Title: **SOCAR Tower: Starting Skyscraper City of Baku, Azerbaijan**

Authors: Young Kyoon Jeong, CEO, Heerim Architects & Planners
Sung Mo Eu, President, Heerim Architects & Planners
Jin Roh, Senior Vice President, Heerim Architects & Planners
Hyungsup Sim, Senior Vice President, Heerim Architects & Planners

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SOCAR Tower: Starting Skyscraper City of Baku, Azerbaijan

Young Kyoon Jeong
CEO

Heerim Architects & Planners,
Seoul, South Korea

Mr. Young Kyoon Jeong, as CEO and Chair of the Board has been in forefront for making Korean Architecture to be known in Global arena. With education from University of Pennsylvania and Professional working experiences in United States, he holds both AIA and KRA. With Numerous Skyscrapers designed by Heerim Architects & Planners under his leadership Heerim practice strong emphasis on research and development, utilizing latest technology tools including, but not limited to BIM, and sustainability with highest quality of total Real Estate solutions. Notable Skyscraper projects include NEAT Tower in Korea, Kyungnam Hanoi landmark tower in Vietnam, etc.

Sung Mo Eu
President

Heerim Architects & Planners,
Seoul, South Korea

Sung Mo Eu has 28 years of experience in architectural design and project management. As a one of the Representatives of Heerim, he plays a key role in domestic and international projects. He has various experiences in tall building projects.

Many of Mr. Eu's projects have required innovative design solutions, including specialized materials and advanced building systems. His strongest competency is bringing a design into reality through thorough management of the design document production phase. His recent experience encompasses tall building projects such as SOCAR Tower, Azersu New Office Tower, and Equatorial Guinea Government Office Building.

Jin H. Roh
Senior Vice President

Heerim Architects & Planners,
Seoul, South Korea

Mr. Jin Hyung Roh is the Senior Vice President of Heerim responsible for overseeing the overall strategic objectives of the firm's international projects and the management of global branch offices. Upon earning his master's degree in design from Pratt Institute at NY, USA, he draws on more than 20 years of experience as an architect in a diverse range of projects, and has been a key member of the firm's notable projects including Keangnam Hanoi Landmark Tower (Vietnam), and Incheon International Airport Terminal 2 (Korea). He primarily focuses on broadening the firm's global growth and seeking new international markets.

Hyungsup Sim
Senior Vice President

Heerim Architects & Planners,
Seoul, South Korea

Serving as an associate at SOM New York office, one of the most influential architectural firms in high rise building design, Hyungsup participated at and AOL Time Warner Center in New York and Lotte Supertower in Seoul, Korea. He returned to Korea in 2009 after 13 year experience in New York firms and continued to engage with technical innovations as imbued in projects such as Lotte Tower in Busan, Korea, Crescent Hotel in Baku, Azerbaijan, and CJ onlyone R&D Center, in Korea as a vice president at Heerim Architects & Planners, one of the largest architectural firms in Korea.

Abstract

City of Baku, the capital of Azerbaijan, has transformed from its state of a traditionally low rise city to that of a modern skyscraper city since the 1990s. New government buildings, cultural centers, and tall buildings including SOCAR Tower, occupy the Heydar Aliev Avenue, where this transformation becomes most evident.

SOCAR Tower has a free formed shape to follow the basic design concept but uses segmented elements based on the local infrastructure and constructability. The Tower uses LED exterior lighting in addition to the medial façade in the podium. To improve the serviceability, Tuned Mass Damper has been installed. Tower also used twin elevators and modern piling method.

Despite many challenges related to design as well as construction, the SOCAR Tower has been built successfully and the lessons learned from the Project has helped not only Heerim but other architects to easily adapt to the building environment in Baku.

Keywords: Baku, Heydar Aliyev Avenue, modern skyscraper, SOCAR, tallest tower, urban tansformation

The City of Baku, the capital of Republic of Azerbaijan ('Azerbaijan' hereafter) as well as the largest city on the Caspian Sea, was traditionally a low-rise city for more than 150 years until the 1990's. Known for strong wind, Baku is also called "City of Winds" and with the discovery of oil in 1846, almost half of world production in the late nineteenth century was extracted in Baku. The oil boom contributed to a massive increase of people coming into the city. Between 1856 and 1910, Baku's population grew at a faster rate than that of London, Paris or New York, the world's biggest metropolitan areas and industrial cities in the early 20th century (Nasibov 2013). During the Soviet occupation from 1920 to 1991, however, the city fell far behind most of industrialized cities around the world in terms of the construction of new buildings and the expansions of the urban territory.

