INELASTIC SEISMIC ANALYSIS OF RC FRAMED STRUCTURE

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Abstract - Earthquake engineering is a vast branch and varieties of method are used to carryout the calculation depending upon either external action of structure or behavior of structure/structural materials. The most common static and dynamic procedures include Linear Static Analysis, Non-Linear Static Analysis, Linear Dynamic Analysis, Non-Linear Dynamic Analysis. Non linear static analysis is also known as Pushover Analysis. For existing structure, it is used to evaluate the strength and drift capacity

This analysis includes mathematical model by non-linear load deformation of individual members and element of multi-storey (G+10 in this case) subjected to increasing lateral loads representing inertia forced in an earthquake until a 'Target Displacement' is exceeded.

Key Words: Flat slab, High-rise building, Seismic analysis, Symmetrical building, Stresses, Seismic Forces, Moments

1. INTRODUCTION

How to make a building seismic resistant? Buildings can become resistant to seismic waves by designing the building stronger and more flexible.

One of the popular techniques which is widely used in medium rise structure is to make moment resistant frame. In special moment resistant frames, beams are rigidly fixed with column in whole structure. If a force tries to bend the beam then column will also come in picture and both frame sections will resist the force simultaneously, thus making the building stable.

Braced framed structural system can also be used which consist of diagonal steel sections primarily designed to resist wind and earthquake forces. Eccentric type of bracing is commonly used in seismic regions.

RC shear walls which is a vertical element of horizontal force resisting system is generally used in high rise building where seismic and wind forces are high. Mechanical dampers are used to dissipate kinetic energy of seismic waves penetrating into the building for skyscrapers and tall building.

Base isolation can be done using rubber bearings which are made from layers of rubbers with thin steel plates between them and thick steel plate on top and bottom.

What are the methods of performing seismic analysis?

There are generally two methods of seismic analysis i.e.,

- Linear/non-Linear Static and
- Linear/non-Linear Dynamic Analysis

The equivalent static analysis is a simplified technique to substitute the effect of dynamic loading of an earthquake by a static force distributed laterally on a structure for design purpose. Assumptions for equivalent static analysis are as follows-

Designed building is assumed to be rigidly constructed.

Fixity between the sub-structure(foundation) andsuper-structure is assumed to be perfect.

Dominant effect of earthquake is equivalent to horizontal force of varying magnitude over the height.

The building responds in fundamental mode with single degree of freedom.

The building is perfectly symmetric to avoid torsional movements over ground motion in-order to avoid twisting moments.

1.1 METHODOLOGY

A grid is a structure made up of a series of intersecting straight lines used to structure content. The grid serves as a framework on which graphic elements can be organized in a rational manner. Number of grid lines used in x and y directions is 4. Spacing between the grids in both x and y directions is 4m. All the grids are uniformly spaced. Spacing between the grid is an important aspect from the frame of reference ofcolumn placement.

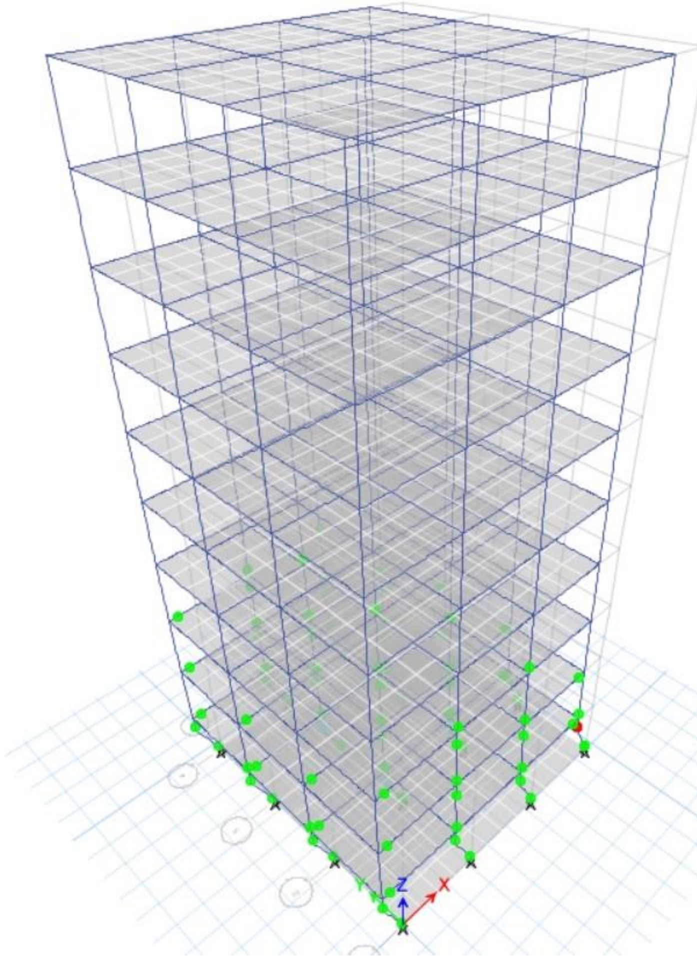
Spacing between 2 immediate column should not be more than 4.5 m. Hence our structure is safe.The height of building is 30m. There are 10 number of stories in building. Each story height is taken as 3m (almost 10 ft). The base story height is 3m. The major advantage of taking tall building is that they are economical in a profit of using less land for construction. Also, there are 3 number of bays in both x and y directions.

