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The Dongbu Securities Headquarters Building

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Abstract

The Dongbu Securities Headquarters Building in Daichi-Dong, Seoul is a dynamic interplay of interlocked, canted forms that fold into each other in a response to neighboring buildings. The 37-story, 37,316-square meter structural steel office tower incorporates state of the art mechanical and telecommunications services. The many sloping planes of the façade helped create a landmark building for the city of Seoul that is well integrated with its surroundings. The use of inclined and discontinuous exterior columns presented the engineers with an opportunity for creative structural design.

Keywords: Seoul; Dongbu; Vierendeel

1. Introduction

In 2001, the Korean conglomerate Dongbu Group, in cooperation with U.S. consultants, completed construction of the Dongbu Securities Headquarters Building. The 37-story, 37,316-square-meter tower provides office space for the owner's securities division, except for portions of the ground and second floors, which house banking functions. These offices incorporate state of the art mechanical and telecommunications services. Retail spaces accessible via the sculpture garden occupy the first floor below grade, meeting and assembly halls the second level; below that are four levels of parking.

Several U.S. consultants were engaged to bring their expertise to the project. Among them were architect Kohn Pedersen Fox Associates, P.C. of New York City and structural engineer Weidlinger Associates, P.C. also of New York City.

2. Architecture

The Dongbu Securities Headquarters Building (Fig. 1.) represents a significant addition to the skyline of Seoul. It occupies one of the city's most visible sites in the Southern commercial center of Kangnan-ku. Because the building is directly adjacent to the POSCO Tower, which sets back from a wide commercial boulevard, Teheran Ro, its corner is directly exposed, giving the tower a position that increases its visual prominence.

The exterior architecture of the building is a direct response to the client's wish to make a bold architectural statement that comfortably sits within its context of rectangular box towers but challenges their orthodoxy. The program and site both suggested a layered organization with the core displaced to the south and major spaces oriented toward the boulevard and park beyond.

The frontal plane constitutes the most important layer, loosely creating a "street wall" in conjunction with other buildings aligned along Teheran Ro. It is as if the normal street wall, which one could expect to find in this location, has been interrupted by folding, undulating expanses of curtain wall. The result is a street elevation characterized by a series of planes, each of which is tilted subtly to reflect a different sector of the sky. The eastern view is more graphically pronounced as it displays the tilted edges where the curtain walls terminate in profiles of stainless steel.

The differences in the elevations of the building are augmented by the utilization of two different curtain wall types for the building. On the front and back (north and south), the viewer is presented with a lightly reflective, tinted glass wall with closely spaced projected horizontal mullions. From the outside, this creates a semi-opaque, consistently textured surface which unifies the wall and emphasizes its volumetric quality. In contrast, on the sides of the building, the expression changes to reveal the edges of the diagonal façade planes.

The transparency of the east and west façades, in conjunction with the reduction in mass at the northeast corner creates a gesture towards the primary approach to the building and helps to establish the main entry to the building from both the street and the adjacent plaza. Entry to the building is via a thin, taut bridge suspended over the sculpture garden below.

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Fig. 1. Dongbu Securities Headquarters

3. Working Point Geometry

The key architectural feature of the building is its sloping façades, which are expressed both in terms of their faces on the north and their edges to the east and west. The transparency of the east and west sides of the building ensured that the structural elements, columns, in particular, would be fully integrated with the architectural expression. For this reason, it was necessary to establish column geometry that would reflect the architect's design precisely, while at the same time providing a means to transmit the vertical forces to the foundation and resolve the horizontal components of the sloping columns. Figure 2 displays the working point geometry for each column line.