After its independence from the Soviet Union in October of 1991, the performance of Azerbaijan in achieving macroeconomic stability and resumption of growth since 1995 has been "impressive" (Bagiyev 2006). With the rapid growth of Baku's economy, Azerbaijan has

Figure 1. Heydar Aliyev Avenue Buildings (Source: Heerim Architects & Planners)

been able to create tall buildings in the city despite the potential earthquake threats to the region and the notoriously strong winds along the Caspian Sea. With the support from the Azerbaijan government, many master plans to revitalize the city were realized in the late 1990's. The initial plan was concentrated mainly on providing more residential buildings. Soon after, commercial buildings including offices and shopping centers in Baku began to be developed. These new high-rise buildings are mostly located along the Caspian Sea and on the Heydar Aliyev Avenue.

Heydar Aliyev Avenue and SOCAR Tower

The Heydar Aliyev Avenue, being named after the former president of Republic of Azerbaijan, starts from the Heydar Aliyev Center (designed by British architect Zaha Hadid) and ends at the Baku 2015 European Games Main Stadium (designed by Heerim Architects & Planners, 'Heerim' hereafter). About 5.6 km long and 10-lanes wide (6-lane highway and 4-lane local roads), the Avenue used to be filled with row-rise (4 – 6 story tall) residential structures, built during the Soviet occupation. Beginning in the 1990's, the Avenue has transformed itself: the existing residential buildings have been renovated and facelifted with the locally available limestone; and new types of buildings started to occupy the Avenue due to the geographical and political importance of the location. The area connects Baku International Airport to both old and new central districts of the Downtown Baku area. More significant changes have been made with the addition of new buildings along the Heydar Aliyev Avenue. The list of notable public buildings along the Avenue is as follows: Heydar Aliyev Center, Baku 2015 European Games Main Stadium, and National Gymnastics Arena and office towers such as SOFAZ Tower (24 floors, 126 m tall, designed by French Company, Inter Art Etudes), Azinko Tower (34 floors, 132 m tall), Baku Tower (49 floors), Property Tower (32 floors, 126 m tall), Azersu Tower (22 floors, 124 m tall) and SOCAR (State Oil Company of Azerbaijan Republic, 'SOCAR' hereafter) (Figure 1). But importantly, SOCAR Tower is the first tall modern buildings designed on the Avenue (Figures 2 & 3).

SOCAR Tower
Project Brief

The old SOCAR office, located in downtown Baku close to the Caspian Sea, was built in 1896 and had been used as a private residence (Figure 4) (Winter 1998). In September 1994, a 30 year contract was signed between SOCAR and 13 foreign oil companies (Heydar Aliyev Foundation 2007). As the facility in downtown was not spacious enough to accommodate increasing numbers of employees, the management decided to build a new office on the Heydar Aliyev Avenue. The design of the new SOCAR Tower began in September of 2007 while Heerim was also designing Crescent Project (Crescent Hotel, Crescent City and Crescent Place) near the Caspian Sea. In 2010, after the final bid package was issued, a Turkish general contractor, TEKFEN, began working on the construction of the Tower, and the new SOCAR Tower was scheduled for completion in August of 2015. Upon the completion of the Tower, it will become the tallest tower not only on the Heydar Aliyev Avenue but also in Azerbaijan. The building is

Figure 2. Aerial Photograph 1
(Source: Heerim Architects & Planners)

Figure 3. Heydar Aliev Avenue Street View
(Source: Heerim Architects & Planners)