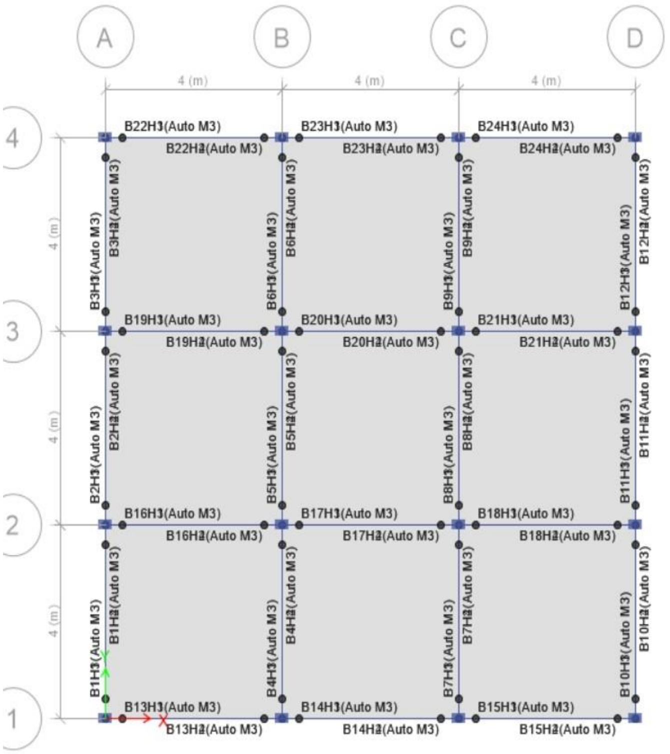
Materials used :

Different types of material are used in construction of G+10 story building. For concrete, M30 grade of concrete is used as per Indian standards. Isotropic type of directional symmetry concrete is used. Isotropic materials are the substance having uniform mechanical and thermal properties in all 3 directions. Weight per unit volume of concrete is 24.9926 kN/m3.Mass per unit volume of concrete is 2548.538 kg/m3. Modulus of elasticity E of concrete is 27386.13 MPa and poisson's ratio U is taken to be 0.2. Coefficient of thermal expansion is 0.0000055C-1. Shear modulus G of concrete is 11410.89 MPa. For M30 grade concretestrain at unconfined compressive strength is 0.0021.

1.2 Objective

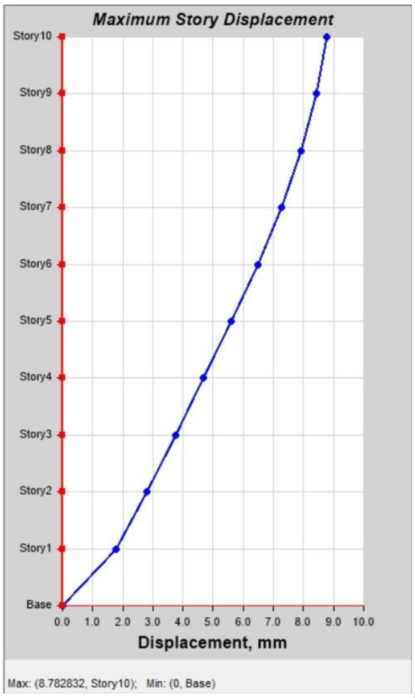
- To analyze irregularities in structures evaluate and design of G+10 storied structure as per code provision.
- Investigate the structures in E-tabs software to carry out the story deflection, story drift, story shear force and base shear of regular and irregular structures using response spectrum analysis and equivalence the results of different methods.
- Time history analysis subjected to transitional frequency ground motion for the response of systematic structures and comparison with response spectrum analysis.





