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Equivalent Lateral Force Procedure for Analysis of Steel Moment Resisting Frames

KEYWORDS

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ABSTRACT *This Paper presents the application of ELF procedure for the analysis of steel MRFs. The load has been calculated using IS 1893-2002. The frames have been analyzed using STAAD-2004. The variation of height of the building along with the lateral displacement and also with the floor weight is studied and the results are presented.*

INTRODUCTION

ELF procedure has been applied in a ten storied MRFs which is in Hyderabad (Zone II). Simplest method of analysis and Static approximation. The design base shear shall first be computed as a whole. Then the design base shear should be distributed along the height of the buildings. The distribution should based upon the simple formulas' appropriate for building with regular distribution of mass and stiffness. Further the frames has been analyzed using STAAD and the results were produced in the form of graphs.

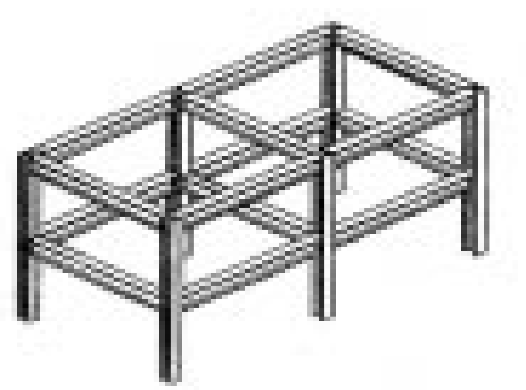
METHODS OF SEISMIC ANALYSIS

Static: Equivalent lateral force analysis & Simplified analysis

Dynamic: Modal response spectrum analysis & Linear response history analysis

Nonlinear : Nonlinear response history analysis

3. MOMENT RESISTING FRAMES



Moment-resisting frame systems can be steel, concrete, or masonry construction. They provide complete space frame throughout the building to carry vertical loads, and they use some of those same frame elements to resist lateral forces.

BASE SHEAR DETERMINATION

Base shear is an estimate of the maximum expected lateral force that will occur due to seismic ground motion at the base of a structure. Calculations of base shear (**V**) depend on soil conditions at the site and proximity to potential sources of seismic activity (such as geological faults)

Base Shear, $V = A_h W$

Where: $A_h = ZI/2R*S_a/g$

W= the effective seismic weight, including applicable portions of other storage and snow loads (IS1893-2002)

ZONE FACTOR

Zone factor given in table 2 of IS 1893-2002(part-1) or it can also be determined from seismic map of India Factor 2 in the denominator used to reduce the maximum considered earth quake zone factor to ht factor for design basis earthquake.

Table:5.1 Zone factor

Zone factor(Z)	Categories
0.1	II
0.16	III
0.24	IV
0.36	V

6. IMPORTANCE FACTOR AND RESPONSE REDUCTION FACTOR

The Importance factor I depends upon the functional use of the structure. It is mentioned in the table of table 6 of IS 1893-2002. Two categories are there based on the functional use. 1. Important service and community buildings (1.5) 2. All other buildings(1.0) Response reduction is based upon the perceived seismic damage performance of the structure, characterized by ductile or brittle deformation. For an extreme brittle building R=1.5. For more ductile building R=5. Sa/g is the average response acceleration co-efficient for rock and soil sites given in IS 1893-2002 Fig:2.

7. APPROXIMATE TIME PERIOD AND SEISMIC WEIGHT (w)

According to the clause 7.6 of IS 1893 it is summarized as $T_a = 0.075\ h^{0.75}$ – Moment resisting Rcc framed building

Fig:3.1Moment resisting frames

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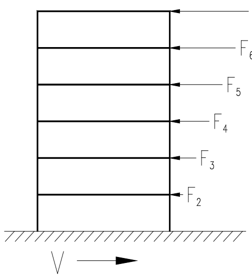
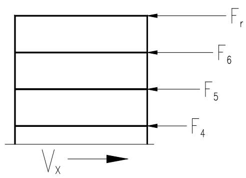
without brick infills. T_a =0.085 $h^{0.75}$ - Moment resisting steel framed building without brick infills. T_a =0.09h/√d –All other buildings.

W is to include all dead load (all permanent components of the building, including permanent equipment) (ie) sum of seismic weight of all the floors. Only 50% of the live load is lumped at all the floors. a) Only a part of the maximum live load will probably existing at the time of earthquake. b) Non- Rigid mounting of the live load absorbs part of the earthquake energy.

8.VERTICAL DISTRIBUTION OF BASE SHEAR

For short period buildings the vertical distribution follows generally follows the first mode of vibration in which the force increases linearly with height for evenly distributed mass. For long period buildings the force is shifted upwards to account for the whipping action associated with increased flexibility. $Q=V_b* w_ih_i^2/\Sigma w_ih_i^2/4$





Story shear, V_x, is the shear force at a given story level and V_x is the sum of all the forces above that level. Being an inertial force, the Story Force, F_x, is distributed in accordance with the distribution of the mass at each level. The Story Shear, V_x, is distributed to the vertical lateral force resisting elements based on the relative lateral stiffness of the vertical resisting elements and the diaphragm

9. PROBLEM STATEMENT

Consider a ten-storey steel office building shown in Fig. below. The building is located in Hyderabad (seismic zone II). The soil conditions are medium stiff and the entire building is supported on isolated rigid column footings. The steel moment resisting frames are infilled with lightweight sheets. The lumped weight due to dead loads is 12 kN/m2 on floors and 10 kN/m2 on the roof. The floors are to cater for a live load of 4 kN/m2 on floors and 1.5 kN/m2 on the roof. Determine design seismic load on the structure as per new code.