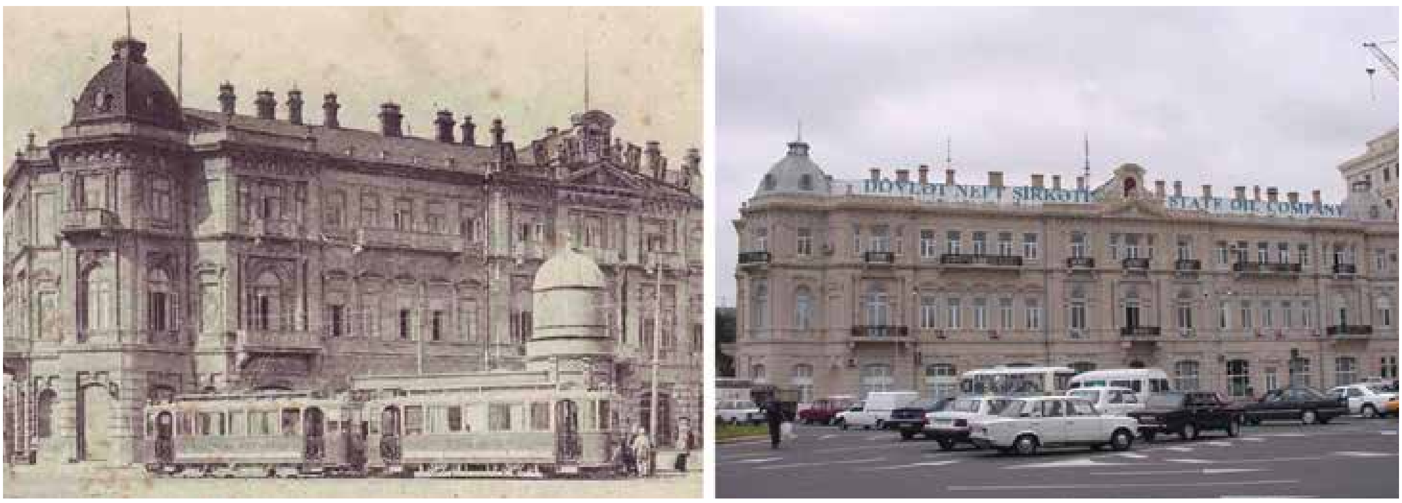

Figure 4. Drawing and Picture of old SOCAR office (Source: Heerim Architects & Planners)

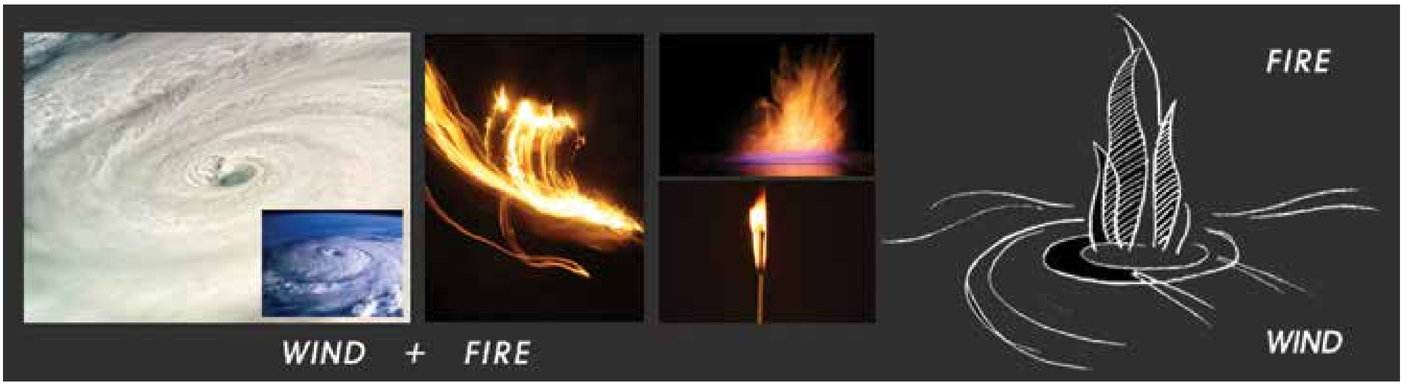

Figure 5. SOCAR Tower Concept Drawing (Source: Heerim Architects & Planners)

