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SEISMIC BEHAVIOUR OF SOFT STOREY EFFECT IN RC STRUCTURE BY SHAKE TABLE TEST

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Abstract - *Soft storey is a typical feature in the modern multistorey construction. The soft storey or weak storey are generally exists at ground floor level, but it could be at any other floor level as well. When a sudden change in stiffness takes place along the building height, the storey at which this drastic change of stiffness occurs is called a soft storey. Dynamic analysis of the building model is performed in ETABS. The performance of structure is evaluated in terms of displacement and acceleration. Different cases are analysed by ETABS for models Change in Height, Change in Location of soft storey and Provision of shear wall. The models are tested for displacement, fundamental time period, natural frequency, acceleration.*

Key Words: *Soft storey, ETABS, displacement, fundamental time period, natural frequency, acceleration, Free Vibration.*

1. INTRODUCTION

The lateral stiffness of the soft storey is less than 70 percent of that in the storey above or 80 percent of of the average lateral stiffness of the three storey above (IS1893:2002) . "Soft story" and "weak story" are irregular building configurations that are a significant source of serious earthquake damage. These configurations that are essentially originated due to architectural decisions have long been recognized by earthquake engineering as seismically vulnerable. Large open areas with less infill and exterior walls and higher floor levels at the ground level result in soft stories and hence damage. soft storey is due to the parking spaces at bottom, openings for commercial spaces, large unobstructed area and gneration of floating column.

1.1 Objectives

1. *To study the soft storey effect.*
2. *To give guideline for elimination of soft storey effect.*
3. *To study the seismic response of soft storey structure.*

1.2 Methodology

1. Selection of model configuration in Shake table.
2. Analysis of structure with Shake table for all cases.
3. Comparative study on results under
i. Relative Deflection
ii. Acceleration
iii. Time period

2. Significance of Shake Table

Shake table is a device for shaking structural models or building components with a wide range of simulated ground motions, including reproductions of recorded earthquakes time-histories. The use of shaking tables for the assessment of the dynamic and seismic behavior of civil engineering structures is effective since the sixties.

2.1 Details of shake table

1. Name of Manufacture:

   MILENIUM TECHNOLOGIES (I) PVT. LTD., BANGALORE

2. Name of Instrument:

   SERVO SHAKE TABLE

3. Capacity of Instrument:

   30 Kg

4. Testing frequency Range

   0 – 12 Hz

5. Supporting Software

   Servo Shake Table Test, Kampana.

6. List count

   Records recording with accuracy of 0.01 mm in all three dimensions at interval of 1 mSec

7. Instrumentation with shake table

5 accelerometers, MILDAK Data collection system, Processing software like LAB SHAKE TABLE TEST and KAMPANA

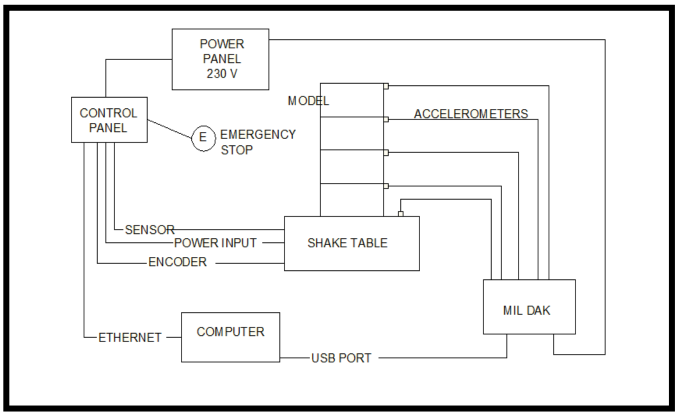


Table -1: 1-Equipment Setup

2.2 Scaling for shake table model

Various parameters are considered for selection of material for model making. Among which 'Stiffness' of member plays a vital role for governing the strength of member. 'Stiffness' of member is composed of 'Moment of Inertia' and 'Modulus of Elasticity' is given in Table