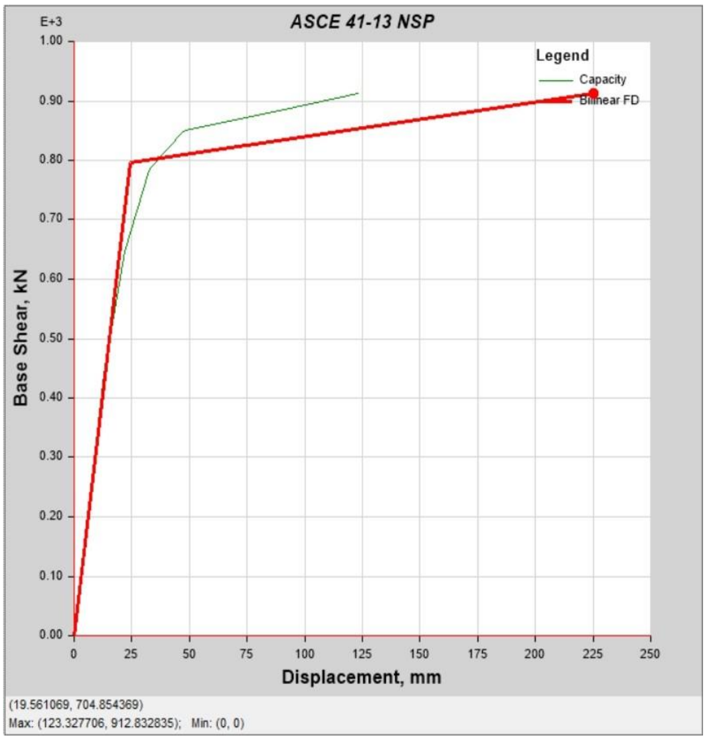
2. RESULT-

2.1 Equivalent Static Method -

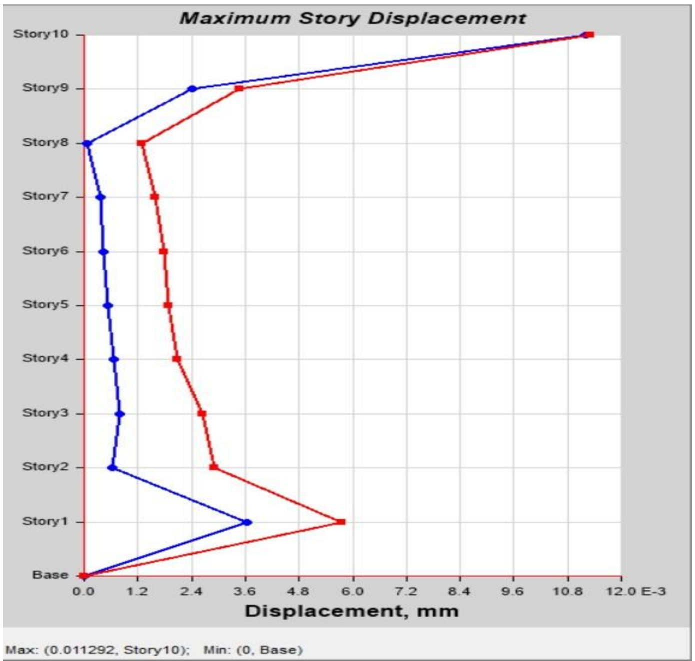


Maximum Displacement is 8.78 mm at 10th story for seismic type of loading and minimum displacement of 0 mm at base story.