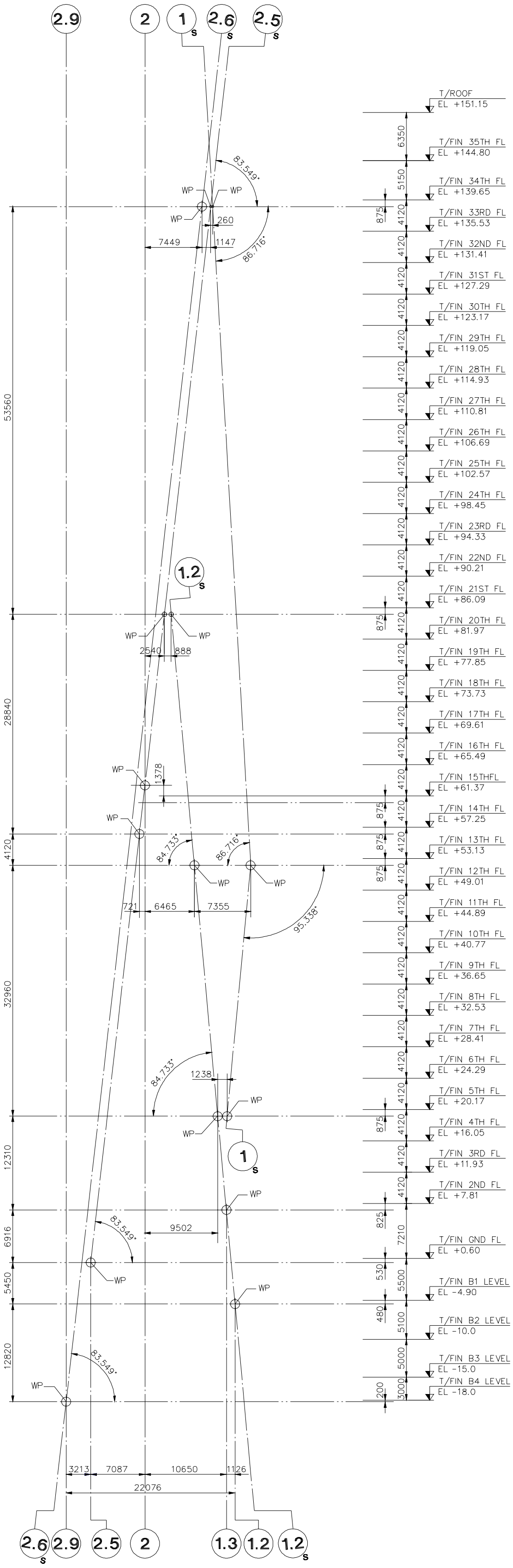

Fig. 2. Working Point Geometry

4. Structural System

The Dongbu Securities Headquarters Building is a slender 37-story tall steel structure. The footprint of approximately 20.9 x 49.8 meters (68.5x163.3 feet) is small for a high-rise building of 155.4 meters (509.7 feet); the aspect ratio (total height to least width) of 7.4 is considered to be high for a typical 37-story structure.

The structural framing system of the superstructure consists of steel beams and columns spaced at approximately 9.0 meters (29.5 feet) in an E-W direction. In the N-S direction, the column spacing varies due to the sloped facade. The framing system of the seven-level basement consists of flat-plate concrete slabs and composite columns of steel encased with concrete.

One effect of the sloping column geometry is that each floor is unique. There is no "typical" floor framing plan. In many cases the steel framing changes substantially from one floor to the next.

In the design of any office building it is important to minimize the impact of structural elements on architectural efficiency. The amount of usable floor space should be kept as high as possible. In this case, because the floor plate is rather small, maintaining efficiency of use is of even greater importance. In particular, the building's shallow depth from front to back, 20.9 meters, greatly underscores the need to have floor efficiency as a key guide to structural design.

For example, the framing around the elevator core was designed such that the columns are recessed within the walls of the core. By suppressing the columns into the space between the elevator shafts, they are prevented from protruding into the usable office space. Structurally, this benefit comes at a price, the beams framing around the elevator openings must be connected eccentrically from the column (Fig. 3.). Not only does this create a more expensive connection detail, but it eliminates the possibility of introducing a moment-frame or braced frame along this edge of the core, which is a typical place to locate the lateral system.

However, the non-structural benefit to this design decision is substantial. There is only about 10 meters of clear space between the outside of the core and the edge of the building. It is architecturally desirable to build a smooth interior wall, rather than bumping the wall out at the columns. Recessing the columns by 250 mm therefore saves 2.5% of the usable floor area in this area, or 170 m^2 throughout the building. Throughout he lifespan of the building, the value of this added space is much greater than the one-time added structural cost.

