4.1 Preamble

This chapter contains the scope of present work, objectives defined based on the identification of the gap in existing research, the hypothesis of thesis and overall design methodology.

4.2 Scope of Work

With certain base isolators going back to the early 1900s, base isolation systems for major framework have been around for a very long time. Base isolation bearings are mounted between the framework and the foundation of an isolated construction. While permitting some relative transverse motion between the framework and the ground, the isolation bearings provide strong support in the upward direction. Structure reaction to seismic shaking is decreased by the adaptability of the framework and the ground.

A method called base isolation gives the new structure earthquake resistance. The base isolation system offers a particularly rigid vertical component to the base level of the superstructure in connection to the substructure, which decouples the framework from the horizontal ground motion caused by earthquakes. It modifies the basic lateral period (Ta), through damping dissipates energy, and lessens the amount of horizontal forces that are transmitted to the floor acceleration & inter-story drift. The building's structural framework will fluctuate violently in tune with the earthquake frequency. The framework is less likely to collapse if it is possible to change the framework's natural cycle so that it does not coincide with earthquake frequency. This is precisely the job of a base isolator. The base damper makes the structure less rigid, which brings down the fundamental frequency. In such situation, instead of resonating with the vibrations, the top of the framework will respond to them as a hard unit. In other words, the base isolator bends to lessen the effects of surface motion on the superstructure as the building's base shift with the earth.

The seismic isolation approach is an innovative seismic design technique meant to shield the framework from seismic danger, lessen the energy and pressures it is subjected to, and prevent it from directly resisting such forces. If the foundation is firmly connected to the deck, the entire force of a quake will be delivered promptly and without any frequency change to the remaining framework. Shear force is applied to the foundation of buildings by earthquakes, which shake the base of structures laterally. The building will fall down if a force of this magnitude has the same frequency as the inherent frequency of the structure. The key idea underlying base isolation is enabling the base to move slightly to the side in order to extend the structure's fundamental time period. Because of the lengthening of the period, the structure will be less vulnerable to seismic pressures and sustain less structural damage. Among the most successful strategies for preventing structural damage from seismic strikes has been the deployment of base isolation techniques, which has grown popular in last two decades. This is due to the fact that the impacts of an earthquake attack are limited by base isolation, the structure is mainly decoupled from ground motion by a flexible base, and structural response accelerations are often lower than ground acceleration. Because of the base's enhanced flexibility, the structure's natural period has expanded enough to move its frequency outside the range of the dominant earthquake frequency. Additionally, the building's ability to dissipate seismic energy and withstand excessive horizontal displacement.

In summary, it is vital to analyze the best base isolation system capable to operate them efficiently and cost effectively in RCC construction industries.

In the current study the objective is to optimize the base isolation bearing by comparing results for Time period, Base shear, Storey-Drift, Storey-Displacement, Percentage steel reduction and cost economy obtained from G+12 & G+22 Storey RC structure with fixed & isolated system base.

4.3 Objectives of the Study

In this work, optimization of base isolation system is performed for objectives given below:

- Study computer-aided software's functionality “ETABS 2016”.
- Preparation of building drawing in AutoCAD.
- Model generation in computer aided software “ETABS 2016”.

- Evaluation and creation of G+12 & G+22 Storey RC structure with fixed & isolated base.
- Design of base isolation bearing.
- Evaluation of results obtained from G+12 & G+22 Storey RC structure with fixed & isolated base for Time period, Base shear, Storey-Drift, Storey-Displacement, Percentage steel reduction and cost economy.

4.4 Hypothesis

In the current study, we shall try to maintain the following:

- Comparison of the time periods between fixed and isolated base structure.
- Comparison of Base shear between structure with fixed & isolated base structure.
- Comparison of Storey-Displacement between structure with fixed & isolated base structure.
- Comparison of Storey-Drift between structure with fixed & isolated base structure.
- Comparison of Percentage steel reduction between structure with fixed & isolated base structure.
- Comparison of cost economy between structure with fixed & isolated base structure.

4.5 Sample Model

This study aims at comparison of structure with fixed base & isolated base for both short and long period of earthquake excitation for Indian subcontinent.

