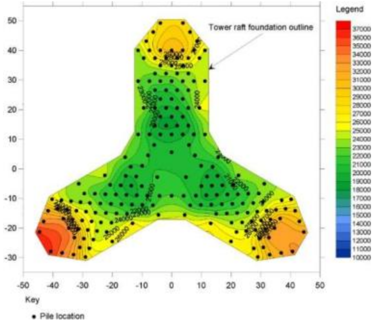

Figure 3. Maximum Axial Load Contours

The tower piles had a minimum center-to-center spacing 2.5 times greater than the diameter of the piles. Assuming that the foundation behaved as a mass of piles and soil or rock, a check was made to ensure that the tower's foundation was both vertically and laterally stable. For vertical block movement excluding base resistance, a safety factor of just under 2 was evaluated, while a safety factor of over 2 was rated for lateral mass movement excluding passive resistance. A safety factor of approximately 5 against block inversion was obtained.

4.2. Independent Review Analysis

Tabel 2 provides a summary of the geotechnical model that was used in the validation analyses.

Table 2. Summary of the Geotechnical Model

Layer Number	Description	RL range DM	Undrained Modulus Eu (MPa)	Drained modulus E0 (MPa)	Definitive Skin Friction (kPa)	Definitive End Bearing (MPa)
1a	Medium-density silt sand	+2.5 to +1.0	30	25	-	-
1b	Loose-v. loose silty sand	+1.0 to -1.2	12.5	10	-	-
2	Weak calcarenite. Weak-mod.	-1.2 to -7.3	400	325	400	4.0
3	V. weak calc. sandstone	-7.3 to -24	190	150	300	3.0
4	V. weak-weak sandstone/calc. sandstone	-24 to -28.5	220	175	360	3.6
5a 5b	V. weak–weak–mod. Weak calcisiltite/conglomerate	-28.5 to -50	250	200	250	2.5
	V. weak–weak–mod. weak calcisiltite/conglomerate	-50 to -70	275	225	275	2.75
6	Calcareous siltstone	-70 and below	500	400	375	3.75

The following methods were used to investigate the potential effects of cyclic loading:

Periodic three-axis laboratory tests, direct periodic shear tests, periodic tests of constant normal stiffness (CNS), and periodic theoretical analysis performed by an independent auditor are all acceptable methods of verification. Direct shear tests revealed a decrease in residual shear strength, although performed using high stress levels that were not indicative of potential field conditions. Periodic triaxial tests revealed some potential for stiffness deterioration and accumulation of excessive pore pressure. As long as the cyclic shear stress remains within the expected range, CNS tests have shown that there is no significant risk of cyclic deterioration of cutaneous friction.

4.3. Test of Outrigger Loads

The Burj Khalifa project implemented two static load testing programs namely static load tests on seven pilot piles prior to foundation construction and also during the foundation construction phase, static load tests were performed on eight piles (about 1 percent of the total number of built piles). In addition, the dynamic pile test was performed on 10 tower work piles and 31 platform work piles, or about 5% of the total number of work piles.

Table 3 provides a summary of information about the piles tested as part of this program. The main objectives of the tests were to validate the design hypotheses and evaluate the general load leveling behavior of piles of expected length below the tower. Since each test pile was unique, several factors could be examined, as follows:

The effects of pile lengthening are as follows: shaft injection effects, shaft diameter reduction effects, (tensile) loading effects, side loading effects, and cyclic loading effects. Instead of the more common bentonite drilling fluid, piles are built using polymer drilling fluid. The use of the polymer appears to have produced piles with above-average performance. Each pile has stress gauges installed along its length, allowing a comprehensive analysis of load transfer along the shaft as well as an assessment of the packed skin friction distribution with depth along the shaft. The reaction system used in axial load tests consists of four or six contiguous reaction stacks, depending on which stack is being tested. These reaction piles can interact with the test pile through the soil and affect the results of the substrate load tests.

