Design Criteria

Design Methodology

The design of a high rise lateral force resisting system and gravity system poses itself as a daunting and cumbersome task. Computer modeling and analysis with the aid of ETABS and RAM was utilized in order to expedite the design process. Spot and hand checks were performed to verify computer analysis, however the size and scope of the project poses too many factors and considerations. Some errors may have gone unnoticed. Conservative assumptions were utilized as to not jeopardize the completion of this year long study and to offset any possible errors or omissions. These assumptions will be clearly stated as they are relevant.

Design Goals

The main goal of a new structural system for the Trump Taj Mahal Hotel is to replace the current concrete shear wall core with a core of braced frames. The current gravity floor system design as a filigree flat plate will be replaced with a precast concrete plank floor and steel frame. This study is being performed in order to understand why a concrete system was chosen over a steel system, considering the much faster erection time that a steel system offers. Numerous other design goals were established prior to the design of the braced frame core and steel frame. These goals are important to this study and have been strictly adhered to. The goals are as follows:

- Design a core of braced frames to effectively handle the design wind and earthquake forces imposed on the structure.
- The core of braced frames shall be provided in the exact location of the current shear wall core. A redesign of the layout of the core is permitted, but the areas of all spaces shall not deviate by more than 20% of the current. The number of elevators may not change.
- The tower's overall floor area must not change.
- The drift of the braced frames under the most severe lateral loading must not exceed H/400.
- Design a steel frame that utilizes a precast concrete plank floor system to effectively handle the gravity design loads.
- Additional columns and transfer girders shall only be provided if no affects are imposed on the layout of the guest room and meeting spaces.
- All structural systems must adhere to model code IBC 2003, ASCE 7-05, and AISC Manual of Steel Construction 13th Edition LRFD.
- Any floor to floor height increase shall be kept to a minimum and will meet the minimum demands of the mechanical and architectural systems of the tower. The use of soffits may be required to conceal the steel structure.
- Effectively reduce the erection time of the structure in order to generate revenue faster and compare to the added cost of the structure, if applicable.

Design Loads - Gravity

The self weight of the concrete planks with a 2 inch topping was taken as 93psf, as specified by Nitterhouse, Inc.

Superimposed dead loads for the tower are taken directly from the load maps provided by the structural engineer of record. Snow loads were calculated using ASCE 7-05. Live loads are taken directly from Table 4-1 of ASCE 7-05. A summary is provided in the following table.

Level	Superimposed Dead Load	Live Load	Live Load Reduction Comments (ASCE 7-05)
1	Partitions: 15psf	100psf	Not Applicable
2	Non-Core Suspended Ceiling: 10psf Suspended MEP: 10psf Floor Finishes: 10psf Core Suspended Ceiling: 10psf Suspended MEP: 10psf Floor Finishes: 10psf	Non – Core: 150psf Core: 100psf	4.8.5 Limitations on One-Way Slabs
3	Non-Core Suspended Ceiling: 5psf Suspended MEP: 10psf Floor Finishes: 5psf Topping Slab: 10psf Core Suspended Ceiling: 5psf Suspended MEP: 10psf Floor Finishes: 5psf Topping Slab: 10psf	Non-Core: 150psf Core: 100psf	4.8.5 Limitations on One-Way Slabs
4	Non-Core & Core Partitions: 15psf Suspended MEP: 15psf	40psf	4.8.5 Limitations on One-Way Slabs
5 Thru 38	Non-Core & Core Partitions: 15psf	40psf	4.8.5 Limitations on One-Way Slabs
39	Non-Core Partitions: 15psf Floor Finishes: 10psf Core Partitions: 15psf	40psf	4.8.5 Limitations on One-Way Slabs
40	Non-Roof Suspended MEP 30psf Roof Snow Load 11.2psf	MEP: 150psf Roof: 20psf	4.8.5 Limitations on One-Way Slabs 4.9.1 Flat, Pitched and Curved Roofs
41	Non-Roof Suspended MEP 30psf Roof Snow Load 11.2psf	20psf	4.9.1 Flat, Pitched and Curved Roofs

Table 3: Superimposed Dead and Live Loads

Design Loads – Lateral

Wind Loads

Wind loads for the Trump Taj Mahal were computed using a wind tunnel test performed by DFA based on a 50 year wind speed. The wind tunnel test loads are compared to the tabulated ASCE 7-05 MWFRS loads, as shown in Figure 17. Detailed calculations of the wind loads can be found in Appendix A. For the purposes of this study, only the wind tunnel test loads will be considered because the concrete shear wall core was designed using these loads (See Note 1 following Figure 17). The wind tunnel loads are permitted to be used despite being smaller overall compared to the wind loads calculated per ASCE 7-05. The wind tunnel loads consider 20 different load cases that include a force in both directions with an applied torsion. The wind tunnel load cases and corresponding loads for each case can be found in Appendix A.