The structure of G+12 & G+22 Storey Reinforced Concrete structure with fixed base & isolated base is considered for study and results carried out is to be differentiate like Time period, Base shear, Storey-Drift, Storey-Displacement, Percentage steel reduction and cost economy.

4.5.1 G+12 Storey Model Details:

Properties

➢ X-direction	=	4000 mm (7-bay)
➢ Y-direction	=	4000 mm (7-bay)
➢ Beam	=	230 x 450 mm
➢ Column	=	450 x 450 mm (Base)
	=	375 x 375 mm (Plinth to Storey-7)
	=	300 x 300 mm (Storey-8 to Terrace)
➢ Ceiling height	=	3000 mm
➢ Plinth level	=	450 mm from G.L.
➢ Foundation depth	=	2100 mm from G.L.
➢ Wall	=	115 mm
➢ Slab depth	=	125 mm

Load

➢ FF	=	1.5 KN/m^2
➢ LL	=	3 KN/m^2

Earthquake Load

➢ EQ Method	=	Response Spectrum IS 1893:2016
➢ Zone	=	3
➢ Soil	=	Hard Soil (Type-I)

- Damping = 5%
- Model Combination Method = SRSS

Material

- Concrete Grade = M20 [20 N/mm^2]
- Steel Grade = Fe500 [500 N/mm^2]
- Concrete density = 25 KN/m^2
- Bricks masonry density = 20 KN/m^2
- Rebar density = 78.5 KN/m^3
- Design basis : = Limit State