Table 3. Pile load test summary—preliminary pile testing

Pile no.	Pile diameter (m)	Pile length (m)	Side grouted?	Test type
TP1	1.5	45.15	No	Compression
TP2	1.5	55.15	No	Compression
TP3	1.5	35.15	Yes	Compression
TP4	0.9	47.10	No	Compression (cyclic)
TP5	0.9	47.05	Yes	Compression
TP6	0.9	36.51	No	Tension
TP7A	0.9	37.51	No	Lateral

None of the six axial load tests appear to have reached maximum axial capacity, at least not in terms of geotechnical resistance. Test piles with a diameter of 0.9 m (TP4 and TP6), 4.5 m (TP5) and 1.5 m (TP1, TP2, and TP3) were loaded to 3.5 times the working load, four times the working load, and twice the working load, respectively. None of the other pillars, besides TP5, showed a stark indication of impending geotechnical failure. At maximum load, TP5 showed a strong increase in failures; However, this has been attributed to the structural failure of the stack itself. An important finding from a design perspective was that the geotechnical failure safety factor at the workload appears to be greater than 3, providing a comfortable margin of safety against failure, especially since the raft would also provide additional resistance to supplement that of the belt.

Behavior when load leveling: Substrate settlements measured at working load and maximum test load are listed in Table 4, along with relevant values for pile head stiffness (load/levelling). Subsequent results are made:

The stiffness was higher for piles with larger diameters as expected. The stiffness of the shaft- immunized substrates (TP3 and TP5) was higher than that of similar non-grooved substrates. The measured stiffness values were relatively large and well above those expected.

Table 4. Summary of Axial Loading Findings From Pie Load Test

Stack number	operating load (MN)	Max. load (MN)	Settlement at W. load (mm)	Settlement at max. load (mm)	Stiffness at W. load (MN/m)	Stiffness at max. load (MN/m)
TP1	30.13	60.26	7.89	21.26	3819	2834
TP2	30.13	60.26	5.55	16.85	5429	3576
TP3	30.13	60.26	5.78	20.24	5213	2977
TP4	10.1	35.07	4.47	26.62	2260	1317
TP5	10.1	40.16	3.64	27.45	2775	1463
TP6	-1.0	-3.5	-0.65	-4.88	1536	717

In light of the alleged low boulder grade at the Burj Dubai site, the pillar head stiffness values for Burj Dubai piles were expected to be slightly lower than those of Emirates Towers based on the experience gained at the adjacent Emirates Project site. The enhanced performance of the piles in the current project can be attributed, at least in part, to the use of polymer drilling fluid instead of bentonite during the construction process. It was also conceivable that the interaction effects of the reaction piles played a role in at least some of the higher stiffness values. Response piles suffer from tension and subsequent rise when a compressive load is applied to the test pile, which tends to reduce the tendency of the test pile to settle. Therefore, the apparent high pile stiffness may not accurately reflect the actual pile stiffness under the building.

4.4. Cyclic Loading Effects

After achieving the working load in each of the axial load tests, the heap experienced a very limited number of load cycles. The test results that were extrapolated from the pregnancy stabilization data are summarized in Table 5. Both adjustments occurred at the maximum load of the spin cycle, and the post-cycle settlement was connected to the first-cycle settlement. It is clear that under the influence of cyclic loading, settlements accumulated, despite the relatively high levels of medium pressure and cyclic pressure of the aggregate, this accumulation was very slight (in all cases, the maximum load reached was 1.5 times the working load). These results were consistent with estimates made during the design, which indicated that the effects of cyclic loading would likely not have a significant impact on this structure.