Level	Height	Wind Tunnel Results					ASCE 7-05 Wind Loads			
		East/West (Kips)	North/South (Kips)	Torsion (in-kips)	Ovt Mom E/W (kip-ft)	Ovt Mom N/S (kip-ft)	North/South (kips)	East/West (kips)	Ovt Mom N/S (kip-ft)	Ovt Mom E/W (kip-ft)
Roof	460	139	191.4	20520	63940	88044	132.58	137.57	2121.26	2201.07
40	437.583	169.3	233.3	31920	138022.802	190132.114	138.86	144.08	5731.50	5947.14
39	422.583	103.2	142.1	19920	181633.368	250181.158	152.24	157.97	14561.39	15109.25
38	412.167	96.3	132.7	18960	221325.05	304875.719	76.11	78.98	19768.92	20512.70
37	401.75	100.2	138	20040	261580.4	360317.219	77.30	80.21	25863.04	26836.11
36	391.333	97.6	134.5	19560	299774.5	412951.508	78.38	81.33	32858.39	34094.65
35	380.917	95.1	131	19080	335999.707	462851.635	79.35	82.34	40767.20	42301.02
34	370.5	92.5	127.5	18480	370270.957	510090.385	80.25	83.27	49601.52	51467.72
33	360.083	90	124	18000	402678.427	554740.677	81.09	84.14	59372.84	61606.67
32	349.667	87.4	120.5	17520	433239.323	596875.55	81.87	84.95	70090.37	72727.43
31	339.25	84.9	116.9	17040	462041.648	636533.875	82.60	85.70	81764.02	84840.29
30	328.833	82.3	113.4	16440	489104.604	673823.537	83.29	86.42	94403.44	97955.25
29	318.417	79.9	110.1	15960	514546.122	708881.249	83.94	87.10	108015.89	112079.85
28	308	77.4	106.6	15480	538385.322	741714.049	84.56	87.74	122609.92	127222.97
27	297.583	74.8	103.1	15000	560644.531	772394.856	85.16	88.36	138194.02	143393.40
26	287.167	72.3	99.6	14520	581406.705	800996.69	85.72	88.95	154774.01	160597.19
25	276.75	69.7	96	13920	600696.18	827564.69	86.26	89.51	172357.52	178842.26
24	266.333	65.8	90.6	13440	618220.891	851694.459	86.79	90.06	190952.25	198136.59
23	255.917	63.3	87.2	12960	634420.437	874010.422	87.29	90.57	210562.87	218485.04
22	245.5	60.8	83.7	12360	649346.837	894558.772	87.77	91.07	231196.38	239894.86
21	235.083	58.3	80.3	11880	663052.176	913435.937	88.24	91.56	252859.92	262373.46
20	224.667	55.8	76.9	11400	675588.595	930712.829	88.69	92.03	275557.19	285924.69
19	214.25	53.3	73.4	10920	687008.12	946438.779	89.13	92.48	299294.75	310555.35
18	203.833	50.9	70.1	10440	697383.219	960727.472	89.56	92.93	324079.31	336272.39
17	193.417	48.4	66.7	9840	706744.602	973628.386	89.96	93.35	349913.76	363078.83
16	183	45.9	63.3	9360	715144.302	985212.286	90.36	93.76	376804.30	390981.10
15	172.583	43.4	59.8	8880	722634.404	995532.75	90.76	94.17	404757.36	419985.85
14	162.167	40.9	56.4	8400	729267.035	1004678.97	91.13	94.56	433775.09	450095.34
13	151.75	38.4	53	7800	735094.235	1012721.72	91.50	94.94	463863.45	481315.74
12	141.333	35.9	49.5	7320	740168.089	1019717.7	91.86	95.32	495028.64	513653.48
11	130.917	33.4	46.1	6840	744540.717	1025752.98	92.21	95.68	527272.14	547110.10
10	120.5	31	42.6	6360	748276.217	1030886.28	92.56	96.04	560599.74	581691.61
9	110.083	28.5	39.2	5760	751413.583	1035201.53	92.90	96.39	595017.46	617404.25
8	99.667	26	35.8	5280	754004.925	1038769.61	93.22	96.73	630526.19	654248.95
7	89.25	23.6	32.5	4800	756111.225	1041670.23	93.54	97.06	667131.56	692231.56
6	78.833	21.1	29.1	4320	757774.601	1043964.27	93.86	97.39	704839.51	731358.23
5	68.417	18.6	25.6	3840	759047.157	1045715.75	94.16	97.71	743650.33	771629.26
4	58	29.8	41.1	4680	760775.557	1048099.55	115.25	119.58	792351.32	822162.56
3	26	9.2	12.6	1800	761014.757	1048427.15	140.26	145.54	853727.65	885848.09
2	16	6.4	8.8	1200	761117.157	1048567.95	84.58	87.76	892632.82	926217.02
		2500.6	3445		761117.157	1048567.95	3725.14	3865.29	892632.82	926217.02

***Figure 17*: Wind Loads per DFA Wind Tunnel Test and ASCE 7-05 MWFRS Method 2**

Note 1: Height increase will alter wind tunnel results, however this will be neglected for the purpose of this study.