  IS: 456-2000

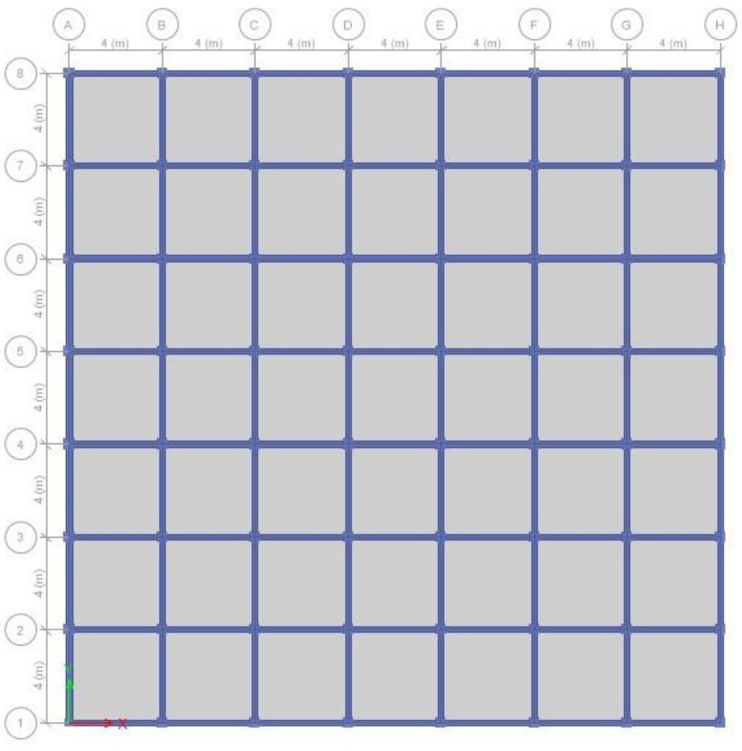


Figure-17. G+12 Storey Sample Model - Plan

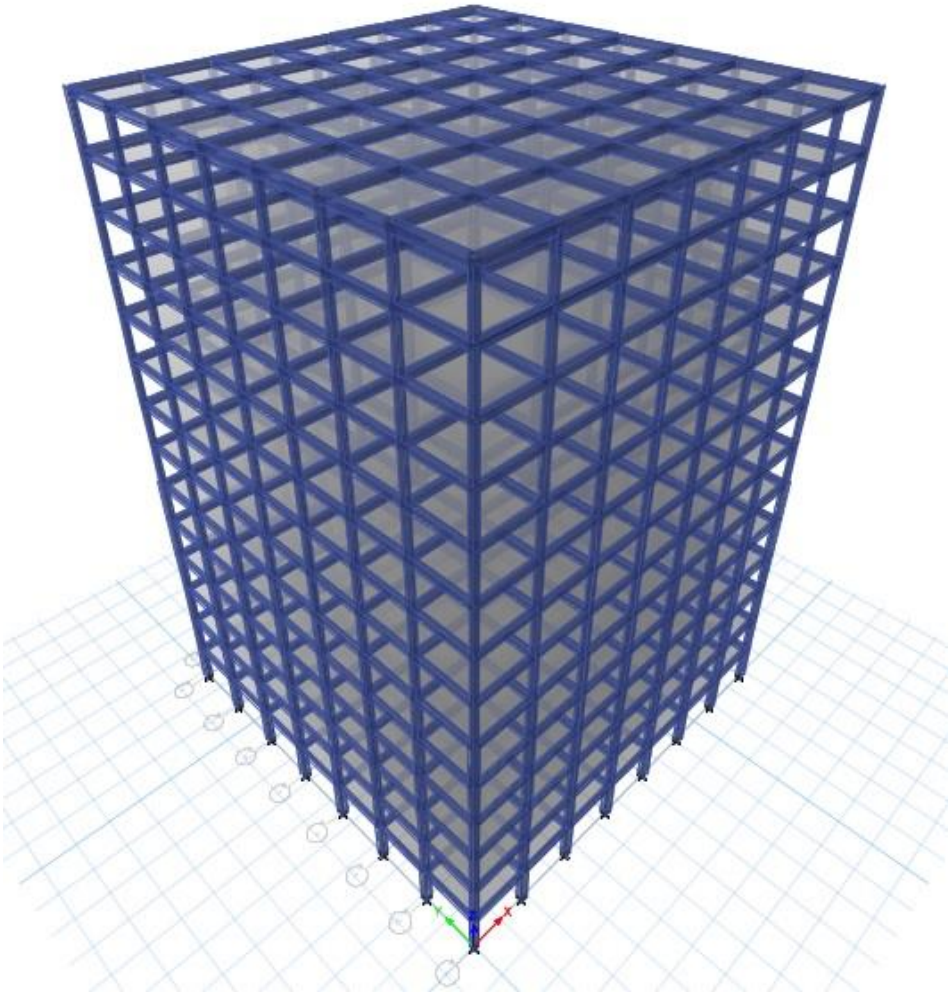


Figure-18. G+12 Storey Sample Model - Elevation

4.5.2 G+22 Storey Model Details:

Properties

- X-direction = 4000 mm (12-bay)
- Y-direction = 4000 mm (12-bay)
- Beam = 230 x 450 mm
- Column = 525 x 525 mm (Base)
  = 450 x 450 mm

		(Plinth to Storey-7)
	=	375 x 375 mm
		(Storey-8 to Storey-16)
	=	300 x 300 mm
		(Storey-16 to Terrace)
➢ Ceiling height	=	3000 mm
➢ Plinth level	=	450 mm from G.L.
➢ Foundation depth	=	2100 mm from G.L.
➢ Wall	=	115 mm
➢ Slab depth	=	125 mm

Load

➢ FF	=	1.5 KN/m^2
➢ LL	=	3 KN/m^2

Earthquake Load

➢ EQ Method	=	Response Spectrum
		IS 1893:2016
➢ Zone	=	3
➢ Soil	=	Hard Soil (Type-I)
➢ Damping	=	5%
➢ Model Combination Method	=	SRSS

Material

➢ Concrete Grade	=	M20 [20 N/mm^2]
➢ Steel Grade	=	Fe500 [500 N/mm^2]
➢ Concrete density	=	25 KN/m^2

➢ Bricks masonry density	=	20 KN/m^2
➢ Rebar density	=	78.5 KN/m^3
➢ Design basis :	=	Limit State
		IS:456-2000