Table 5. Displacement accumulation for Cyclic Loading Summarized

Stack number	Mean load/Pw	Cyclic load/Pw	No. of cycles (N)	SN/S1
TP1	1.0	±0.5	6	1.12
TP2	1.0	±0.5	6	1.25
TP3	1.0	±0.5	6	1.25
TP4	1.25	±0.25	9	1.25
TP5	1.25	±0.25	9	1.3
TP6	1.0	±0.5	6	1.1

Positive and reassuring information on the capacity and stiffness of the piles was provided by both the preliminary test piling program and the tests on the work piles. The measured pile head stiffness values far exceeded the expected values. Although the increased apparent pile head stiffnesses may have been caused by interactions between the test and reaction piles, the heaps nevertheless went above and above expectations. Although none of the tests fully mobilized the potential geotechnical resistance, it appeared that the piles' capacity was greater than the projected values. Up to a maximum test load of 1.5 times working load, the works piles behaved even better than the earlier trial piles and showed nearly linear load-settlement behavior. Given the excellent performance of the unrouted piles, it was determined that shaft grouting would not be necessary for this project. Shaft grouting appeared to have improved the load-settlement response of the piles. Although it was acknowledged that the overall settlement behavior (and possibly the overall load capacity) would depend not only on the individual pile characteristics but also on the characteristics of the ground within the structure's zone of influence, it was inferred from the pile load test data that the design estimates of capacity and settlement may be conservative.

4.5. Execution of Settlement During Construction

After the pouring of concrete was completed, the settlement of the tower raft was observed. Stress rosettes were placed at the top and bottom of the raft to measure the stress conditions inside. In order to evaluate the load distribution between and below the pile, the pressure of five piles was measured in addition to the three pressure cells which were placed at the base of the raft. Measured adjustments will be found to be less than those expected during the design process. The piling system would still have to undergo some dead and direct loading, and it must be emphasized that the observed values do not take into account the effects of rafting, cladding, and direct loading, which would account for more than 20% of the total volume. Final settlement was estimated to be about 55-60mm, which is comfortably lower than the expected final settlement by about 70-75mm, and extrapolated to full dead load plus live load. The total maximum expected settlement may drop to approximately 52 mm. The measured settlement parameters are shown in Figure 4. The general distribution matches what the diversified analysis predicted. The calculated shortening of the structure after 30 years was expected to be about 300 mm, much more than the foundation settlements, to put the foundation settlements into perspective.

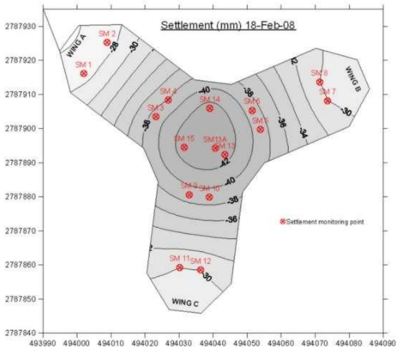

Figure 4. Measured settlement contours as of February 2008

5. Summary and Conclusion

Many people today live in urban cities and they are increasing every year due to their need to live and work. High-rise towers are considered one of the most important components of the country's economic strength and a sign that distinguishes it from other countries. Attention and focus must be given to the stability of these buildings due to the different loads in tall buildings compared to low buildings because they are exposed to wind, and an increase in building height increases the impact of increased winds and increased wind loads, causing safety concerns for the structure envelope and the integrity of the structural system. The possibility of high-rise buildings being exposed to these vibrations that may occur, and the most important factor in the design of tall buildings is the need to withstand external forces through the use of cross walls to provide a solid structural frame with greater strength to withstand wind stresses. Assessment of building movement is a prerequisite, and stability under wind load is important for structural structures.

Some methods have been used to investigate potential effects of cyclic loading and they are triaxial cyclic laboratory tests, direct cyclic shear tests, periodic tests of constant normal stiffness (CNS), and cyclic theoretical analysis performed by an independent auditor are all acceptable methods of verification. Direct shear tests revealed a decrease in residual shear strength. Periodic triaxial tests revealed some potential for stiffness deterioration and excessive pore pressure build- up. As long as the cyclic shear stress remains within the expected range. It is clear that under the influence of periodic loading, settlements accumulated and this accumulation was very slight. These results were consistent with estimates made during the design, which indicated that the effects of cyclic loading likely did not have a significant impact on this structure.

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