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FOUNDATION SIGN CORRECTION IN STOCHASTIC ANALYSIS PROCEDURES

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ABSTRACT

There are "ABS, SRSS, CQC, MSRSS, ... " methods in stochastic analysis of structures, that are based on the mean of the response squares.

One of the most accurate stochastic methods is MSRSS, that is defined as equation (1).

$$E\left[y^2\right] = \sum_{j=1}^{N} R_j^2 + 2\sum_{j=1}^{N=1}\sum_{k=j+1}^{N} R_{jk} \qquad (1)$$

The maximum modal responses are positive or singles, and therefore direction of the forces act on the foundation are alike. In these cases foundation analysis is not valid and the force sign correction must be used.

In this paper, besides considering the stochastic methods shortly, a method for sign correction based on the time history analysis will be presented.

KEYWORDS

Stochastic analysis, time history, satirically analysis, response spectrum,

STOCHASTIC & TIMEHISTORY ANALYSIS

The most famous computer stochastic analysis is complete quadratic combination (CQC) that the elements internal forces will be determined from eq. (2).

$$F = \sqrt{\sum_{j=1}^{N} F_j^2} \qquad (2)$$

Therefore all internal forces would be positive. For finding the method for sign correction the work schedule used as follows.

1- A four storeys building frame is considered, Fig.(1).

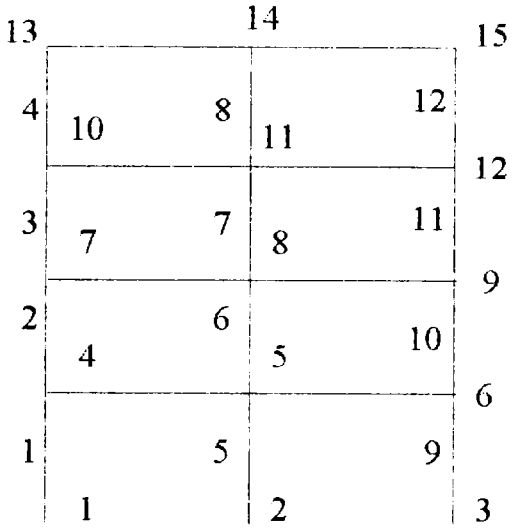
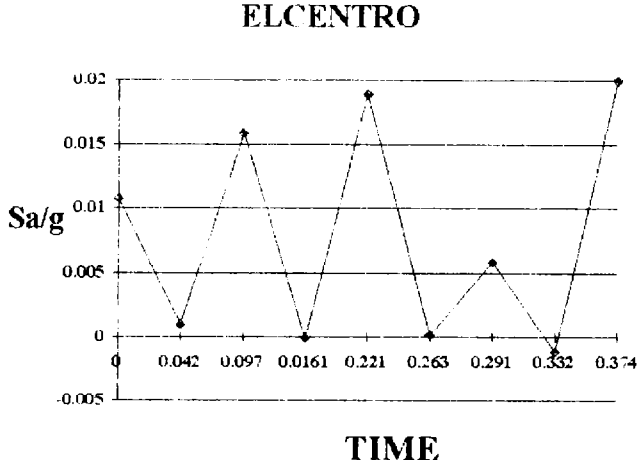


Fig.1. Building Frame

2- Nine acceleration from the first of El Centro (1940) accelerogram were choosed, as table (1).

Table 1. El Centro (1940) accelerogram

TIME	Sa/g
0	0.0108
0.042	0.001
0.097	0.0159
0.161	-0.0001
0.221	0.0189
0.263	0.0001
0.291	0.0059
0.332	-0.0012
0.374	0.02



3- Using time history analysis, and shears, axial forces and also moments were determined in each time, tables (2), (3) and (4).

Table 2- shears in time history analysis

Time	El.1	El.5	El.9
0.042	169.9	197.9	169.9
0.097	408.5	502.3	408.5
0.161	892.6	1131	892.6
0.221	1126	1432	1126
0.263	1567	1984	1567
0.291	1551	2003	1551
0.332	1505	1940	1505
0.374	1362	1734	1362
MAXIMUM SHEAR (kg)	1579*	2016	1579

Table 3- Axial forces in time history analysis

Time	El.1	El.5	El.9
0.042	-96.62	0	96.62
0.097	-512.6	0	512.6
0.161	-1772	0	1772
0.221	-2987	0	2987
0.263	-3670	0	3670
0.291	-3867	0	3867
0.332	-3910	0	3910
0.374	-3621	0	3621
MAXIMUM AXIAL FORCE	-3920*	0	3920

* The maximum forces occurred in the time that aren't in the tables.

Table 4- Moment in time history analysis

	BOTT			TOP		
Time	1	5	9	1	5	9
0.042	-285.3	-312.2	-285.3	224.3	281.6	224.3
0.097	-720.4	-810.1	-720.4	505.2	696.3	505.2
0.161	-1620	-1849	-1620	1057	1545	1057
0.221	-2061	-2354	-2061	1316	1942	1316
0.263	-2850	-3249	-2850	1851	2704	1851
0.291	-2869	-3302	-2869	1783	2706	1783
0.332	-2784	-3200	-2784	1730	2619	1730
0.374	-2493	-2849	-2493	1594	2354	1594
MAXIMUM MOMENT (kg.m)	-2891	-3314	-2891	1855	2737	1855

4- After determining the periods of the four modes, the response spectrum for single degree of freedom is determined. The response spectrum is showed in Fig.(2).

