

CHAPTER FIVE

ANALYSIS AND DISCUSSION OF RESULTS

5.1 Comparison Between Computer and Manual Calculations

Approximate Methods (cantilever and moments distribution):

The results of the two types of analysis are compared and analyzed. The manual methods of gravity and lateral loads analysis include moment distribution and cantilever methods. The results of the manual approximate methods are compared to ETABS computer program.

The results of comparison are shown in tables (5.1) to (5.6). These show that there are a lot of differences between the computer method and manual approximate methods. However, a significant value in results at 40th story is shown by comparing cantilever method (2-D analysis) to ETABS (2-D analysis) program. Generally, the different accuracy can be achieved using two dimensional analysis shown in table (5.7). Hence, the frame (1) shown in fig. (4.1) separated with a proportional percentage of wind loads and analyzed as individual two-dimensional structure for lateral loads analysis, The results of ETABS (3D and 2D) analysis are shown in Appendix (B and C).

Table (5.1): Wind Loads per Story Level

Level	Manual	Computer	Diff%
40 th	98.8	97.4	1.42
39	197	194.5	1.27
38	195.8	194	0.92
37	195.7	193.4	1.18
36	195.3	192.8	0.52
35	194.6	192.3	1.18
34	194.1	191.7	1.24
33	193.4	191.1	1.19
32	192.7	190.5	1.14

31	192.3	189.8	1.30
30	191.6	189.2	1.25
29	190.8	188.5	1.21
28	189.8	187.8	1.05
27	189.5	187.1	1.27
26	188.7	186.4	1.22
25	188	185.7	1.22
24	187.2	184.9	1.23
23	186.4	184.1	1.23
22	185.5	183.3	1.19
21	184.7	182.4	1.25
20	183.7	181.5	1.19
19	182.9	180.6	1.26
18	181.9	179.6	1.26
17	180.8	178.6	1.22
16	179.7	177.5	1.22
15	178.6	176.4	1.23
14	177.3	175.2	1.18
13	176.1	173.9	1.25
12	174.6	172.6	1.15
11	173.2	171.1	1.21
10	171.8	169.6	1.28
9	170	167.9	1.24
8	168.2	166.1	1.25
7	165.3	164.1	0.73
6	163.6	161.8	1.10
5	161.2	159.2	1.24
4 th	158.2	156.1	1.33
3 rd	154.3	152.4	1.23
2 nd	149.5	147.5	1.34
1 st	162	160.6	0.86

Table (5.2): Max Moments and Shear Forces on beam (Gravity Loads)

Level	Beam (A1-B1)					
	Max Moment		Diff %	Shear Force		Diff%
	Manual	Computer		Manual	Computer	
40 th	116	119.6	-0.86	68	86.5	-21.38
39	128	159.6	-19.79	100	106.8	-6.36
38	128	157.4	-18.67	100	106.2	-5.83
37	128	157.4	-18.67	100	106.2	-5.83
36	128	157.3	-18.62	100	106.2	-5.83
35	128	157.3	-18.62	100	106.2	-5.83
34	128	157.2	-18.57	100	106.2	-5.83
33	128	157.2	-18.57	100	106.2	-5.83
32	128	157.1	-18.52	100	106.2	-5.83
31	128	156.9	-18.41	100	106.1	-5.74
30	128	156.7	-18.31	100	106	-5.66
29	128	156.5	-18.21	100	105.9	-5.57
28	128	156.2	-18.00	100	105.8	5.48
27	128	155.9	-17.89	100	105.7	-5.39
26	128	155.5	-17.68	100	105.6	-5.30
25	128	155.1	-17.47	100	105.4	-5.12
24	128	154.7	-17.25	100	105.2	-4.94
23	128	154.2	-16.99	100	105	-4.76
22	128	153.6	-16.66	100	104.8	-4.58
21	128	153	-16.33	100	104.6	-4.39
20	128	152.3	-15.95	100	104.3	-4.12
19	128	151.5	-15.51	100	104	-3.84
18	128	150.6	-15.00	100	103.7	-3.56
17	128	149.6	-14.43	100	103.3	-3.19
16	128	148.5	-13.80	100	102.8	-2.72
15	128	147.2	-13.04	100	102.3	-2.24
14	128	145.8	-12.20	100	101.8	-1.76
13	128	144.1	-11.17	100	101.1	-1.08