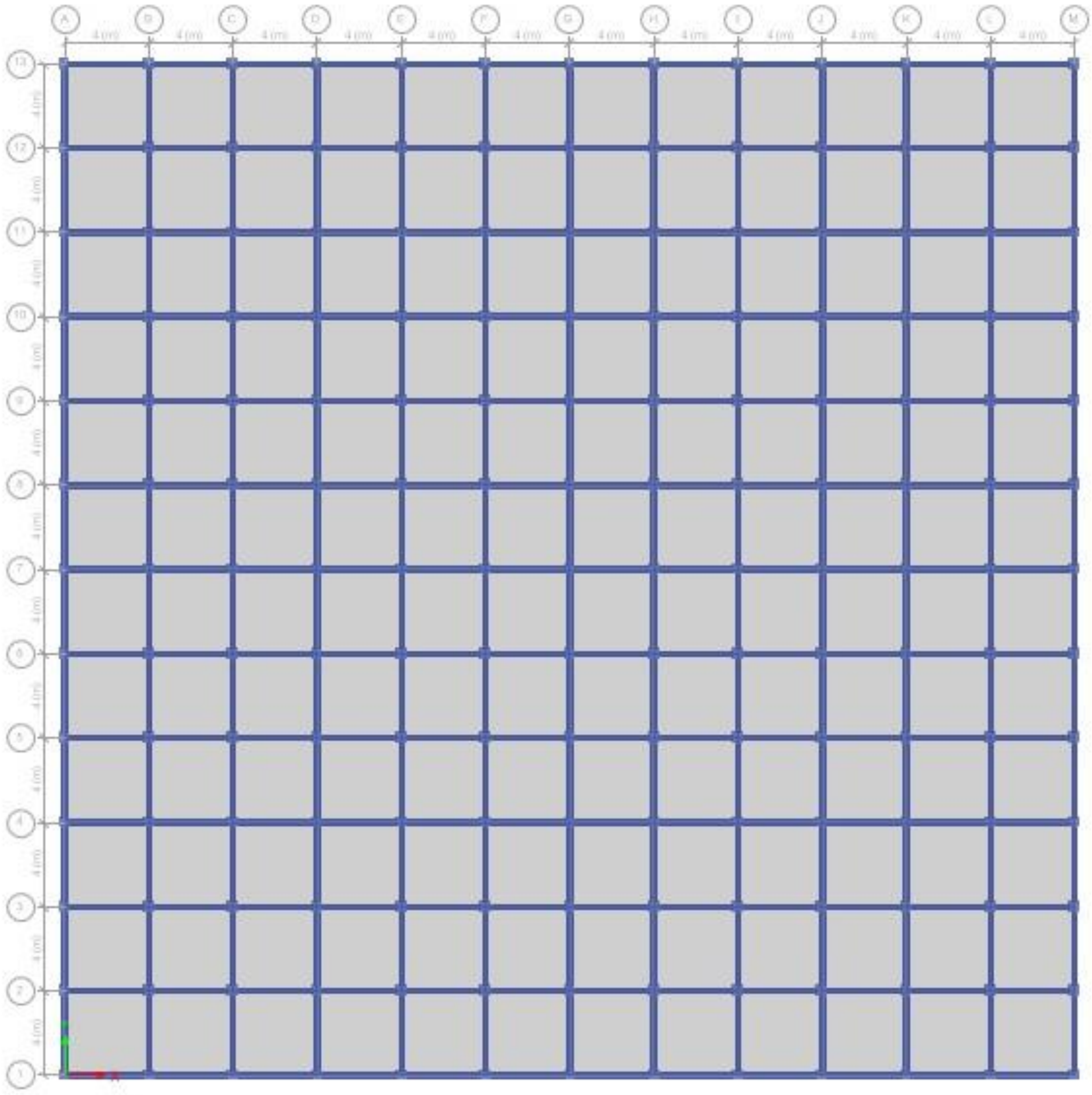


Figure-19. G+22 Storey Sample Model - Plan

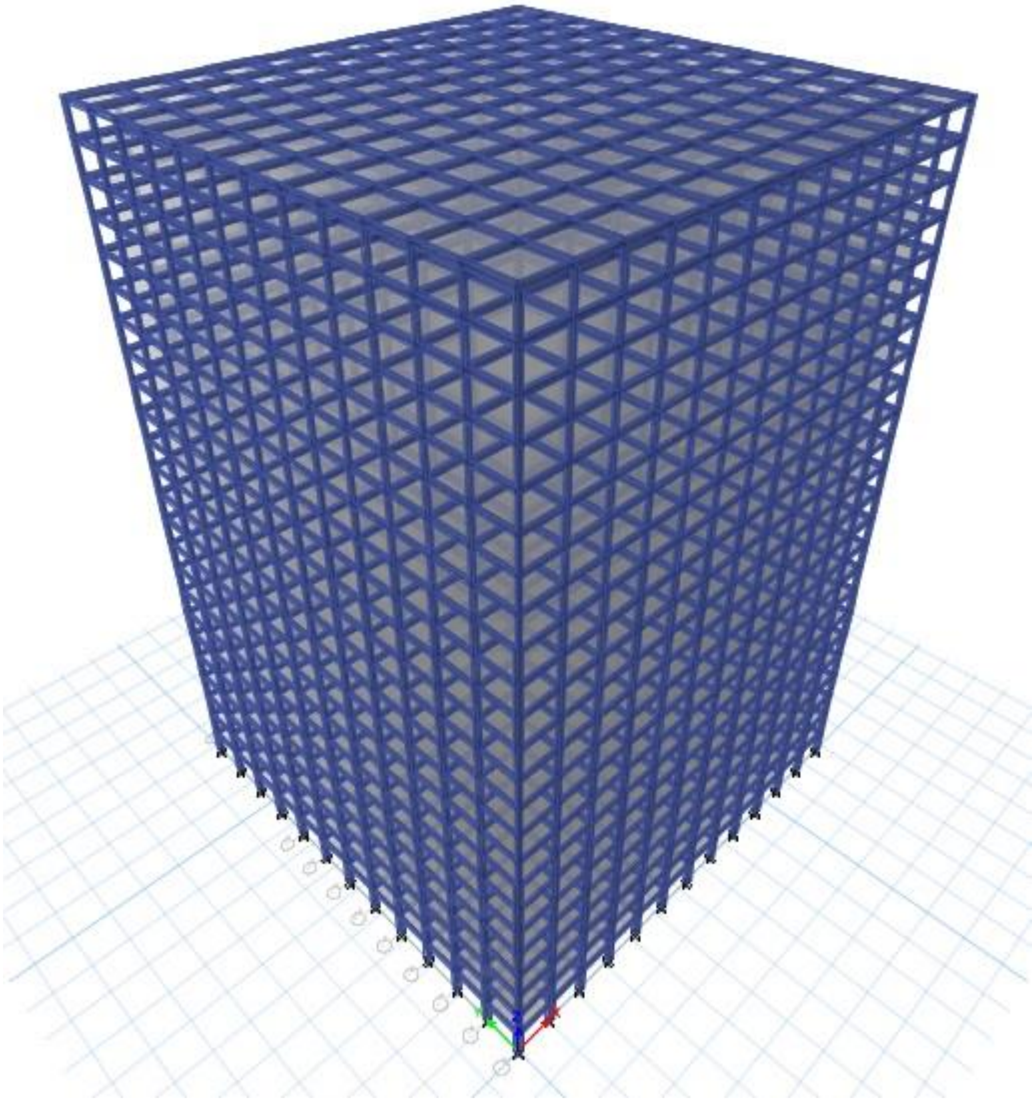


Figure-20. G+22 Storey Sample Model - Elevation

4.6 Sample Model Case

Following cases are considered for analysis and design of structure

4.6.1 Case (a) G+12 Storey Reinforced Concrete (RC) Structure

Case-I: Fixed Base Structure.

Case- II: LRB Base Structure.

Case-III: TFPB Base Structure.

4.6.2 Case (b) G+22 Storey Reinforced Concrete (RC) Structure

Case-IV: Fixed Base Structure.

Case- V: LRB Base Structure.

Case-VI: TFPB Base Structure.

4.7 Important Design Factors

4.7.1 Loads

Throughout its useful life, a building is susceptible to the following loads.

i. Dead Load

The weight of all the walls, wall panels, floors, and roofs, as well as the total weight of the building's different permanent structures, make up the dead loads in a building.

ii. Live Load

Live loads, also known as superimposed loads, are all moving or fluctuating loads brought on by humans or other occupants, including their furniture, temporary storage, machinery, and other items. Every load on floors must be a live load, excluding dead loads. In IS 875: 1987, several live loads acting on the various floors are listed.

iii. Earthquake Load

During a quake, the framework is subject to EQ load. It will affect the structure horizontally. It also goes by the name seismic force.