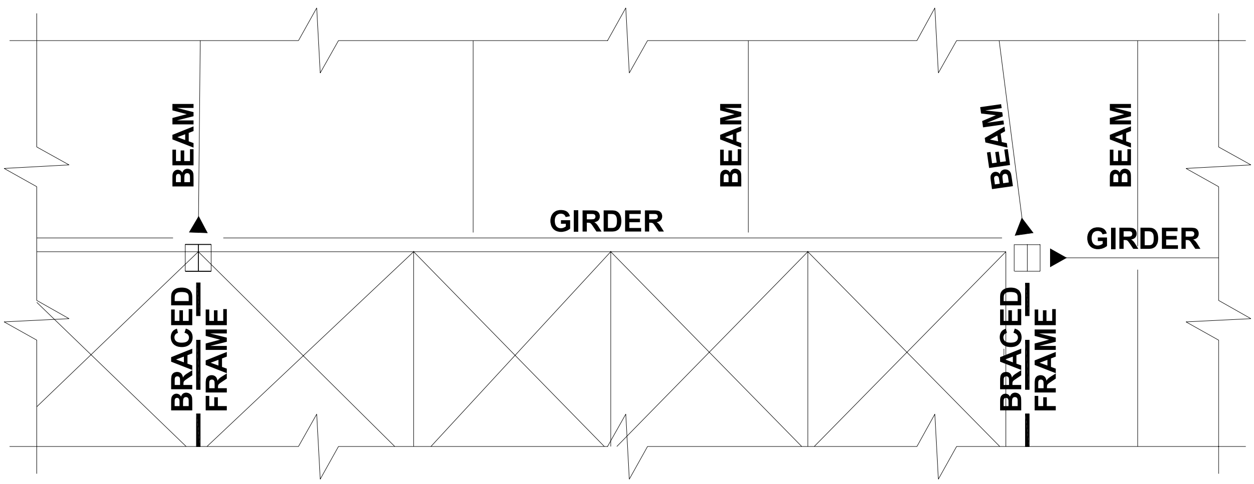

Fig. 3. Eccentric Connection at Elevator Core

The need for efficient floor plate design dictated that the use of interior columns should be kept to a minimum. The floor framing spans column free from the elevator core to the sloping north façade.

As expected for a tall, steel building in a region of moderate seismicity, the lateral system design is controlled by wind loads. Due to the unusual geometry of the building envelope, the code equations cannot be relied on to produce precise values for wind loading. Thus, the Hyundai Institute of Construction Technology was engaged to perform a wind tunnel test.

Due to the slenderness of the building, the demands on the wind force resisting system are severe, especially in the North-South direction. However, it is critical to the success of the design that the structure does not interfere with or distract from the aesthetic objectives. In addition, obstruction of the usable space, as described earlier, must be kept to an absolute minimum.

Wind loads are clearly most critical in the shorter North-South direction. The lateral system in this direction consists of two components. First are the massive A-frames on the East and West faces of the building (Fig. 4.). These frames follow the edges of the sloping façades. Instead of being buried within the walls, these frames are jacketed with stainless steel to increase their prominence behind the transparent East and West façades. The A-frames provide substantial lateral stiffness while acting as an integral part of the building's visual expression. The second component of the North-South lateral system is the braced frames. Diagonal braced frames, each one column bay long, lay buried with the elevator core walls, providing additional lateral resistance with no obstruction to the room layout.

