A steel-framed office building in Baghdad is successfully rehabilitated after a series of missile strikes.

Ruin to REHAB

BY NABEEL A. IBRAHEEM

Photos: Nabeel A. Ibraheem

▲ The seven-story Almansour governmental office building in Baghdad, before renovation.

▼ Holes where missiles pierced the roof.

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STRUCTURALLY, BUILDINGS ARE TASKED with handling quite a lot—from dead and live loads to earthquake and wind loads. But a series of devastating explosions, while rare, is a rather tall order.

Built in 1982, the seven-story Almansour governmental office building in Baghdad, Iraq, incorporates a structural steel frame with external cast-in-place reinforced concrete walls. During air strikes in 2003, the building was hit by five smart missiles that penetrated the roof; two detonated on the second and third floors while the remaining three detonated in the basement. Several interior framing bays were destroyed.

Worth Rehabilitating

Over the next several years following the air strikes, several consulting firms and individuals studied the building and submitted proposals to either demolish or rehabilitate the structure, but none of those proposals came to fruition. Then, in December 2013, a detailed investigation and survey were performed by the author to record the damage to each and every steel member. The investigation, aided by original documentation from its 1982 construction, confirmed heavy structural damage to the second and third floors. Two major interior steel columns—both members about 16 in. deep and 16 in. wide, with 1⅛-in. flanges and ¾-in. webs, and roughly 14 ft long—sustained the most significant damage, rendering them useless as supporting members. In addition, many surrounding girders, beams and joists, along with con-

➤ Various views of the existing condition of the building's interior. Of the five smart missiles that penetrated the roof; two detonated on the second and third floors while the remaining three detonated in the basement.

crete floor panels and steel decks within the affected void from the first to the fourth floor, were damaged to some degree.

In spite of the significant damage, it was decided that the building could be rehabilitated, and a plan was proposed, submitted and approved after extensive discussion with the client consultant. Given the nature of the damage, especially to the two main columns, member forces were being redistributed to the surrounding still-standing members. Based on the site survey and original building calculations, a structural model was created with STAAD.Pro. All remaining steel framing components were represented regardless of their level of damage. The most important function of the model was to represent each member in its current, real-life condition. For example, some of the members were damaged partially through their webs or flanges, which necessitated reducing member sectional properties in the model in some cases to simulate the weaker, damaged members or introducing member releases/internal hinges in these members. Using this main model, several structural models were prepared for the building: the theoretical as-built designed steel frame; the existing damaged frame; the steel frame after removing the most heavily damaged members in the most affected region (floors one through four); and the steel frame following the introduction of new members. Replacing the two main columns was, of course, the primary objective in getting the building stabilized and fit for occupancy again.

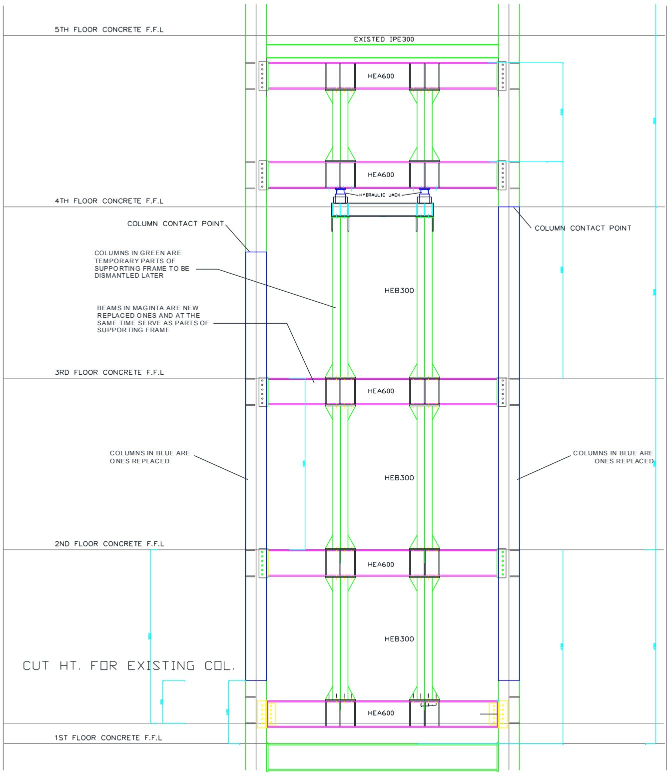
Into the Void

Although the blasts that created the damage were certainly catastrophic, they ironically created a favorable erection scenario to build a supporting frame composed of permanent steel girders and temporary columns in between, starting from first floor up to the fourth. The frame and replacement columns could be inserted through the void made by the explosion, starting from the first floor and working up to the fourth. The damaged main columns and connection elements were dismantled and removed at the same time that the new replacement columns and supporting frame components were erected until their tops were about to touch the original cut parts of fourth-floor columns. In addition, the surrounding framing was reinforced with lateral

▲ The new column system was held together with a predesigned connection using both welding and bolts.

▼ A framing plan for the replacement of the two main columns and supporting steel.

▲▼ New structural steel. Framing for the main columns was reinforced with HSS lateral supports at each floor.



supports (approximately HSS5×5×½) at each floor. But space was limited to fit the new main columns in to come in contact with the old ones. The solution was to raise the portion of the building above this main construction area—levels four through seven—in order to introduce enough of a gap to insert new columns to support the structure above. Two 200-ton capacity hydraulic jacks were used to lift these four floors through the supporting frame, leaving a gap between the new replacement column and the existing upper old column portion. The minimum required jacking force to lift the upper part of the building by about ½ in. could be as high as 337 kips (1,500 kN) at each of the two jacking points.

The lifting operation raised the two splice locations of the original upper columns approximately ½ in. using a hydraulic jacking force of 247 kips (1,100 kN) at each of the two points, slightly less than predicted by calculations. Following the lift, steel plates were inserted firmly in the two gaps, and a predesigned connection, using both welding and bolts, was used. At the same time, the damaged columns were dismantled and new ones were fabricated and erected in place starting at the bottom. When the new columns reached the remaining portions of the fourth floor columns, the hydraulic jacks were slowly released, transferring the cumulative loads from the upper floors (four through seven) into the new main columns. Afterwards, the remaining damaged steel members were removed and replaced with new members as necessary.

The structural rehabilitation is now complete, and the building is currently undergoing interior fit-out. ■