MATERIAL	Type	Cost ($/kg)	Density (ρ, Mg/m^3)	Young's Modulus (E, GPa)	Shear Modulus (G, GPa)	Poisson's Ratio (ν)	Yield Stress (σ_Y, MPa)	UTS (σ_f, MPa)	Breaking strain (ε_f, %)	Fracture Toughness (K_c, MN m$^{-3/2}$)	Thermal Expansion (α, 10^{-6}/C)
Alumina (Al_2O_3)	ceramic	1.90	3.9	390	125	0.26	4800	35	0.0	4.4	8.1
Aluminum alloy (7075-T6)	metal	1.80	2.7	70	28	0.34	500	570	12	28	33
Beryllium alloy	metal	315.00	2.9	245	110	0.12	360	500	6.0	5.0	14
Bone (compact)	natural	1.90	2.0	14	3.5	0.43	100	100	9.0	5.0	20
Brass (70Cu30Zn, annealed)	metal	2.20	8.4	130	39	0.33	75	325	70.0	80	20
Cermets (Co/WC)	composite	78.60	11.5	470	200	0.30	650	1200	2.5	13	5.8
CFRP Laminate (graphite)	composite	110.00	1.5	1.5	53	0.28	200	550	2.0	38	12
Concrete	ceramic	0.05	2.5	48	20	0.20	25	3.0	0.0	0.75	11
Copper alloys	metal	2.25	8.3	135	50	0.35	510	720	0.3	94	18
Cork	natural	9.95	0.18	0.032	0.005	0.25	1.4	1.5	80	0.074	180
Epoxy thermoset	polymer	5.50	1.2	3.5	1.4	0.25	45	45	4.0	0.50	60
GFRP Laminate (glass)	composite	3.90	1.8	26	10	0.28	125	530	2.0	40	19
Glass (soda)	ceramic	1.35	2.5	65	26	0.23	3500	35	0.0	0.71	8.8
Granite	ceramic	3.15	2.6	66	26	0.25	2500	60	0.1	1.5	6.5
Ice (H_2O)	ceramic	0.23	0.92	9.1	3.6	0.28	85	6.5	0.0	0.11	55
Lead alloys	metal	1.20	11.1	16	5.5	0.45	33	42	60	40	29
Nickel alloys	metal	6.10	8.5	180	70	0.31	900	1200	30	93	13
Polyamide (nylon)	polymer	4.30	1.1	3.0	0.76	0.42	40	55	5.0	3.0	103
Polybutadiene elastomer	polymer	1.20	0.91	0.0016	0.0005	0.50	2.1	2.1	500	0.087	140
Polycarbonate	polymer	4.90	1.2	2.7	0.97	0.42	70	77	60	2.6	70

Table -2: Engineering Properties of Various Material.

From studying all the parameters we choose 'ALUMINIUM' is simulated for 'CONCRETE'. The comparison of various engineering properties for material is as follows Table

.

Engineering Properties	***ALUMINIUM***	***CONCRETE***
Modulus of Elasticity (GPa)	70	25
Coefficient Of Thermal Expansion (10-6/oc)	33	12
Specific Gravity	2.7	2.5
Shear Modulus (GPa)	28	20
Yield Stress (MPa)	500	25
Breaking Strain (%)	12	0

Table -3: Comparison of Engineering Properties of Aluminium and Concrete

2.2 Calculated scaling factor for sample model *from calculation of acceleration, mass ,time, frequency and force (as shown in table5.4) model for shake table is prepared by using aluminum material with different sizes.*

Parameters	***Symbols***	***Factor***
Length	S1	1/35
Elastic Modulus	SE	1/4
Acceleration	Sa	1.4
Mass	Sm	1/6860
Time	St	1/7
Frequency	Sf	7
Force	SF	1/4900

Table -4: Calculated Scaling Factor for Model

2.3 Shake Table Model

Table No. 5: Sizes of Flat Used for Shake Table Model

Particular	***Size (in mm)***
Beam	10 X 5
Column	12 X 6
Connections	3mm button headed screw
Base plate	0.5 mm thickness

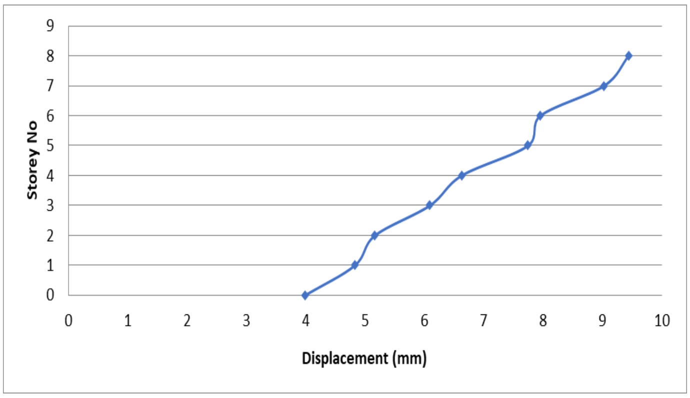
3. RESULT

3.1 Free vibration results

a) Bare frame model

FREQUENCY	Storey	Displacement	Acceleration
5.5	Base	3.99	0.486
	1	4.828	0.588
	2	5.167	0.634
	3	6.091	0.761
	4	6.626	0.813
	5	7.742	0.943
	6	7.953	0.986
	7	9.025	1.099