12	128	142.2	-9.98	100	100.4	-0.39
11	128	140.1	-8.63	100	99.5	0.5
10	128	137.6	-6.97	100	98.5	1.5
9	128	134.7	-4.97	100	97.4	2.6
8	128	131.3	-2.51	100	96	4
7	128	127.3	0.54	100	94.5	5.5
6	128	122.6	4.21	100	92.6	7.4
5	128	117	8.59	100	90.3	9.7
4 th	128	110.3	13.82	100	87.5	12.5
3 rd	128	102.2	20.00	100	84.1	15.9
2 nd	128	92.1	28.00	100	79.7	20.3
1 st	85	77.3	9.00	80	73.6	8

Table (5.3): Max Moments and Shear Forces on Beam (Wind Loads)

Level	Beam (A1-B1)					
	Max Moment		Diff %	Max Shear Force		Diff%
	Manual	Computer		Manual	Computer	
40 th	3.75	1.42	62	1.5	1.19	21
39	15	5.92	60	5	2.03	59
38	28.8	19	34	11.5	7.03	39
37	43.3	32.37	25	17.3	12.19	29
36	57.6	45.7	20	23	17.35	24
35	73	58.94	19	29	22.46	22
34	87	72	17	35	27.52	21
33	101	85	15	40.2	32.53	19
32	114	97.9	14	45.4	37.5	17
31	130	110.69	17	52	42.4	18
30	143	123.38	15	57	47.31	17
29	158	135.98	22	63	52.17	17
28	170	148.53	12	68	57	16
27	183	161	12	73	61.8	15
26	198	173.43	12	80	66.58	15

25	213	185.8	13	85	71.35	16
24	225	198.13	12	90	76.1	15
23	240	210.4	12	96	80.83	16
22	253	222.69	12	101	85.55	15
21	268	234.92	12	107	90.26	15
20	300	247.144	17	120	94.97	20
19	291	259.36	11	117	99.68	15
18	307	271.57	11	123	104.39	15
17	318	283.79	11	127	109.11	14
16	326	296	9	130	113.84	12
15	352	308.32	12	141	118.59	15
14	360	320.65	11	145	123.37	15
13	367	333.1	9	149	128.18	14
12	398	345.57	13	159	133	16
11	411	358.19	13	165	137.94	16
10	440	370.96	15	180	142.92	20
9	450	383.92	15	180	147.98	18
8	450	397.1	31	184	153.14	16
7	450	410.55	8	180	158.42	12
6	450	424.3	6	180	163.84	9
5	450	438	3	180	169.4	6
4 th	400	452.55	-11	160	175	-8
3 rd	425	465.65	-9	170	180.27	-5
2 nd	450	472.17	-5	180	182.98	-2
1 st	350	451.27	-22	140	173.69	-19

Table(5.4): Max Axial Forces and Moments on Column (C11)

Level	Dead Load			Dead Load + Live Load		
	Axial force		Diff %	Moment (Max)		Diff %
	Manual	Computer		Manual	Computer	
40 th	118.2	171.5	-30	94	90.3	3.94
39	334.1	208.9	37	89	84.8	4.72

38	554.7	429.9	22	89	84.7	4.83
37	775.4	650.5	16	89	84.7	4.83
36	996	871	12	89	84.7	4.83
35	1216.6	1091.6	10	89	84.7	4.83
34	1437.3	1312.2	8.7	89	84.7	4.83
33	1657.9	1532.7	7.5	89	84.6	4.94
32	1878.6	1753.2	6.6	89	84.6	4.94
31	2099.2	1973.7	6	89	84.5	5.05
30	2319.8	2194.1	5.4	89	84.4	5.16
29	2540.5	2414.4	4.9	89	84.3	5.57
28	2761.1	2634.7	4.5	89	84.1	5.51
27	2981.8	2854.8	4.2	89	84.0	5.62
26	3202.4	3074.9	3.9	89	83.8	5.84
25	3423	3294.9	3.7	89	83.6	6.06
24	3643.7	3514.7	3.5	89	83.4	6.29
23	3864.32	3734.5	3.3	89	83.1	6.63
22	4085	3954	3.2	89	82.8	6.96
21	4305.6	4173.5	3.1	89	82.5	7.30
20	4526.2	4392.7	2.9	89	82.1	7.75
19	4746.9	4611.7	2.8	89	81.7	8.20
18	4967.5	4830.5	2.8	89	81.3	8.65
17	5188.2	5049.1	2.7	89	80.7	9.32
16	5408.8	5267.3	2.6	89	80.1	10.00
15	5629.4	5485.2	2.6	89	79.5	10.67
14	5850	5702.8	2.5	89	78.7	11.57
13	6070.7	5919.8	2.5	89	77.8	12.58
12	6291.4	6136.4	2.5	89	76.7	13.82
11	6512	6352.3	2.5	89	75.5	15.16
10	6732.6	6567.4	2.5	89	74.1	16.74
9	6953	6781.5	2.5	89	72.5	18.53
8	7173.9	6994.4	2.5	89	70.5	20.78
7	7394.6	7205.8	2.6	89	68.2	23.37