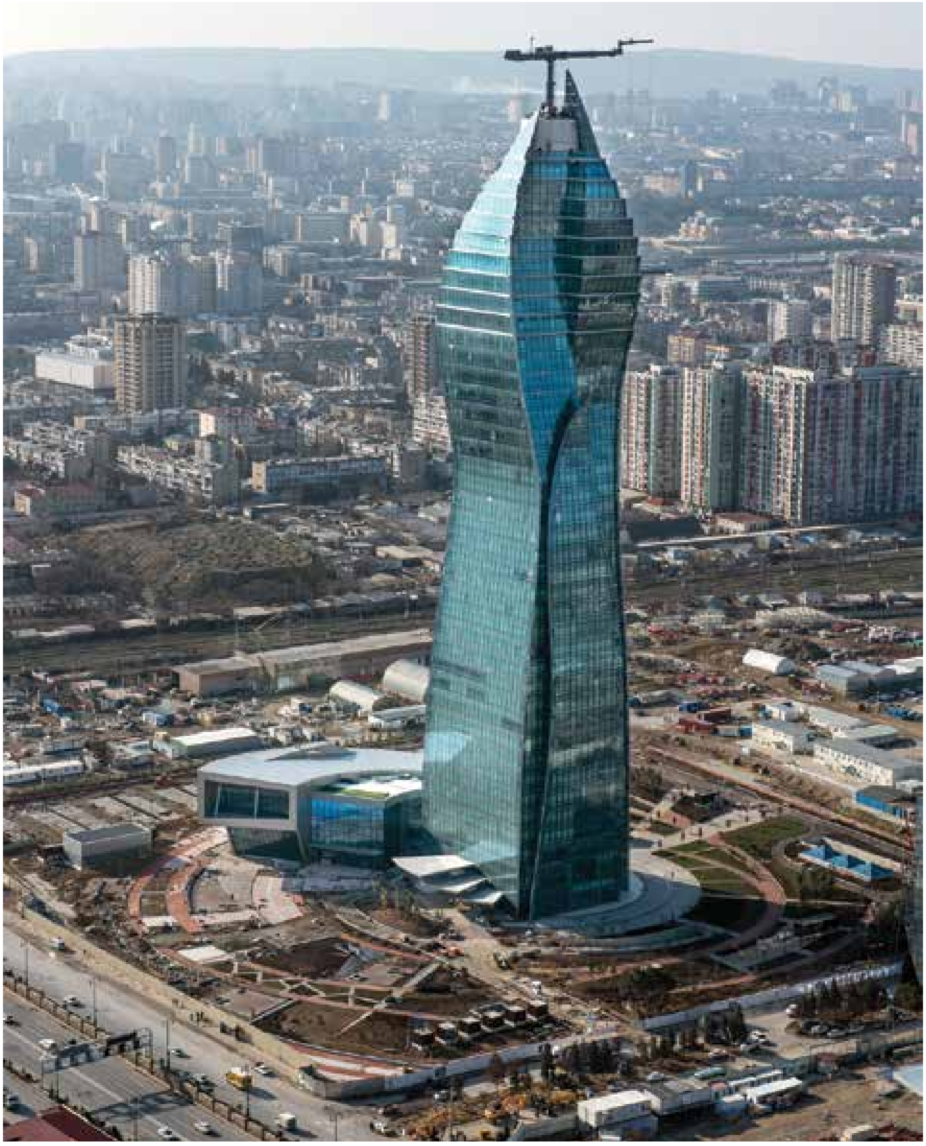

Figure 6. Aerial photograph 2 (Source: Heerim Architects & Planners)

38-stories tall (with two below grade floors) with its height of 200.45 m and a gross floor area of 100,047 m2. As the major users of the building are SOCAR's management employees, it consists of offices, conference rooms and amenity spaces such as restaurants, a cafeteria, retail, and a fitness club. In the construction process, Heerim participates not only as the architect, the landscape designer and the interior designer of the Tower but also as the overarching construction manager of the entire Project.

Design Motives and Design Process

The 38-story tall SOCAR Tower is inspired by the motif of fire, wind and energy, which represent Azerbaijan, Baku and SOCAR, respectively. Designing and constructing the final building out of the intangible symbols of fire, wind and energy, was far from an easy task. After several brainstorming meetings during the early stage of the design process, Heerim researched how abstract and amorphous substances and concepts of fire and energy can be visually rendered.