2.2 Pushover Analysis-

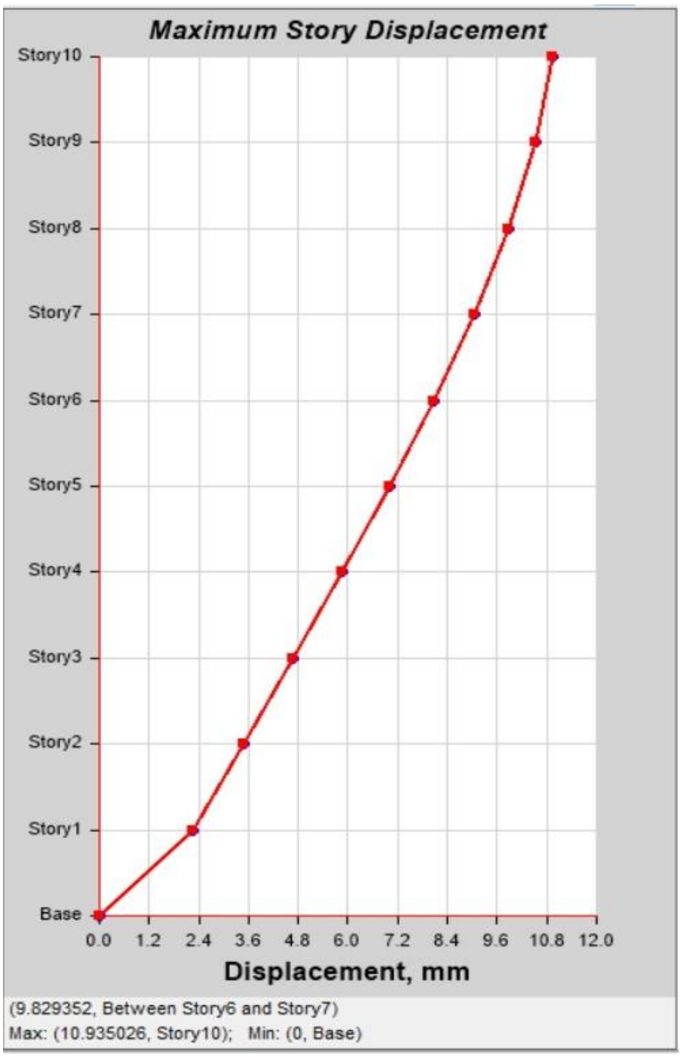


Above graph clearly show that maximum Base Shear of 912.83 kN at 123.23 mm displacement.



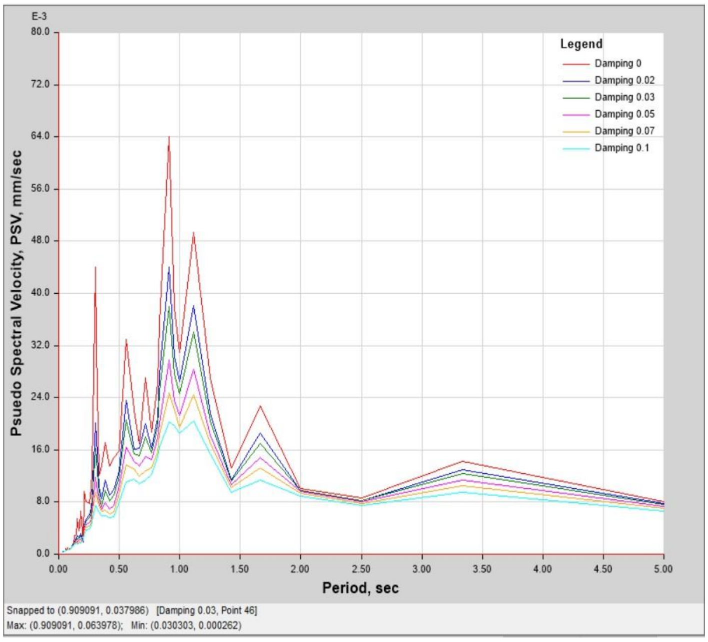
Maximum Story Displacement of 11.292 mm at 10th story can be seen clearly and minimum displacement of 0 at thebase.