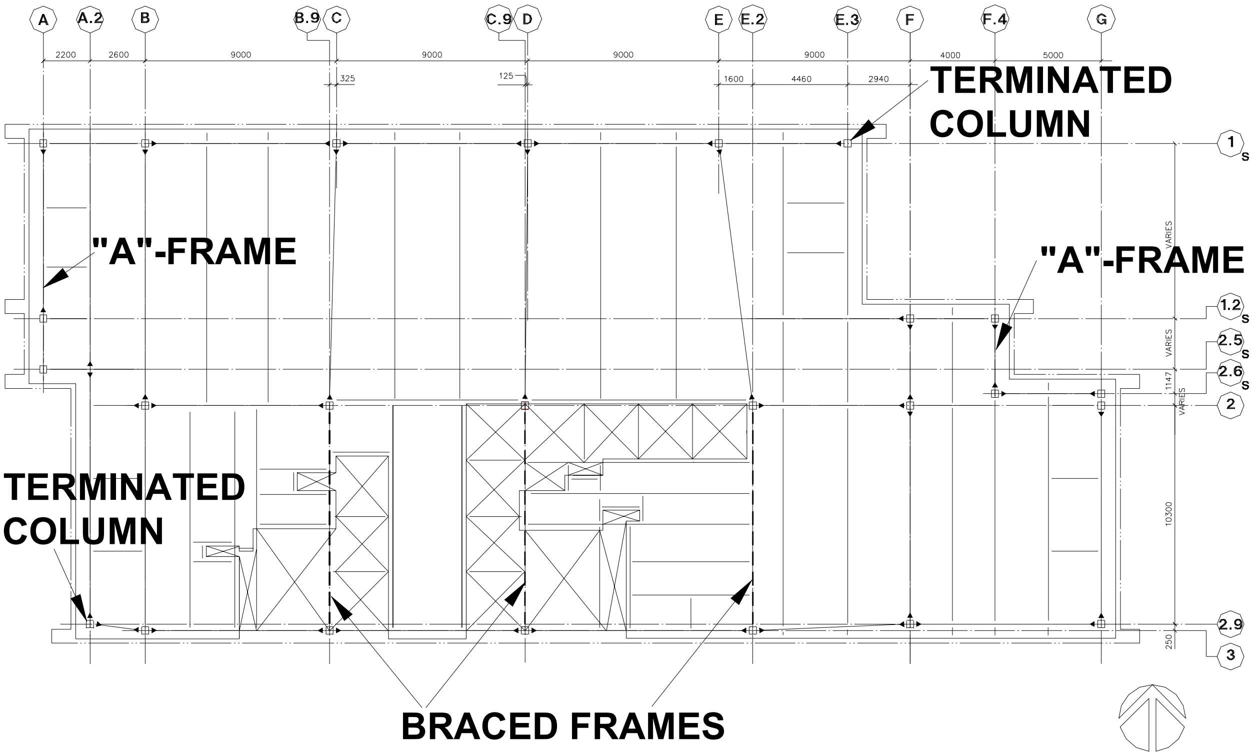

Fig. 4. 18th Floor Framing Plan

In the East-West, or long direction, wind forces are much smaller, but not insignificant. The lateral loads are resisted by moment frames at the North and South exterior faces. The heavy built-up sections of these frames are hidden by the North and South Façades, which, with their horizontal mullions, appear nearly opaque from outside.

Additional structural challenges were created at several locations where there are column discontinuities. The sloping planes of the North face do not merge smoothly, but instead the outer plane ends abruptly at the 5th floor. This condition was resolved using the detail shown in Figure 5, which relies on the floor beams of the 5th and 6th floors to resolve the horizontal components of the eccentric column loading. Thus, the heavy column loads are transferred with minimal interruption to the interior space.

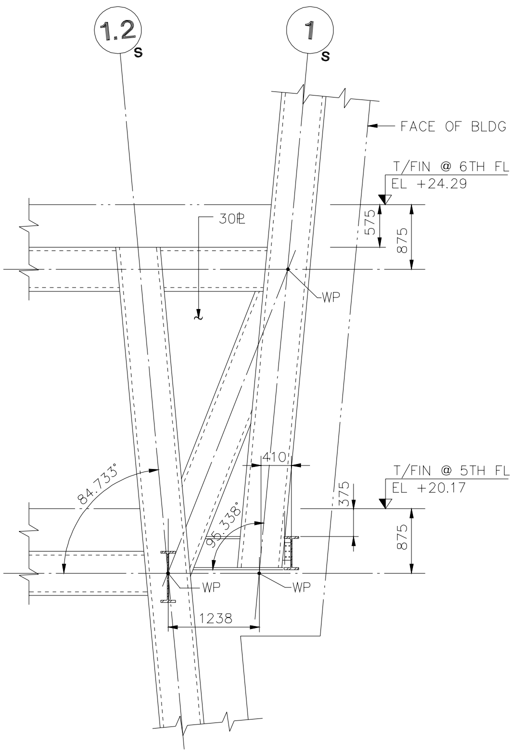

Fig. 5. Column Transition Detail

Additional column discontinuities occur where columns terminate at the northeast corner of the fifth floor and at the southwest corner of the second floor (Fig. 4.). These conditions are handled by providing a moment connection at every beam framing into the discontinuous column. The result is, in effect, a Vierendeel truss that is as deep as the full height of the building and cantilevers the length of one column bay.

The cantilevered Vierendeel truss only becomes fully effective once the entire truss has been constructed. This created a minor complication for the construction sequence, since it would be unacceptable to apply loads to the cantilever when only a few stories of the truss have been constructed. Matters were further complicated by the fact that the curtain wall that is attached to the cantilever has strict deformation restrictions.

Fig. 6. Temporary Shoring

To resolve this issue, temporary shoring was provided under the discontinuous columns during construction. The inverted "V" and the diagonal connecting to the same node from above shown in Figure 6 are temporary members. In order to determine the appropriate points in the construction sequence to remove the shoring and to begin installation of the curtain wall, in-depth analyses of the construction sequence were performed. In addition, monitoring procedures were set up to measure the actual deflections at these locations throughout the construction process.

5. Conclusions

The Dongbu Securities Headquarters Building has established itself as a visually compelling architectural landmark within the city of Seoul. It makes an important contribution to the streetscape and skyline of the city, and satisfies the client's desire for a building that is clearly identified as a signature of the forward vision of the Dongbu Corporation. At the same time, an efficient, state of the art, work space has been created for the owner's securities division.

The success of the project is largely due to the integration of the architect's vision with the structural requirements. Viewed from the exterior, the building is such that architecture and structure work together generating an effect that is visually stunning. Yet when regarded from the interior, the structural elements are tucked away to create a comfortable, productive place of work.