Seismic Loads

Seismic loads for the Trump Taj Mahal were calculated using ASCE 7-05, Equivalent Lateral Force Procedure. The details of the calculations, parameters, and seismic load cases can be found in Appendix A of this report. The base shear for both directions was calculated to be approximately 720kips. Seismic forces can be seen below in Figure 18.

Seismic Forces ASCE 7-05 Lateral Force Procedure			
Level	Height	Shear Per Floor (kips)	Overturning Moment
Roof	460	40.93	18829.93
40	437.583	55.56	43143.44
39	422.583	43.18	61391.68
38	412.167	41.08	78323.55
37	401.75	39.03	94003.79
36	391.333	37.03	108495.66
35	380.917	35.09	121860.89
34	370.5	33.19	134159.32
33	360.083	31.35	145449.29
32	349.667	29.57	155787.59
31	339.25	27.83	165229.17
30	328.833	26.15	173827.44
29	318.417	24.52	181634.26
28	308	22.94	188699.67
27	297.583	21.41	195072.16
26	287.167	19.94	200798.65
25	276.75	18.52	205924.29
24	266.333	17.15	210492.65
23	255.917	15.84	214545.70
22	245.5	14.57	218123.70
21	235.083	13.36	221265.28
20	224.667	12.21	224007.51
19	214.25	11.10	226385.70
18	203.833	10.05	228433.60
17	193.417	9.05	230183.32
16	183	8.10	231665.29
15	172.583	7.20	232908.31
14	162.167	6.36	233939.58
13	151.75	5.57	234784.61
12	141.333	4.83	235467.29
11	130.917	4.14	236009.88
10	120.5	3.51	236432.99
9	110.083	2.93	236755.57
8	99.667	2.40	236994.98
7	89.25	1.93	237166.89
6	78.833	1.50	237285.36
5	68.417	1.13	237362.81
4	58	0.93	237416.73
3	26	0.22	237422.56
2	16	0.077823311	237423.80
		718.5	237423.80

***Figure 18*: Seismic Loads per ASCE 7-05 Equivalent Lateral Force Procedure**

Comparison

The following graph, Figure 19, compares the lateral loads of the Trump Taj Mahal Hotel. It can be seen that the wind tunnel loads in the north/south direction have the largest wind forces overall. The wind loads calculated according to ASCE-7-07 MWFRS Method 2 appear to be more uniform and yield higher base shears compared to the wind tunnel loads. Seismic forces appear to be well below that of the wind forces and will probably not govern design.

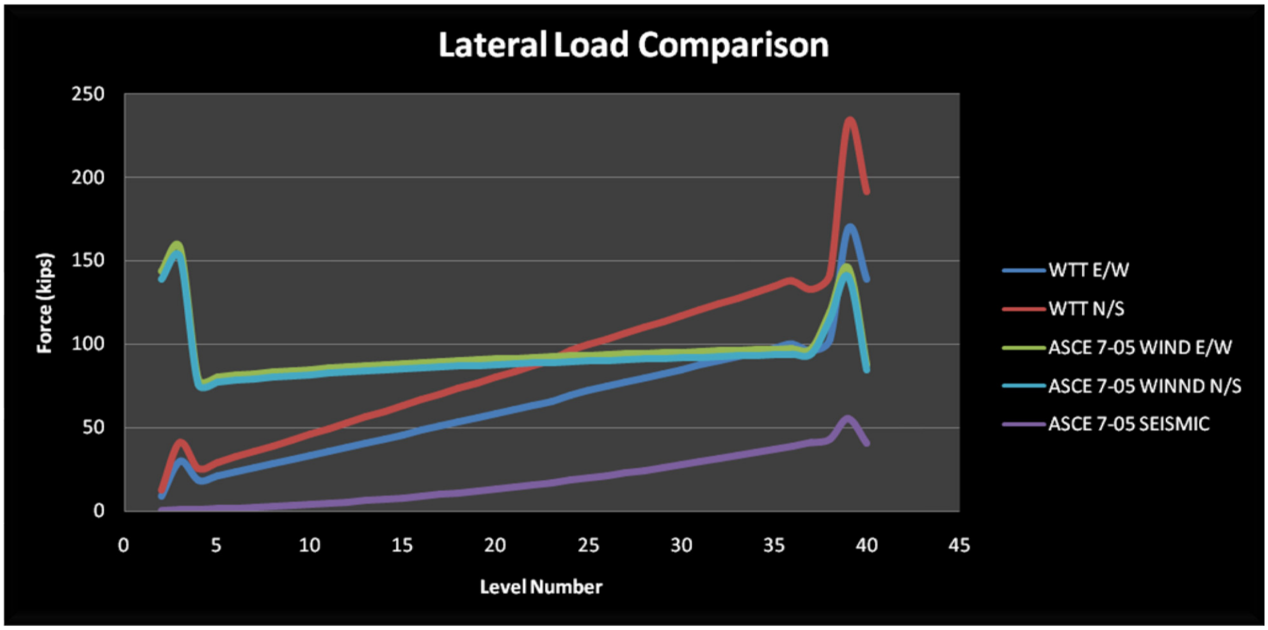

***Figure 19*: Lateral Load Comparison**