- Concept No. 1: Fire is the symbol for Azerbaijan. The dynamically burning image of fire can represent a continuous development of the country and its future.
- Concept No. 2: Since fire is generated from the chain reaction of air, fuel and heat, all of which is called the 'energy triangle', for continuous combustion of fire the energy triangle is necessary element.
- Concept No. 3: The formation of the energy triangle is also a prerequisite element for representing the flow of energy or eruption of energy. With continuous reaction with the flow of energy, the fire triangle was replaced by the main space elements of SOCAR Tower such as ecological void, programmed layer and dynamic movement.
- Concept No. 4: Based upon the reactions of the three space elements of concepts 1-3, the symbolic image of the SOCAR Tower, fire, is able to be evolved and the vision of Azerbaijan will be further radiated (Figure 5).

Drawing upon the basic design concepts described above, the spatial arrangement of horizontal program, accompanied by the concept of imaginary energy within the boundary of the site, was finally developed. As the energy surpassed the limit of program, the flow of energy became the vertical eruption. By setting imaginary nodes on the path of the vertical movement and adding up the vertically formed layers, the nodes expanded and transformed the layers of horizontal spatial concept and the skin of vertical spatial concept through the chain reaction with skin which surrounded the layers. Subsequently, as the transformation exceeded the limit, rotation centered on the hinged points also occurred; it became the basic form of the Tower.

Utilizing the basic form derived from the design process, the horizontal massing of Podium and the rotation angle and the size

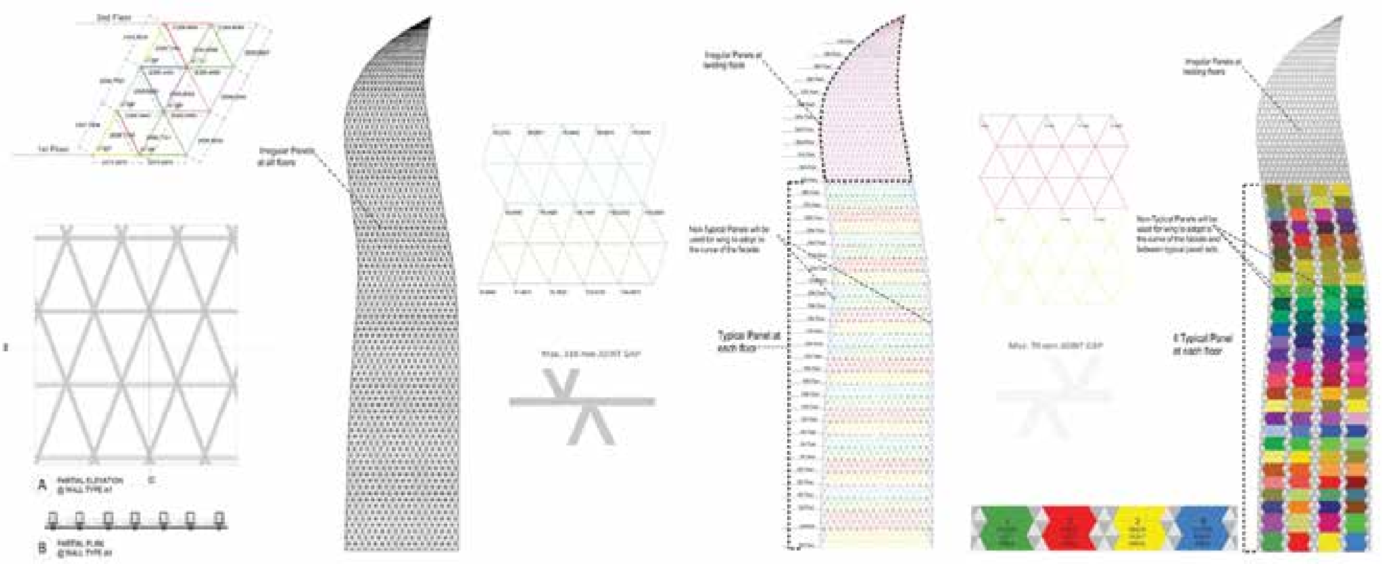

Figure 7. Exterior Skin Geometry Study © Heerim Architects & Planners

of the vertical Tower became determined. Heerim also used mass model studies. The geometry was optimized using Rhino, and therefore the refined space program could be achieved. To highlight the symbolic form of the Tower, drawn upon the ideas of fire, wind, and energy, the mass of the Podium is physically separated from the Tower, except for a bridge on the 2nd floor and underground connection. The connection from the Tower to the Podium is then expressed though the landscape designs on the ground (Figure 6).