6	7615.2	7415.3	2.6	89	65.4	26.51
5	7835.8	7622.1	2.7	89	62.1	30.22
4 th	8056.5	7825.2	2.9	89	58	34.83
3 rd	8277	8023.4	3	89	52.8	40.67
2 nd	8497.8	8214.9	3.3	89	51.3	42.35
1 st	8718	8396.5	3.6	24	23	4.16
Base	8958	8576.3	4.2	-	-	-

Table (5.5): Max Axial Forces and Moments on Column (C11)

Level	Wind Load					
	Axial force		Diff %	Moment (Max)		Diff %
	Manual	Computer		Manual	Computer	
40 th	1.5	1.19	20	5	-8.18	-37
39	8	0.84	9	13	10.56	19
38	18.7	7.86	58	18	13.38	25
37	36	20.1	44	25.3	16.35	35
36	59	37.4	36	30	19.18	33
35	87.8	59.86	32	38	25.32	33
34	122.4	87.38	28	47	32.07	32
33	162.6	119.91	26	53	38.8	27
32	208	157.4	24	60	45.52	24
31	260	199.82	23	70	52.22	25
30	317	247.13	22	73	58.93	19
29	380	299.3	21	84	65.63	22
28	448	356.3	20	86	72.33	16
27	521	418.1	20	95	79.04	17
26	600	484.68	19	103	85.76	17
25	685	556	19	110	92.49	17

24	775	632.12	18	115	99.24	14
23	871	712.94	18	125	106	15
22	970	798.49	17	128	112.8	12
21	1079	888.75	17	139	119.61	14
20	1191	983.73	17	142	126.46	11
19	1308	1083.41	17	149	133.34	11
18	1430	1187.8	17	158	140.26	11
17	1559	1296.9	17	162	147.23	9
16	1689	1410.75	16	166	154.24	7
15	1830	1529.34	16	180	161.33	10
14	1974	1652.71	16	180	168.48	6
13	2121	1780.89	16	192	175.72	8
12	2280	1913.92	16	200	183.04	8
11	2400	2051.86	14	200	190.49	5
10	2580	2194.78	15	203	198.06	2
9	2760	2342.76	15	215	205.79	4
8	2944	2495.9	15	220	213.69	3
7	3123	2654.33	15	227	221.82	2
6	3300	2818.17	15	231	230.21	0.3
5	3480	2987.57	14	247	239.1	3
4 th	3640	3162.6	13	255	249.15	2
3 rd	3780	3342.86	11	260	263.36	13
2 nd	3960	3525.85	11	285	283.91	0.38
1 st	4140	3699.54	11	665	638.7	3.9

Table (5.6): Max Shear Forces on Colum (C11)

Level	Wind Load		
	Manual	Computer	Diff%
40 th	3.1	3	3.2
39	8	3.93	50
38	11.3	8	29
37	15.8	12.22	23
36	18.7	16.4	12
35	23.7	20.54	13
34	29.4	24.62	16
33	33	28.68	13
32	37.5	32.7	13
31	43.7	36.68	16
30	45.6	40.65	10.8
29	52	44.59	14.3
28	54	48.51	10.2
27	59.4	52.41	11.8
26	64.4	56.30	12.6
25	68.8	60.17	12.5
24	72	64	11
23	79	71.71	9.2
22	81	75.54	6.7
21	87	79.37	8.8
20	89	83.2	6.5
19	94	87.03	7.4
18	98	90.86	7.3
17	101	94.7	6.2
16	103	98.56	4.3
15	112	102.44	8.5
14	112	106.34	5
13	117	106.34	9
12	125	110.28	11.7

