Trump Taj Mahal Hotel

Atlantic City, New Jersey

Thesis Proposal

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Executive Summary

The Trump Taj Mahal Hotel is a 40 story hotel tower being built along the boardwalk in Atlantic City, New Jersey. It serves mainly as an expansion to the existing hotel on the adjacent lot. The tower's main lateral force resisting system is a massive concrete shear wall core. The floor system is comprised of both a filigree flat plate system in the main area of the floor plan and a conventionally reinforced concrete flat plate located in the core of the tower.

The proposed thesis project will investigate the relocation of the hotel tower to Las Vegas, Nevada. Las Vegas is classified by ASCE 7-05 as a Seismic Design Category "D" region. Seismic forces will likely control in this region, and a new core layout will be investigated in order to effectively handle the governing seismic forces. The addition of a perimeter steel moment frame to increase the torsional stiffness of the tower will also be investigated. Both the core and moment frame will be designed for the seismic provisions specified by the AISC Structural Steel Specification and ACI 318-05.

Because the filigree flat plate system designed for the Trump Taj Mahal is a proprietary system of Mid State Filigree, a local filigree contractor in the state of New Jersey, it is not likely to be a system of choice in a high seismic region. Because of this, the gravity floor system will be redesigned as a composite steel frame with slab on metal deck. This system will prove to be the most beneficial, as it was the lightest of those systems analyzed in Technical Report Two. Because it is a light system, seismic design forces will be substantially lower. Special seismic provisions specified by the AISC Structural Steel Specification will also be investigated.

By proposing to build the new Trump Taj Mahal Hotel in Las Vegas instead of Atlantic City, various opportunities will arise for breadth study. Two studies will be conducted; the architectural impacts resulting from the newly designed core and the effects on the mechanical system of the building.

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Introduction

The Trump Taj Mahal Hotel is currently under construction on the boardwalk in Atlantic City, New Jersey. It is scheduled for completion by the end of summer 2008. The tower rises 40 stories to a height of 434 feet from the base to the top of the large trump sign above the roof. The New Jersey State Uniform Building Code, parent code IBC 2000, was the code used in the design of the tower. The code references ASCE 7-02 for the determination of design loads. For the remainder of this project ASCE 7-05 as an update.

Background

Foundation

The entire tower rest on a reinforced concrete mat foundation, typically 9' thick around the core area; 6' thick elsewhere. The specified concrete compressive strength of the mat foundation is 5000psi. A geotechnical report prepared by Geotech, Inc., dated April 25, 1996, specifies the allowable bearing capacity of the soil on site as 4TSF and recommends that the site be classified as Site Class “D”.

Columns

Square, rectangular, and round reinforced concrete columns with standard ties are used throughout the hotel tower, with a wide range of sizes and reinforcing arrangements. Columns taper in size, decreasing in depth at the higher levels of the tower. Specified concrete compressive strengths also vary from 9000psi at the base to 5000psi at the higher levels.

Floor System

Two types of floor systems are used on a typical floor of the hotel tower. A one-way pre-stressed filigree flat plate system is utilized in the areas outside of the central core. Inside of the core, a conventionally reinforced flat plate system is utilized. 5000psi is the specified compressive strength of both systems.

A filigree flat plate floor slab acts as a composite system, utilizing both pre-cast and cast-in-place components. 8’-0” wide 2 ¼” thick pre-stressed planks form the base of the system.

Foam voids are cast on top of the planks, lowering the dead weight of the system. However, some floors of the tower with higher loads may have solid slabs instead of voided slabs. A layer of concrete is poured on top of the planks and 2 ¼" on top of the voids, if present. 10x10 W4xW4 Welded Wire Fabric is used as temperature reinforcing for the cast –in-place concrete.

The gravity loads of the filigree flat slab floors are transferred to the columns via 8'-0" wide conventionally reinforced in-slab beams that run 32'-0" x 16'-0" bays, typically. The filigree flat slabs are connected to the in-slab beams by reinforcing dowels, typically #7 bars on the top layer. The base of the beams are formed using the filigree planks, however the planks are not utilized in the strength of the beam.

Filigree Flat Slab System (Non-Core)

The proceeding diagram describes the various filigree flat slabs, by level number.

Level Number	Solid or Voided	Total Depth (inches)
2, 3	Voided	12
4	Solid	10
5 thru 39	Voided	10
40	Solid	12
41	Solid	10

Conventionally Reinforced Flat Plate System (Core)

The proceeding diagram describes the various conventionally reinforced flat plate slabs, by level number.