TIME	ω (rad/sec)	Sa (m/s^2)
0.0573	109.5	0.1072
0.0702	89.4	0.2056
0.0811	77.4	0.1847
0.094	66.8	0.2661
0.1073	58.5	0.3344
0.1175	53.4	0.3037
0.125	50.2	0.2931
0.14	44.8	0.2274
0.1804	34.8	0.2689
0.211	29.7	0.2016
0.222	28.2	0.1821
0.324	19.3	0.2098
0.646	9.7	0.1529
0.678	9.2	0.1532
0.702	8.9	0.1525
0.725	8.6	0.1513

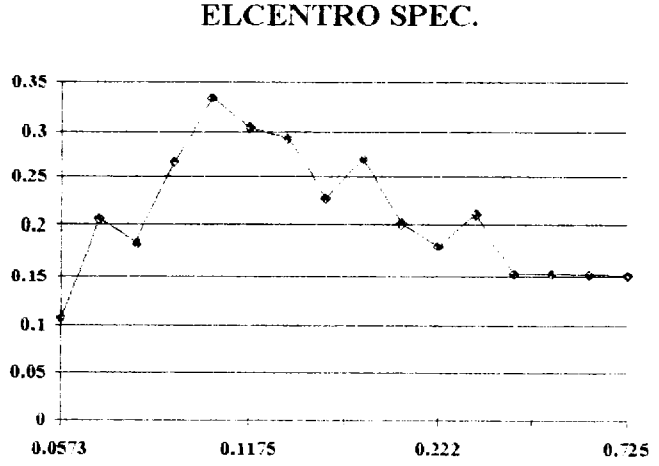


Fig.2 Response Spectrum due to El Centro (1940)

5- Based on the given response spectrum, the maximum forces from pseudo dynamic analysis, determined and illustrated in table (5).

Table 5- Maximum forces due to pseudo dynamic analysis

ELEMENT	V(kg)	MOMENT (kg.m)		AXAIL FORCE (kg)
		BOTT	TOP	
1	1535.38	2838.4	1769.5	4239.26
2	1223.27	1780.6	1892.9	2687.9
3	921.39	1240.3	1528.7	1299.3
4	468.63	558.5	855.1	378.8
5	1977.3	3261.7	2670.5	0
6	2004.77	3005	3009.8	0
7	1480.24	2140.9	2300.6	0
8	809.76	1110	1320.1	0
9	1535.38	2838.4	1769.5	4239.26
10	1223.27	1780.6	1892.9	2687.9
11	921.39	1240.3	1528.7	1299.3
12	468.63	558.5	855.1	378

As the mentioned, it can be seen that, all the forces are singless.

6- from the results of the pseudo dynamic analysis, the horizontal forces acts on all of the joints are calculated. The said forces are given in table (6).

Table 6- Joints horizontal forces

JOINT	HOR. FORCE
1	1535.37
2	1977.3
3	1535.37
4	439.42
5	367.93
6	439.4247
7	406.487
8	650.99
9	406.48
10	521.44
11	754.48
12	521.44
13	468.62
14	809.75
15	468.62

7- By using the statically analysis based on the table (6) forces, the new internal forces as table (7) were determined.

Table 7- Forces due to statically analysis

ELEMENT	V(kg)	MOMENT (kg.m)		AXAIL FORCE (kg)
		BOTT	TOP	
1	1750.61	-3205.53	2046.3	-4361.76
2	1224.96	-1731.72	1943.18	-2659.37
3	827.55	-1090.97	1391.66	-1270.16
4	469.94	-555.6	854.23	-377.91
5	2232.47	-3666.51	3030.9	0
6	2036.98	-3032.17	3078.77	0
7	1367.84	-1966.62	2136.91	0
8	807.13	-1106.53	1314.85	0
9	1750.61	-3205.53	2046.3	4361.76
10	1224.96	-1731.72	1943.18	2659.37
11	827.55	-1090.97	1391.66	1270.16
12	469.94	-555.6	854.23	377.91

8- Finally, the internal elements 1,5 and 9 forces due to time history, pseudo and statically analysis are given in table (8).

Table 8- Comparison of the time history (T.H), pseudo (P.A) and statically (S.A) analysis forces

FORCE		ELEMENT		
		1	5	9
SHEAR FORCE	T.H	1579	2016	1579
	P.A	1535.38	1977.3	1535.38
	S.A	1750.6	2232.47	1750.61
AXIAL FORCE	T.H	-3920	0	3920
	P.A	4239.26	0	4239.26
	S.A	-4361.7	0	4361.7
MOMENT (BOTT)	T.H	-2891	-3314	-2891
	P.A	2838.4	3261.7	2838.4
	S.A	-3205.5	-3666.5	-3205.5
MOMENT (TOP)	T.H	1855	2737	1855
	P.A	1769.5	2670.5	1769.5
	S.A	2046.3	3030.9	2046.3

CONCLUSION

Based on thecomparis table (8) and another considerations, it can be said that, using statically analysis with horizontal forces due to pseudo dynamic analysis besides correction the signs of the forces, the magnitude of them should be almost equal the maximum time history analysis results.

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