11	125	114.26	8.6
10	127	118.29	6.8
9	134	122.39	8.7
8	138	126.56	8.3
7	142	130.83	7.8
6	144	135.22	6.1
5	147	139.75	4.9
4 th	159	144.58	9
3 rd	167	149.96	10.2
2 nd	178	153.97	13.5
1 st	186	201.52	-8.3

Table (5.7): Comparison Between (2D and 3D) Models in ETABS9.5.0

Level	Wind Loads					
	Axial force on Column A1		Diff %	Max Moment on Column A1		Diff %
	ETABS 3D	ETABS 2D		ETABS 3D	ETABS 2D	
40 th	-6.8	-1.19	82	-15.2	-8.18	46
39	-6.7	0.84	87	24.3	10.56	56
38	3.1	7.86	-60	32.4	13.38	58
37	23.4	20.1	14	40.3	16.35	59
36	54.3	37.4	31	47.5	19.18	59
35	95.6	59.86	37	60.95	25.32	58
34	147.2	87.38	40	77.3	32.07	58
33	208.8	119.91	42	93.6	38.8	58
32	280.3	157.4	43	109.9	45.52	58
31	361.6	199.82	44	126.1	52.22	58
30	452.6	247.13	45	142.3	58.93	58
29	553.1	299.3	45	158.5	65.63	58
28	663.2	356.3	46	174.7	72.33	58
27	782.8	418.1	46	190.8	79.04	58
26	901.7	484.68	46	207.1	85.76	58
25	1050	556	47	223.2	92.49	58

24	1197	632.12	47	239.5	99.24	58
23	1354.7	712.94	47	255.7	106	58
22	1521	798.49	47	272	112.8	58
21	1696.5	888.75	47	288.3	119.61	58
20	1881.5	983.73	47	304.7	126.46	58
19	2075.7	1083.41	47	321.3	133.34	58
18	2279.3	1187.8	47	337.8	140.26	58
17	2492.4	1296.9	47	354.4	147.23	58
16	2714.9	1410.75	48	371.2	154.24	58
15	2947	1529.34	48	388.2	161.33	58
14	3188	1652.71	48	405.2	168.48	58
13	3440.5	1780.89	48	422.6	175.72	58
12	3702.3	1913.92	48	440.1	183.04	58
11	3974.4	2051.86	48	458	190.49	58
10	4257.3	2194.78	48	476.3	198.06	58
9	4551.2	2342.76	48	495	205.79	58
8	4856.9	2495.9	48	514.3	213.69	58
7	517	2654.33	48	534.5	221.82	58
6	5506.4	2818.17	48	555.8	230.21	58
5	5852.2	2987.57	48	579.5	239.1	58
4 th	6212.7	3162.6	49	607.5	249.15	58
3 rd	6586.6	3342.86	49	656.5	263.36	59
2 nd	6962.2	3525.85	49	738.3	283.91	61
1 st	7293.1	3699.54	49	1235.6	638.7	48

5.2 Discussion of Results:

From the results obtained from table (5.1) to (5.6) it can be observed that, shear forces and bending moment which produced from gravity loads analysis by using moments distribution made difference between 0.39% from table (5.2) at 12th story level, and 42% from table (5.4) at second story level, when it was compared with ETABS results. Whereas, shear forces, bending moments and

axial forces which are produced from lateral load by using cantilever method has made difference between 0.3% from table (5.5) at 6th story level, and 62% as a significant difference between ETABS program and approximate methods from table (5.3) at 40th story level. These differences may be due to the following:

- ETABS is a finite element program.
- Assumption of the approximate methods that the contra flexure points occur at each middle span of elements. The moment diagram of columns and beams (Appendix A) the points of contra flexure are not placed at the mid story height and mid span of beams.
- The object-based approach of ETABS allows for the automatic modeling of semi-rigid floor diaphragms, each floor plate essentially being a floor object.
- ETABS allows for modification factors to be assigned to both line and area objects. In many cases, especially for taller buildings because the effect is cumulative, the analytical results of the final structure can be significantly altered by the construction sequence of the building.
- For lateral drift effects, the program assumes that the P-delta analysis is performed and that the amplification is already had included in the result. The moments and forces obtained from P-delta analysis are further amplified for individual column.
- The results of approximate methods are very conservative which unable reflect the actual behavior of the frames.
- Approximate analysis methods are applied on determined range of stories.