Level	Reinforcing	Thickness (inches)
2, 3	#6 @ 12" Bottom, Each Way	12
4	#7 @ 12" Bottom, Each Way	10
5 thru 39	#6 @ 12" Bottom, Each Way	10
40	#6 @ 12" Bottom, Each Way	12
41	#7 @ 12" Bottom, Each Way	10

Lateral System

Four ordinary reinforced concrete shear walls, spanning from the base of the tower to level 41, are the primary lateral force resisting system of the Trump Taj Mahal Hotel. Two 58' long walls resist the forces in the east/west direction, as well as the north/south direction. These four walls form the core that lies in the geometric center of the tower.

The shear walls decrease in thickness, 24" from levels 1 through 4 and 16" from levels 4 through 41. Because numerous openings exist, link (coupling) beams provide load transfer across the openings, providing added stiffness for the entire system. Specified compressive strength of the concrete used for the shear walls varies by level, matching that of the columns.

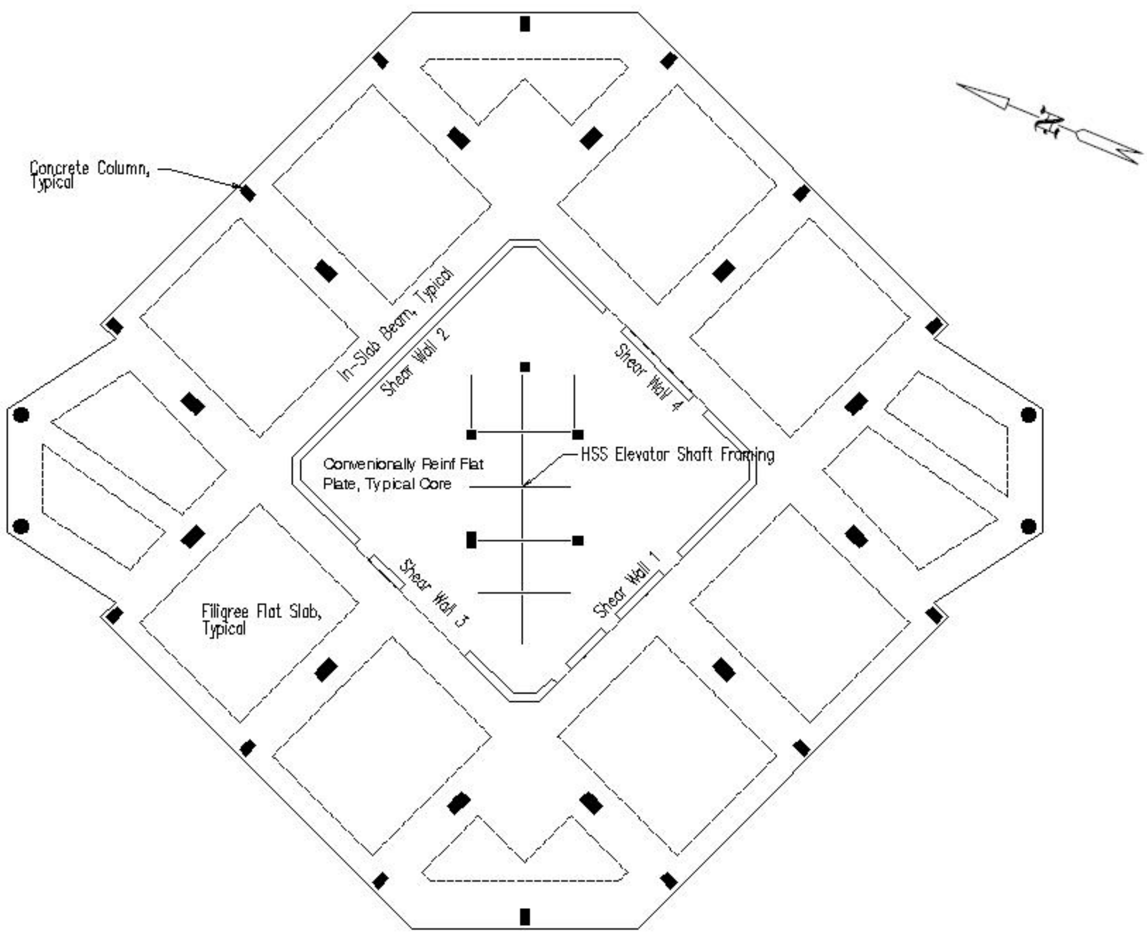

Figure 1: Typical Framing Plan

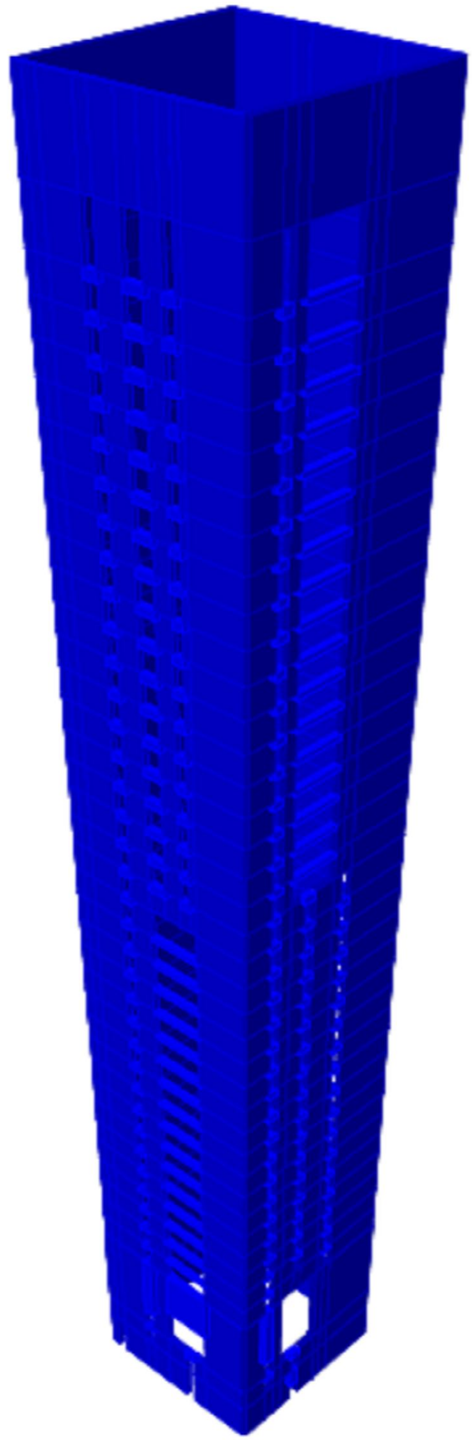

Figure 2: Ordinary Reinforced Concrete Shear Wall Core

Problem Statement

While investigating the effectiveness of the current concrete shear wall core with the use of ETABS, it was found that large inherent torsions were present under the wind loading specified by the wind tunnel test performed by DFA. This inherent torsion exists because the center of mass and the center of rigidity of the building do not coincide. This happens because each wall has a different stiffness, caused by the unsymmetrical layout of the core openings, and the perimeter of the building is not restrained torsionally.

Despite its inherent torsion, the concrete core shear wall was still able to effectively handle hurricane prone wind forces of Atlantic City, New Jersey. However, what if Donald Trump's research and develop team were to recommend that his new hotel tower be built in Las Vegas, Nevada, due to current market trends? Would the concrete core shear walls be able to effectively handle the seismic forces and design requirements of a Seismic Design Category "D" region?

The gravity system of the tower must also be considered, as it too must conform to the required seismic provisions of Seismic Design Category "D". The current filigree flat plate system of the Trump Taj Mahal Hotel is a proprietary system of Mid State Filigree, a local filigree contractor in New Jersey. Thus, the system is not specified for use in high seismic zones; an alternative floor system should be chosen for consideration.