Façade Design

This office tower has a free formed shape to follow the basic design concepts of fire, wind, and energy. The first floor and two basement floors have rectangular shapes, but as the Tower goes up, the north and south facades rotate resulting in spiral shapes. To implement the concept throughout the conceptual and construction document phase of the design, numerous ways to define the exterior skin of the building and to build economically were experimented with. As the SOCAR Tower is an office building, the maximization of usable space is a design priority and, as a result, the gap between the skin and slab edges has to be minimized. The first process was to determine how to design the form of the exterior skin which covers rotated slab edges as building goes up and has different concave and convex lines. Since the Tower was envisioned with a curtain wall, all efforts were made in examining the property of glass, size and strength of mullion as well as their constructability and cost.

In the process, three alternatives for the exterior skin geometry were developed:

- Alternative No. 1: Use all different shapes of triangular units. This approach would have been ideal for expressing free formed shapes especially at the top portion of the Tower, which has fin shape and requires the most expensive solution.
- Alternative No. 2: Use the projected line of a parallelogram. It can produce typical triangular shaped units but linear projected lines produce the different shape from the original one.
- Alternative No. 3: Use 4 types of projected lines of parallelograms. This is similar to the second alternative but reduces sharp connections and is cheaper than the first alternative (Figure 7).

After numerous iterations of geometric shapes using 3 dimensional software programs such as Rhino and Revit, the alternative no. 3 was finally chosen. The alternative no. 3 was considered as the most suitable for realizing the original design while reasonably reducing the construction cost and time required to complete the project.

During the design development phase, however, it was discovered that the triangular shaped curtain wall was not practical in Baku considering the local infrastructure and the construction practices of the early 2010's in Azerbaijan. The triangular shape curtain wall system was not available in Azerbaijan, and therefore all construction materials would need to be imported from either European or Middle Eastern countries. Moreover, the façade maintenance system for the irregular shaped Tower also had to be resolved. With the regular window washing system and retractable arms usually located on the top of the building, it was impossible to reach the concave and convex surfaces of the Tower. To resolve the maintenance issue, an automatic window washing system, which was placed inside the horizontal and vertical window mullions, with water supply pipes, was researched in depth.

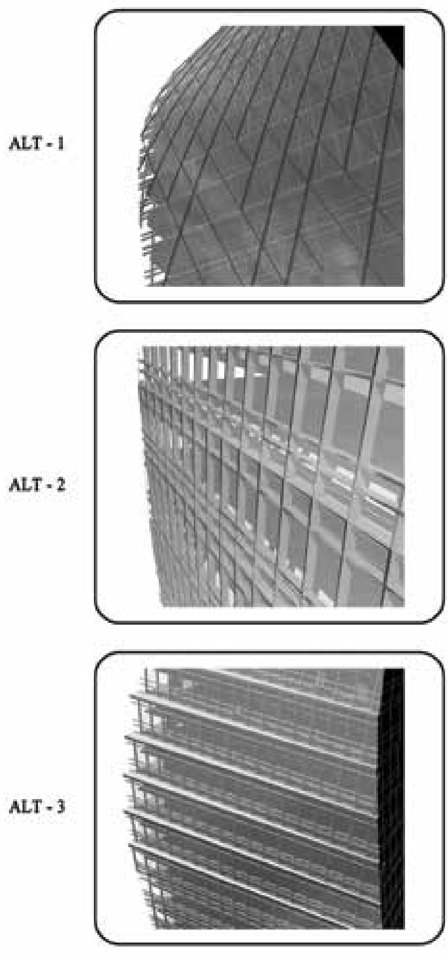

Figure 8. Curtain Wall System Study 1 (Source: Heerim Architects & Planners)