2.3- Response Spectrum Analysis-

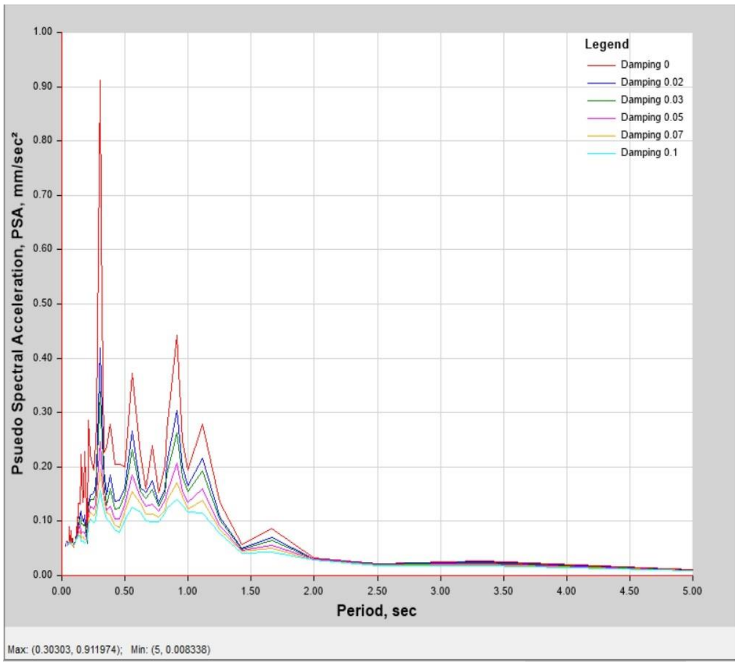


Maximum value of Displacement can be observed at top story with value of 10.93 mm.

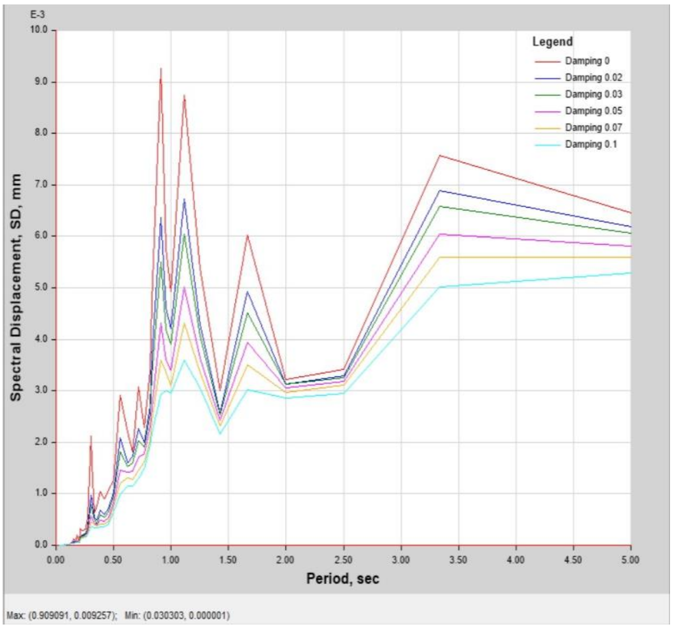
2.4- Time History Analysis-



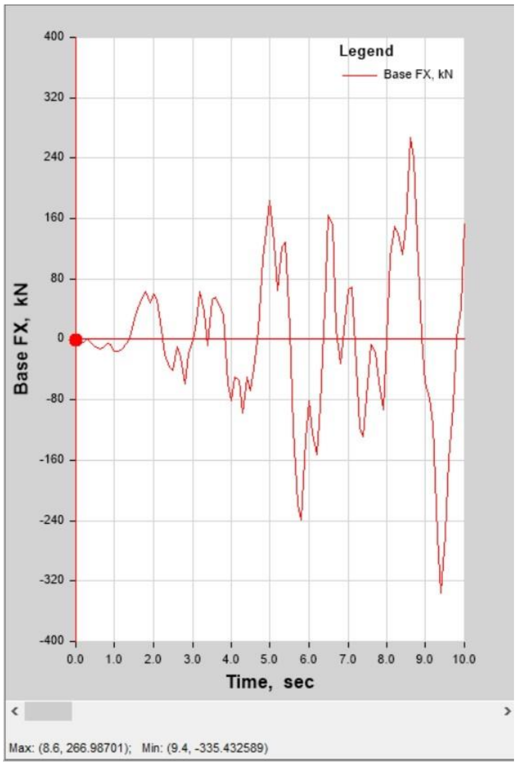
Maximum value of Pseudo Spectral Velocity is 29.836 $mmsec^{-1}$ at 0.909 second.



Maximum Pseudo Spectral Acceleration for 5% damping works out to be 245.69 $mmsec^{-2}$ at 0.303 seconds.