Table no 5 - Observation of Displacement and Acceleration



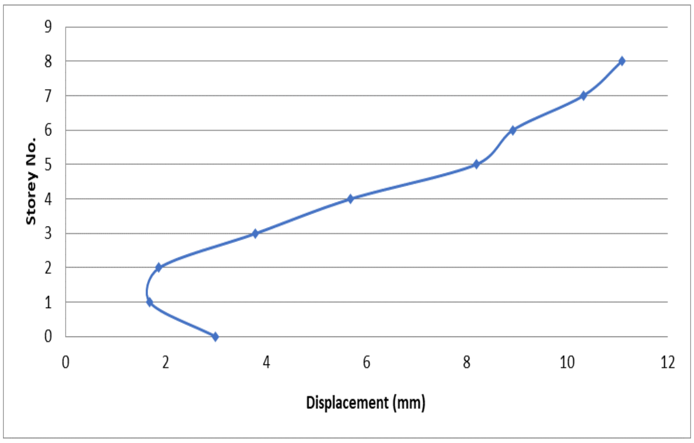
Graph 1– Peak Displacement Graph

From graph it is clearly observed the displacement of bare frame model is uniform. Displacement stats from 3.99 mm and varies up to 9.44 mm .The graph is uniform in nature.

b) Ground floor increased height

FREQUENCY	Storey	Displacement	Acceleration
4.5	Base	2.998	0.261
	1	1.677	0.137
	2	1.863	0.152
	3	3.793	0.309
	4	5.686	0.464
	5	8.189	0.733
	6	8.921	0.734
	7	10.331	0.874
	8	11.097	0.92

Table no 6 - Observation of Displacement and Acceleration



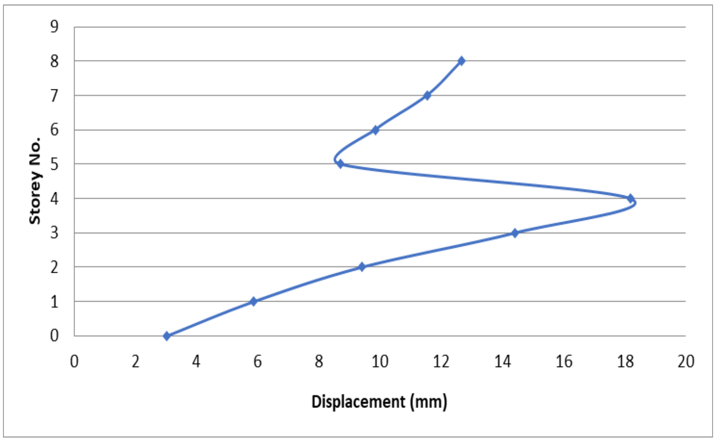
Graph 2– Peak Displacement Graph

Increment in height at ground storey increases the displacement at 8th storey as compare to bare frame model. The displacement at 8th storey is 11.097 mm which is more than the displacement of bare frame model.

c) G+2 increased height

FREQUENC	**Store**	**Displacemen**	**Acceleratio**
4	Base	3.032	0.197
	1	5.881	0.379
	2	9.411	0.606
	3	14.428	0.929
	4	18.191	1.172
	5	8.708	0.561
	6	9.847	0.634
	7	11.544	0.744
	8	12.674	0.816

Table no 7 - Observation of Displacement and Acceleration



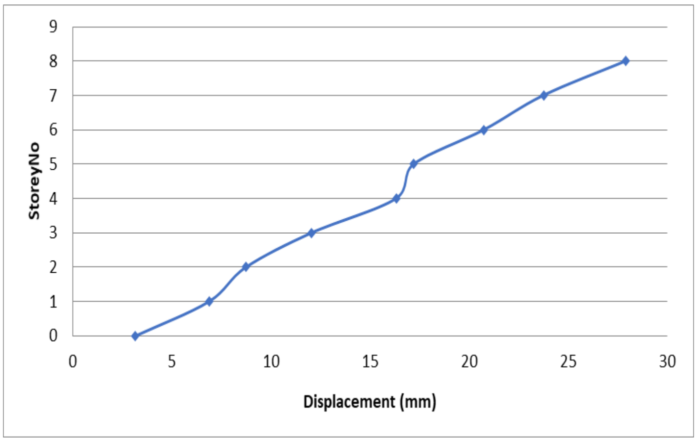
Graph 3– Peak Displacement Graph

Observation shows that the displacement at 3rd storey is 14.428 which is more than the displacement of 3rd storey of bare frame model.

d) G+4 storey increased height

FREQUENC	Store	Displacemen	Acceleratio
4	Base	3.177	0.205
	1	6.883	0.443
	2	8.752	0.564
	3	12.056	0.777
	4	16.327	1.052
	5	17.222	1.088
	6	20.762	1.314
	7	23.764	1.5
	8	27.919	1.761

Table no 8 - Observation of Displacement and Acceleration



Graph 4– Peak Displacement Graph

Increment of height in 5th storey doesn't influence so much in displacement. The graph varies uniformly.

4. CONCLUSIONS

In case of 1st, 3rd, and 5th soft storey structures there is abrupt variation in the displacement of subsequent floors. The storey drift in case of building with soft storey is very large as compare to normal structure. Large changes in relative storey drift are observed across the soft storey. These large drift leads to undesirable bending moments in column which leads to failure of structure as whole.

Bare frame structure and all floor wall structure have linear variation in displacement at various storey levels. Shear wall at bottom storey behaves excellent for free vibration, force vibration as well as for test. These three structures would perform very well at the time of earthquake which is desirable.

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