To resolve the issues of availability of curtain wall material and the façade maintenance system, the following three options were presented to the client:

- Option no. 1: Keep the triangular shaped curtain wall on the top portion of the building while installing dummy diagonal mullions on other parts of the Tower.
- Option no. 2: Apply a rectangular

Figure 9. Curved Exterior Study
(Source: Heerim Architects & Planners)

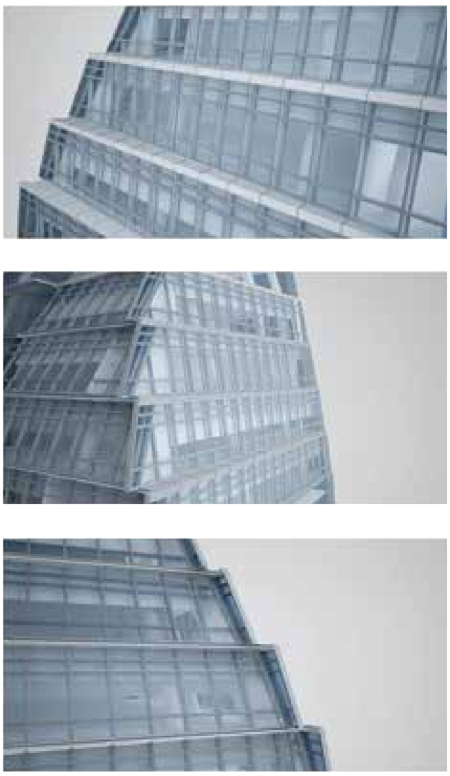

Figure 10. Curtain Wall System Study 2
(Source: Heerim Architects & Planners)

shaped curtain wall on the top portion of the Tower and provide each unit with a concave-convex connection

- Option no. 3: Make all curtain walls on one floor (with rectangular shape) on the same plane and each floor concave-convex (Figure 8).

Following a decision by the Client and the design team, Option no. 3 was selected. It was considered to provide smooth curvature of the curtain wall for typical floors where the curvature is not steep while at the same time resulting in segmented floor lines on the top portion of the building where the curvature is quite steep. With this decision, it was possible to use a rectangular shaped typical curtain wall throughout the Tower while keeping the curved exterior lines over most of the building. Heerim used the original 3-dimensional modeling file to generate segmented lines for each floor and enclose the segmented floor lines with rectangular shaped curtain wall units except for the corner cases (Figure 9). The process of the adjustment of the building geometry also required architectural and structural revisions in addition to the façade design modifications (Figure 10).

Exterior Lighting

SOCAR Tower uses Light Emitting Diodes (LED hereafter) exterior lighting for the Tower in addition to the media façade in the Podium to enhance its stature among buildings located on the Avenue as well as from above. The design motifs of fire and wind are repeated with the LED lighting. A total number of more than 3,000 LED fixtures are used on the Tower. The fixtures are incorporated into H-shaped bar which are embedded into the floors. To maximize the effect of the lighting, an interior shade system was tied to the exterior lighting system such that the system could automatically lower the shade to provide the perfect background for the lighting system, an unusual feature for an exterior lighting control system. Compared to a typical mullion installed exterior lighting system, the H-shaped bar and shade system can express full resolution of the image that the system intends to present. The exterior lighting system can display a full range of RGB color, which will be visible from the street. An example of an image is shown in Figure 11.

In addition to the LED lighting on the Tower, 74 flood lighting fixtures which also can produce the full range of RGB color were used at the top of the building to enhance the overall appearance of the Tower. For the Podium of the building, the media façade comprised of more than 1,600 LED fixtures placed outside of the Podium in a series of horizontal bars similar to the curtain wall mullions, which do not block the view coming from the inside of the building. The total size of the media façade is about 20 m long by 10 m high and the brightness of the board is more than 2,900 nit: therefore the façade lighting is visible in daylight.