It was found in technical report 2 that a steel frame with slab on metal deck is the lightest alternate framing system. A composite steel frame with slab on metal deck will reduce the dead weight of the system by approximately 30 to 40 percent. This will be beneficial in reducing the seismic loads of the tower because the weight of the structure will be significantly reduced.

Problem Solution

In an effort to reduce the inherent torsion of the shear wall core, a more symmetrical opening layout will be investigated in order to increase efficiency. A perimeter structural steel moment frame will also be considered to increase the torsional resistance of the building (this will be discussed later on), creating a dual lateral force resisting system. The shear wall core will be analyzed and designed in accordance with ACI 318-05 and will consider all seismic provisions.

A steel composite frame with slab on metal deck (lightweight concrete) is being proposed as an alternative gravity system to the existing filigree flat plate system. To provide added torsional resistance to the building, a perimeter steel moment frame will also be utilized. Although this system will increase the floor to floor height of the tower, the steel frame with slab on metal deck provides a faster erection time, construction sequencing, and may decrease the cost of the foundation system. The steel composite frame will be analyzed and designed in accordance with the AISC Manual of Steel Construction 13th Edition, LRFD. Seismic provisions of the AISC structural steel specification will also be investigated. The slab on metal deck will be designed using the USD deck manual. Using RAM Structural System Steel Module, steel members will be sized and designed for superimposed dead and live loads per ASCE 7-05.

Seismic loads will be calculated in accordance with ASCE 7-05, Equivalent Lateral Force Procedure, based on the seismic design requirements of Seismic Design Category "D" in Las Vegas, Nevada. Because the DFA wind tunnel test is only applicable to Atlantic City, New Jersey, wind forces will be calculated in accordance with ASCE 7-05, Main Wind Force Resisting System Method 2. Using ETABS, a 3D model of the shear wall core and steel moment frames will be created and analyzed under user-defined gravity and lateral loads. Spot checks will be performed by hand in order to verify computer analysis and design.