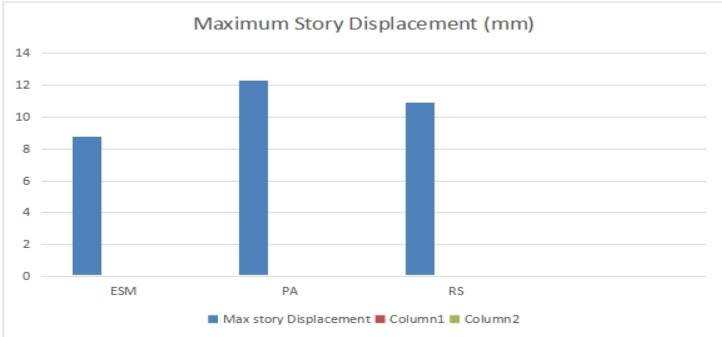
For 5% damping, Maximum Spectral Displacement of 6 mm is observed at 3.33 second.



Maximum value of base shear is 266.98 or 267 kN at 8.6 second while minimum value of Base Shear is -335.43 kNat 9.4 second.

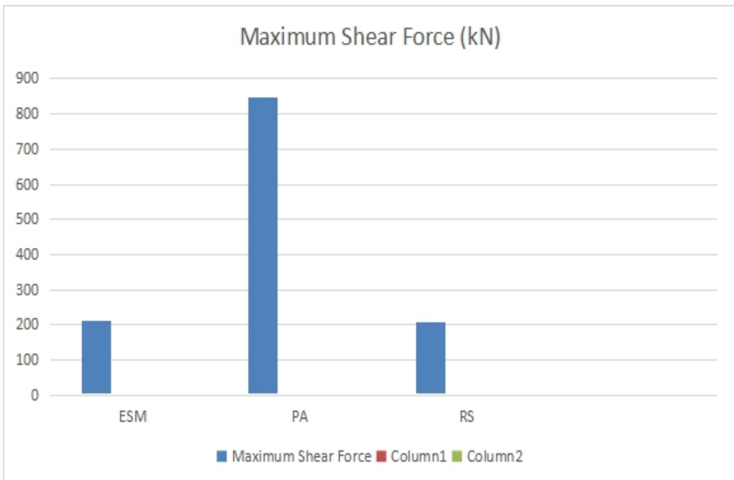
3. CONCLUSIONS

3.1- Maximum Story Displacement-



1. It can be clearly observed from the above graph that increment of **28.73%** of maximum story displacement takes place from equivalent static method to pushover analysis with a difference of **3.54 mm.**
2. When moving from pushover analysis to response spectrum analysis, there is a sudden decrease of maximum displacement of **10.84%** with a small difference of **1.42 mm.** This variation could be due to change from static to dynamic approach of analysis.
3. Similarly, for a response spectrum analysis to equivalent static method, there is a decrement of **19.67%** with a difference of **2.15 mm.** The reasoncan be due to change from non-linear approach to linear approach of analysis.

3.2- Maximum Shear Force-



1. Maximum Shear Force for equivalent static method of analysis to pushover analysis increases about **75.02%** with a difference of **635.04 kN.** This drastic change could be due to change in linearity to non-linearity method of analysis. This is majorly due to change in linearity of the methodfrom linear to non-linear. The graph for pushover analysis is plot for base shear Vs maximum displacement and hinges are developed as a resultof analysis which shows the most critical element at failure. PA is the most advanced approach and hence result are expected to be unbelievable but are true at the same time.
2. Maximum Shear Force for Pushover Analysis to response spectrum analysis decreases around **75.60%** and difference of **639.93 kN.** This large difference could be due to change from static approach to dynamic approach of analysis.
3. Maximum Shear Force for Response Spectrum to Equivalent static method increases **2.30%** with asmall difference of **4.87 kN.** This could be due to change from dynamic analysis to static analysis method.

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I.S. Code	Title
456:2000	Code of practice for plainand reinforced concrete (fourthrevision)
800:1984	Code of practice for general construction in steel (second revision)
875	Code of practice for designloads (other than earthquake)for buildings and structures:
(Part 1) 1987	Dead loads — Unit weightsof building material andstored materials (second revision)
(Part 2) 1987	Imposed loads (secondrevision)
(Part 3) 1987	Wind loads (secondrevision)
(Part 4) 1987	Snow loads (secondrevision)
(Part 5) 1987	Special loads and load combinations (second revision)
1498:1970	Classification and identification of soils for general engineering purposes (first revision)
13935:1993	Repair and seismic strengthening of buildings