Design Parameters: For seismic zone II, the zone factor Z is 0.1 (Table 2 of IS: 1893). Being an office building, the importance factor, I, is 1.0 (Table 6 of IS: 1893). Building is required to be provided with moment resisting frames detailed as per IS: 13920-1993. Hence, the response reduction factor, R, is 5. (Table 7 of IS: 1893 Part 1)

Seismic Weights: The floor area is (width: 4 bays each 6m and length: 6 bays each 7m) 24×42=1008 sq. m. Since the live load class is 4kN/sq.m, only 50% of the live load is lumped at the floors. At roof, no live load is to be lumped. Hence, the total seismic weight on the floors and the roof is:

Level	W_i	h_i	$w_ih_i^2$*1000	$w_ih_i^2/Ew_ih_i^2$	V_b* $w_ih_i^2/\sum w_ih_i^2$	V_b* $w_ih_i^2/\sum w_ih_i^2/4$
10	10080	30	9072000	0.20040	343.40	85.85
9	14112	27	10287648	0.22725	389.42	97.35
8	14112	24	8128512	0.17955	307.69	76.92
7	14112	21	6223392	0.13747	235.57	58.89
6	14112	18	4572288	0.10100	173.07	43.26
5	14112	15	3175200	0.07014	120.19	30.04
4	14112	12	2032128	0.04489	76.92	19.23
3	14112	9	1143072	0.02525	43.26	10.81
2	14112	6	508032	0.01122	19.23	4.80
1	14112	3	127008	0.00280	4.80	1.20
		Σ=	45269280	1	1713.6	

TABLE 9.1. Lateral Load Distribution with Height by the Equivalent Lateral Force (ELF) Procedure

W 1 = W 2 = W 3 = W 4 = W 5 = W 6 = W 7 = W 8 =W9=1008×(12+0.5×4)

=14,112KN

Roof: *W10* = 1008×10= 10,080 kN (Clause7.3.1, Table 8 of IS: 1893 Part 1)

Total Seismic weight of the structure,

W = Σ*Wi* = 9×14,112 + 10,080= 1,37,088 kN

Fundamental Period:

Lateral load resistance is provided by moment resisting frames infilled with steel panels. Hence, approximate fundamental natural period: Ta=0.085 $h^{0.75}$ (Clause 7.6.2. of IS: 1893 Part 1)

Ta=0.085*$30^{0.75}$=1.089 sec.

The building is located on Type II (medium soil). From Fig. 2 of IS: 1893, for T=1.089 sec, Sa/*g*=1.25

A_h= =0.10*1.0*1.25/2*5 =0.0125

Design Base Shear

$V_B=A_h$*Ws

= 0.0125*1,37,088

= 1713.6KN

9.2.3. Force Distribution with Building Height:

The design base shear is to be distributed with height as per clause 7.7.1. Table 1.1 gives the calculations. Fig. 1.2(a) shows the design seismic force in X-direction for the entire building.

Level	W_i	h_i	$w_ih_i^2$*1000	$w_ih_i^2/Ew_ih_i^2$	V_b* $w_ih_i^2/\sum w_ih_i^2$	V_b* $w_ih_i^2/\sum w_ih_i^2/4$
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TABLE 9.2. weight of each floor

Floor No.	weight of beams(kg)	weight of columns(kg)	total weight(kg)
Roof(Floor-10)	280.53	76	356.53
9	433.15	111.14	544.29
8	450.47	135.62	586.09
7	446.93	164.94	611.87
6	420.64	204.63	625.27
5	435.21	195.4	630.61
4	378.83	254.97	633.8
3	407.01	270.66	677.67
2	484.73	285.34	770.07
1	438.37	288.68	727.05

Fig:9.1 Total weight vs No of floors

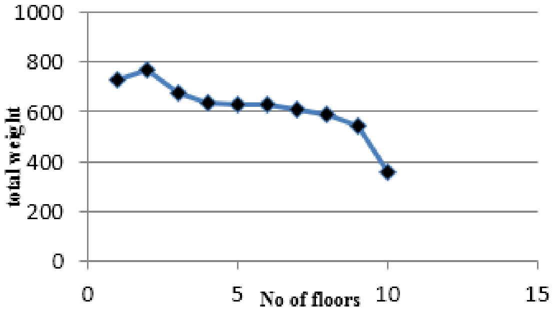
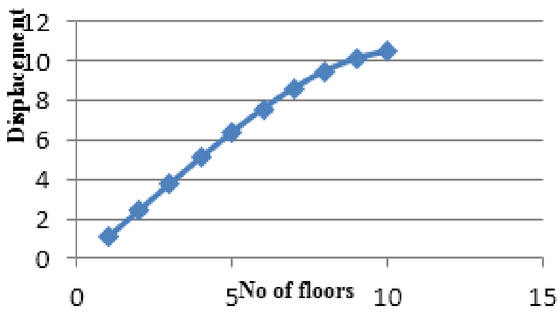


Fig:9.2 Displacement vs No of floors



10. CONCLUSION

It has been concluded that the Displacement is directly proportional to No of Floors and the Total weight is inversely proportional to No of Floors.

Seismic design provisions for architectural, mechanical and electrical components in the building. These are integral part of a building, and damage to these may constitute a significant loss.

Seismic design provisions for different types of foundations for buildings. Foundations are indeed very important component of the building and need to be protected during strong ground shaking. Foundations require additional conservatism in design as compared to that for the superstructure because (i) the foundations support the entire superstructure and hence loss of foundation support can be disastrous and (ii) the damage to foundation will be difficult to inspect or 8.1991 uniform 8. 8. UBC building code, International conference of building officiers, whitier, California,1991 repair after the earthquake events.

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