Breadth Proposals

By proposing to build the new Trump Taj Mahal Hotel in Las Vegas, Nevada, instead of Atlantic City, New Jersey, various opportunities will arise for breadth study. Two studies will be conducted; the architectural impacts resulting from the newly designed core and the effects on the mechanical system of the building.

Because of the significant amount of changes being made to the shear wall core, a study will be conducted on the architectural impacts resulting from the newly designed core. The impacts to the architectural layout of the core will include alterations of the core openings, stairs, elevators, and service areas.

There is a substantial difference between the average outdoor temperatures in Las Vegas and Atlantic City. For example, the average January outdoor air temperature of Atlantic City is 19F cooler than that of Las Vegas. Thus, the cooling and heating loads of both cities will vary. This will have a significant impact on the mechanical system of the tower. With that in mind, I will determine the current heating and cooling loads, new heating and cooling loads, and choose an appropriate system for Las Vegas.

Tasks and Tools

I. Redesign of Lateral Force Resisting System for Design Loads of Las Vegas, Nevada

1. Task 1: Determine Design Loads

   a) Determine the superimposed live and dead loads from design documents and ASCE 7-05

   b) Determine wind loads based on ASCE 7-05, MWFRS Method 2

   c) Determine seismic loads per ASCE 7-05, Equivalent Lateral Force Procedure

2. Task 2: Determine a symmetrical/asymmetrical layout scheme for the core openings

   a) Sketch various options

   b) Note architectural impacts for breadth study later on

3. Task 3: Set up a 3D model using ETABS

   a) Select trial steel member and core sizes

   b) Perform iterations until most efficient member and core sizes are found

   c) Check lateral drift and story drift against criteria set forth in ASCE 7-05

4. Task 4: Design and spot check critical members

   a) Utilize PCA column to design 2 or more levels of the shear wall core

   b) Follow seismic provisions set forth by the AISC structural steel specification and ACI 318-05

   c) Perform spot checks using hand calculations

II. Redesign of Gravity Floor System as Composite Steel with Slab on Metal Deck

1. Task 5: Set up framing plan model using RAM Structural System Steel Module

   a) Determine framing plan

   b) Size members for loads determined in Task 1

   c) Follow seismic provisions set forth by the AISC Structural Steel Specification

d) Spot check members to verify computer design

III. Breadth Studies

1. Task 6: Discuss architectural impacts on the core and service areas of the tower

   a) Redesign the core area to fit the needs of the occupants and services of the tower, but also the structural needs of the core based on Task 1

   b) Analyze and discuss the impacts of any changes

2. Task 7: Mechanical System Analysis and Redesign

   a) Determine the current heating and cooling loads of the tower

   b) Determine the new heating and cooling loads for Las Vegas

   c) Determine new mechanical system requirements

Proposed Work Schedule

January, 2008

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
30	31	1 Winter Break	2	3	4	5
6 Winter Break	7	8	9	10	11	12
13 Winter Break	14 Task 1 - Determine Design Loads Classes Begin	15	16	17	18	19
20	21 Task 2/Task 6 - Determine New Layout Scheme for the Core and Service Areas	22	23	24	25	26
27	28 Task 3 - Setup 3D Model of Core and Moment Frame in ETABS	29	30	31	1	2

February, 2008

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
27	28 Task 3 - Setup 3D Model of Core and Moment Frame in ETABS	29	30	31	1	2
3	4 Task 4 - Design and Spot Check Critical Members of Core and Moment Frame	5	6	7	8	9
10	11 Task 4 - Design and Spot Check Critical Members of Core and Moment Frame	12	13	14	15	16
17	18 Task 5 - Steel Composite Frame Design	19	20	21	22	23
24	25 Task 5 - Steel Composite Frame Design	26	27	28	29	1

March, 2008

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
24	25 Task 5 - Steel Composite Frame Design	26	27	28	29	1
2	3 Task 6 - Discussion of Architectural Impacts to Core and Service Areas	4	5	6	7	8
9	10 Spring Break	11	12	13	14	15
16	17 Task 7 - Mechanical System Analysis and Redesign	18	19	20	21	22
23	24 Task 7 - Mechanical System Analysis and Redesign	25	26	27	28	29
30	31 Work on Written Report Work on Presentation	1	2	3	4	5

April, 2008

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
30	31 Work on Written Report Work on Presentation	1	2	3	4	5
6	7 Work on Presentation Work on Written Report	8	9	10	11 Written Report Due	12 Rehearse Presentation
13 Rehearse Presentation	14 Present to Faculty Jury	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	1	2	3