Problem Statement

The actual design for the Hyatt is very suitable for the design conditions given. Analyzing alternative floor systems for the tower revealed that the current design was likely the best solution to the design problem. However, while the current design may be the best solution to the problem as it was stated there are many other viable solutions to the problem.

In the case of the Hyatt, at the time of its design, the codes used did not require seismic loading analysis to be performed. In the lateral analyses of the existing structure, it was found that the large self-weight greatly increases the seismic loading to the building. While the system was found to be adequate to resist the lateral loadings, there may be alternate designs that can better resist these lateral loads or decrease the building weight to in turn decrease the seismic loading on the building. The main area of concern for these seismic loadings is the concrete tower.

With its location in Pittsburgh, PA, the site has a 0.2 second spectral response acceleration of 0.127g and a 1.0 second spectral response acceleration of 0.054g. These values are very low in comparison to critical locations in the United States such as California with 0.2 second spectral response accelerations up to 2.5g and 1.0 second spectral response accelerations up to 1.5g. Based on the location of the Hyatt, seismic loading should not be a great consideration; however, based on the original design, the weight of the structure greatly increases the seismic loading on the building.

Proposal

Research and calculations will be performed to design the tower as a steel framed system. There are multiple types of steel framing that can be used, so preliminary research has looked into the most feasible and best alternatives. From previous analysis, a non-composite steel floor system was analyzed, which warranted further investigation. In addition, composite steel framing will be considered, which will likely be the best alternative due to increased strength and stiffness based on composite action. To select preliminary beam and column sizes, hand calculations will be performed.

The lateral resisting system will also require a re-design with the change from concrete moment frames to steel. Both braced and moment frames will be considered with research to determine which would be the most viable solution. Consideration will be taken to place frames so that they do not interfere with architectural room layouts.

Once a preliminary design is established, computer modeling will be performed using RAM, which is a commonly used structural engineering software package for structural steel design. Using the software, models can be created for the tower framing.

If a 3-dimensional model is created, the building weight can be determined and compared to the calculated weight of the concrete tower. New lateral loading analysis will be performed to determine the decrease in loading due to the decrease in building weight. Analysis will also look at the impact the changes can make on the foundation of the building. With decreased building weight, it is believed that the foundation size can be decreased as well. Calculations from the design software will be verified with hand calculations.

Once a new structural system has been designed, it will be compared with the current system to see if it meets all of the requirements and design criteria set for the project. Upon comparison to the design criteria, it will be determined whether the steel framing is a more viable option for the tower or if the existing concrete structure is the best choice for the design.

The new design will update to the IBC 2003 code requirements. Design loads will be determined using the ASCE 7-02: Minimum Design Loads for Buildings and Other Structures. Steel design procedures by hand and computer calculations will be performed in accordance to the AISC Manual of Steel Construction, 3rd Edition LRFD. It will utilize A992 wide-flange structural steel. The columns will be selected from a trial group of W14 sections spliced every 3 levels or as needed. The new design will adhere to the floor plan laid out by the architects; this will prevent columns from interfering with guest rooms.

Design Criteria

A major design criterion for the project was the building height, which is critical because of FAA regulations for buildings in close proximity to airports. The restrictions imposed on the architectural design were based on limitations in the FAA Advisory Circular AC 150/5190-4A which basically states that within a 5,000 ft radii from runways designated utility and 10,000 ft radii from other runways, the Horizontal Zone is established that is 150 feet above airport elevation. Another restriction on height, FAR Part 77, Objects Affecting Navigable Airspace, sets a zone sloping 7 ft horizontal to 1 ft vertical from a 'primary surface,' 1000 ft wide, centered on each runway. (The hotel is virtually centered between the northern Runway 10L-28R and the southern Runway 10R-28L.)

In conversation with the design architects, the Hyatt was within these set limits; however, greatly increasing the building height would not be possible for the conditions set by the regulations. Thus, the height of the building is a major restriction to be followed. While it may not be possible to stay completely within the original architectural constraints, any deviation will be considered in the resulting conclusions of the new design and compared to the original design.

Another design criterion that must be followed is the layout of the floor plans. In similar conversation with the design architects, the Global Hyatt Corporation has set criteria for general building design. In order to prevent architectural conflict, the new design will try to constrain to architectural layout with any variations noted in the conclusions.

Overview of New Design

The new design for the Hyatt tower is structural steel framing with symmetrically placed chevron braced frames to resist lateral loads. The preliminary design compared similar systems to determine the most viable option for a full new design. Various non-composite and composite steel floor systems were compared to select the primary system used in typical bays in the new design.

Non-composite systems were analyzed with 4'-0", 4'-6", and 5'-0" beam spacing in both typical bay sizes: 24'-0" x 27'-0" and 18'-6" x 27'-0". All non-composite designs resulted in deep sections (compared to the existing 8" filigree slab). Composite systems were then analyzed to determine the feasibility of composite steel framing. With the use of W8x48 beams and composite action, the total floor depth was increased to 12", significantly smaller than the 14" depth of typical non-composite configurations.

Using the composite floor framing, preliminary sizes were found for beams and columns. A computer model was created in RAM Structural Systems to assist in calculations and distribution of loads. Using code specified loads and load cases; the new structure was designed. Braced frames were selected to prevent greatly increasing member sizes through the use of moment frames.

Member sizes of beams, columns, and braces were edited to reduce moment-axial interaction to levels below 95% of allowable interaction. In addition, member sizes were standardized throughout the design to minimize the number of different sections used and create more typical framing. Column splices were placed every 3 levels (main level counted as 2 levels due to increased height).

New seismic and wind loads are compared to the original loads on the original design to compare the effects of the new design on the loading. The seismic loading decreased significantly with the significant decrease in building weight, while wind loads increase slightly based on the small increase of building height.

A vibration analysis has been calculated to determine the impact of walking induced vibrations in guest rooms based on the excitation force from the corridors. This check determines whether or not the lighter framing could cause serviceability issues for guests.