Tuned Mass Damper & Twin Elevator

Based on a wind tunnel study, the predicted peak accelerations of the building did not meet the suggested criteria for an office building. To improve the serviceability of the Tower, it was decided to use a supplementary Tuned Mass Damper (TMD) at the top of the building. It was located inside the flame shaped roof top (Figure 12), instead of revising the shape of building or increasing stiffness of the building structure. The weight of damper used in the Tower (Figure 13) is about 600 t, which also required advanced coordination with the building structural engineers during the early design stage. With the installation of the damper, the building's peak acceleration is predicted to meet the criteria of the International Organization for Standardization (ISO) 10137 and provide a comfortable environment for the users especially on the high floors, where executive offices and a sky lounge are located.

A twin elevator system has two independent elevator cabs operating in the same shaft. It

Figure 11. LED Lighting
(Source: Heerim Architects & Planners)

takes up less space and in turn enhances the efficiency of the elevator compared to the most common type of elevator system where there is only one elevator cab per shaft. The system was adopted after being favorably reviewed from the beginning of the Project due to the limited size of the typical floor (gross floor area of the typical floor is from 900m2 to 1,400 m2). Touch screen panels for the destination control system, which is an essential element for a twin elevator system and also optimally allocates calls to individual elevators, were placed in the elevator lobbies. With the twin elevator system in SOCAR Tower (the first to be installed in any building in Azerbaijan), it was possible to achieve the same travel time as typical elevator systems while preserving the usable space as much as possible.

Blast Resistant Improvement Design

During the construction of the building, it was realized that, due to the strategic importance of the Tower in Baku and Azerbaijan, stronger security measures had to be in place. From simple methods, such as installing traffic barriers outside building and security gates in the building, to more complex approaches, such as conduct of structural redundancy studies, these methods were incorporated into the building design. To improve the building's safety from more serious terrorist attack, it was decided to make the structure more resilient to the blast and to provide a refuge area in the 2nd basement floor. For structural reinforcement, core walls in the two basement floors were thickened as much as 750mm and concrete fin walls as thick as 1,600mm were added to the core. This has the effect of drastically improving the overall stability of the building during possible terrorist attacks. These additional walls were painstakingly tied to the already installed building structure.

For the refuge area on the 2nd basement floor, 600 mm to 900 mm thick concrete walls were provided to withstand GP 1,000 lb. blast at a distance of 10 m. In addition, explosion proof equipment such as blast resistant doors and valves with storage space for emergency food and protection equipment were designed. The refuge area is able to house about 60 people who can command the operation of the company and the building from the secured area. With the inclusion of the blast resistant design in the main structure of the building, the SOCAR Tower has a more resilient structure designed to survive attack from conventional weapons and blast without compromising the integrity of the building.

Construction Related Issues

Serving as a construction manager for the Project as well as the construction administrator and the design architect, Heerim was involved in the whole construction process. Some of the challenges for the construction managers were related to the procurement of construction equipment and the building materials for the Project in Azerbaijan. The first challenge was to pile up the foundation of the Tower; originally the piles below the 3.5 m thick mat foundation for the Tower were designed as site poured concrete Reversed Circulation Drilling (RCD) piles with diameters of 1.5 m to 2.0 m. However, due to the unavailability of a piling machine with those diameters, the design of the piles had to be revised to a maximum diameter of 1.2 m based on the largest piling equipment available in Azerbaijan at that time. With the arrangement of the general contractor, TEKFEN, however, the sub-contractor agreed to purchase a new machine with a 2.0 m diameter, with resultant savings in construction cost.

Conclusion

SOCAR Tower is one of the first high-rise buildings to be constructed on the Heydar Aliyev Avenue and in Baku after Azerbaijan's independence from the Soviet Union in 1991. After the completion of the SOCAR Tower, many other tall buildings such as Flame Tower (designed by HOK), Port Baku Tower (designed by Chapman Taylor Architects) and Azersu Tower (Heerim is the design architect and the construction manager) are following in Baku. Despite many challenges related to design of the unique shape of the Tower as well as the construction process, the SOCAR Tower has introduced new design and construction technologies related to high rise buildings in Baku. The lessons learned from the SOCAR Tower Project have helped not only Heerim, in a range of aesthetic, technical, and social perspectives, but architects from around the world to build high rise buildings in Azerbaijan, which had a limited history of constructing contemporary buildings during the 20th century.

Figure 12. Damper Room (Source: Heerim Architects & Planners)

Figure 13. Tuned Mass Damper (Source: Heerim Architects & Planners)

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