4.7.2 Analytical Procedures

Plane grid method, Plane frame method, and Space frame method are the three building methodologies that have been utilised to analyse reinforced concrete structures.

The most precise and ideal way of analysis is the space frame method. For human computations, this approach is challenging to use, but it works well for computer-assisted analysis.

The rigidity of pillars is included for analysis in the space frame approach. Beams are created as structural systems with end supports that are fixed. Columns will have axial loads and moments in the directions X and Y included into their design. Additionally, biaxial bending into the footing is required.

4.7.3 Design Philosophies

For the creation of reinforced concrete structures, three design philosophies have been employed namely, the working stress method, the ultimate load approach, and the limit state method. Currently, the IS 456-2000 advises against using the limit state method of design. However, the working stress technique of design has also been kept. Below is a short introduction to the limit state method.

i. Limit State Method (IS 456-2000)

The goal is to achieve an acceptable chance that the structure won't become unusable over its lifetime. Therefore, this approach is founded on the idea that the structure should be able to resist the working load safely throughout its lifetime and also meet the serviceability requirement. The following limit states in the design are looked at:

ii. Limit State of Collapse:

According to the ultimate capacity carrying capacities, it corresponds to failure but does not necessarily entail total collapse. The following limit states are associated with it: flexion, compression, shear, and torsion.

iii. Limit State of Serviceability:

It is consistent with the progression of severe deformation. This condition is equivalent to Defection on Vibration and Cracking.

4.7.4 Building Component Design

The sections below give a quick overview of explanation of the major framework elements, as well as the analysis and design methodology.

i. Slabs

Depending on the aspect ratio, slabs can be either one-way or two-way. When (ly/lx)>2, the aspect ratio. It is intended to be a one-way slab. However, when the aspect ratio is 2, it is created as a two-way slab.

- ❖ One-way slabs are constructed with a beam in mind because they are one metre wide.
- ❖ Based on the border criteria, two-way slabs are further divided into nine categories as stated in IS456:2000.
- ❖ The two-way slabs are constructed using edge strips and central strips, respectively.

ii. Beams

These are the primary flexural members that support the slab. The columns that the beam is supported by transfer the loads to. Beams can have cross-sections that are square, rectangular, or flanged. With regard to the support offered. Beams can be double- or single-reinforced.

iii. Column

They are the vertical skeleton structural elements, and their cross-sectional shapes can be rectangular, square, round, etc. The effective length of the columns and the loads acting on them, which then in turn have an impact on the kind of floor system, the spacing between the columns, the number of stories, etc., determine the dimensions of the section. The column is often designed to withstand axial compression as well as uni- or bi-axial bending moments caused by the frame's movement. Additionally, it is preferable to limit the columns' unsupported length by include the proper tie beams; otherwise, slender columns may have to be created.

iv. Footing

These are the components that are available at ground surface to transfer the column's load to the soil. Flexure, one-way shear, and two-way shear are taken into account when designing the footing. Depending on the soil carrying capacity, a foundation area is provided.

4.8 Design Calculation for R.C.C.

4.8.1 Analysis Method

There are several ways to analyse a multistory building:

i. Approximate Methods

- ❖ Substitute frame method
- ❖ Portal frame method
- ❖ cantilever frame method

ii. Computer Methods

- ❖ Matrix methods
- ❖ Finite Element methods
- ❖ Finite difference methods

Computer-aided software is the most accurate way out of all those mentioned above. Software like STRUDS 2008, STADD PRO V8i, ETABS, and ANSYS, among others, is available on the market for computer-aided structural analysis and design.
The computer aided software "ETABS 2016" analyses the entire project. This software operates in three modes to model, analyse, and design the structure. The ETABS 2016 analytical process is as follows:

a. Modelling

The steps in this technique are as follows:

- ❖ Story and grid system
- ❖ Define & assign material property

- ❖ Define & assign section property
- ❖ Define & assign spring property
- ❖ Define & assign Diaphragms
- ❖ Define Response spectrum functions
- ❖ Define Mass source
- ❖ Define Modal cases
- ❖ Define load pattern
- ❖ Define load cases
- ❖ Define load combination
- ❖ Check warnings

b. Run Analysis

This process consists of the following procedure:

- ❖ Time period
- ❖ Base shear
- ❖ Storey-Displacement
- ❖ Storey-Drift
- ❖ Reactions (Cumulative load)

c. Concrete Frame Design

This process consists of the following procedure:

- ❖ Design parameters preferences
- ❖ Design of section
- ❖ Steel quantity

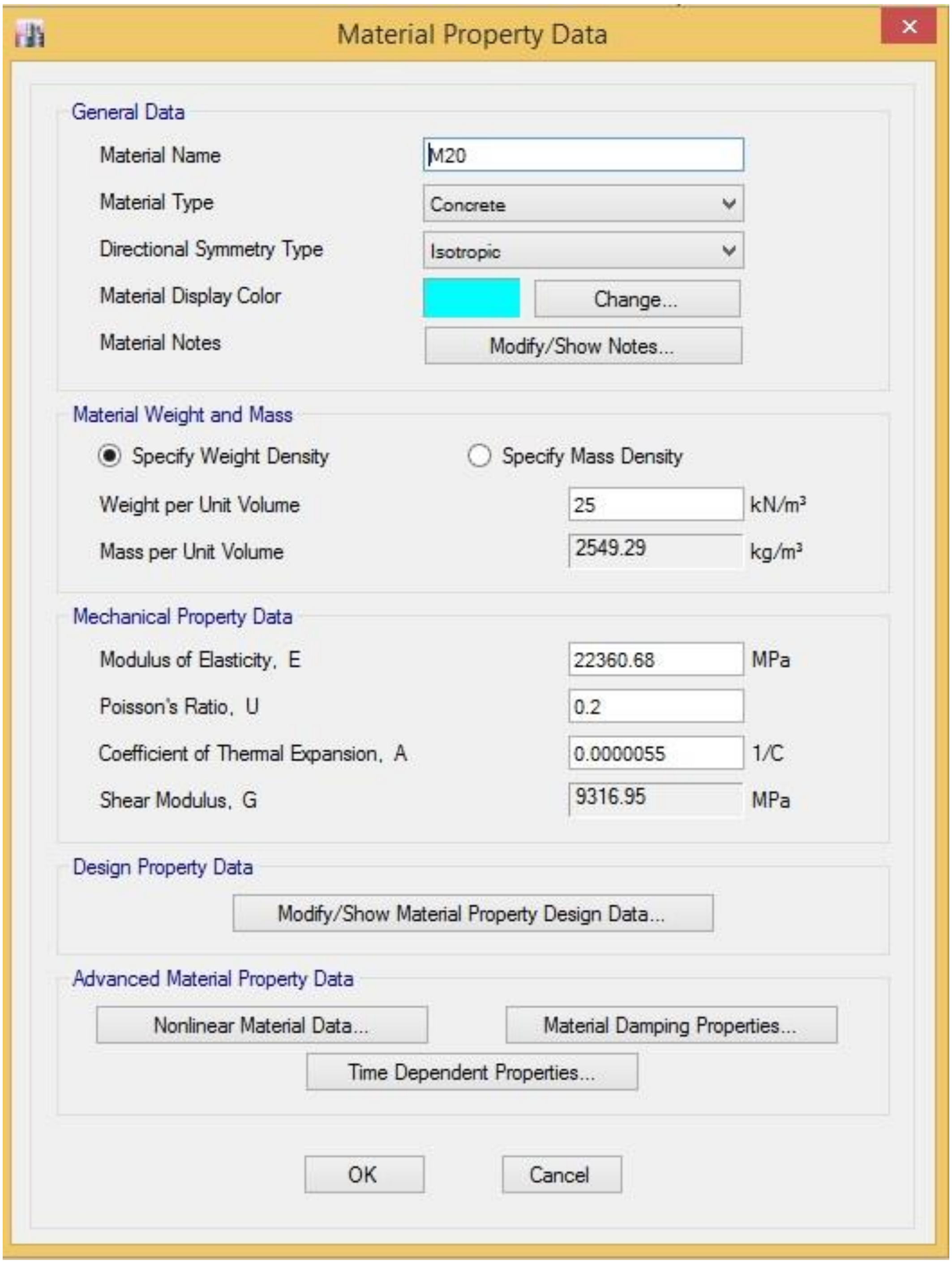


Figure-21. Sample Material Property – Concrete M20

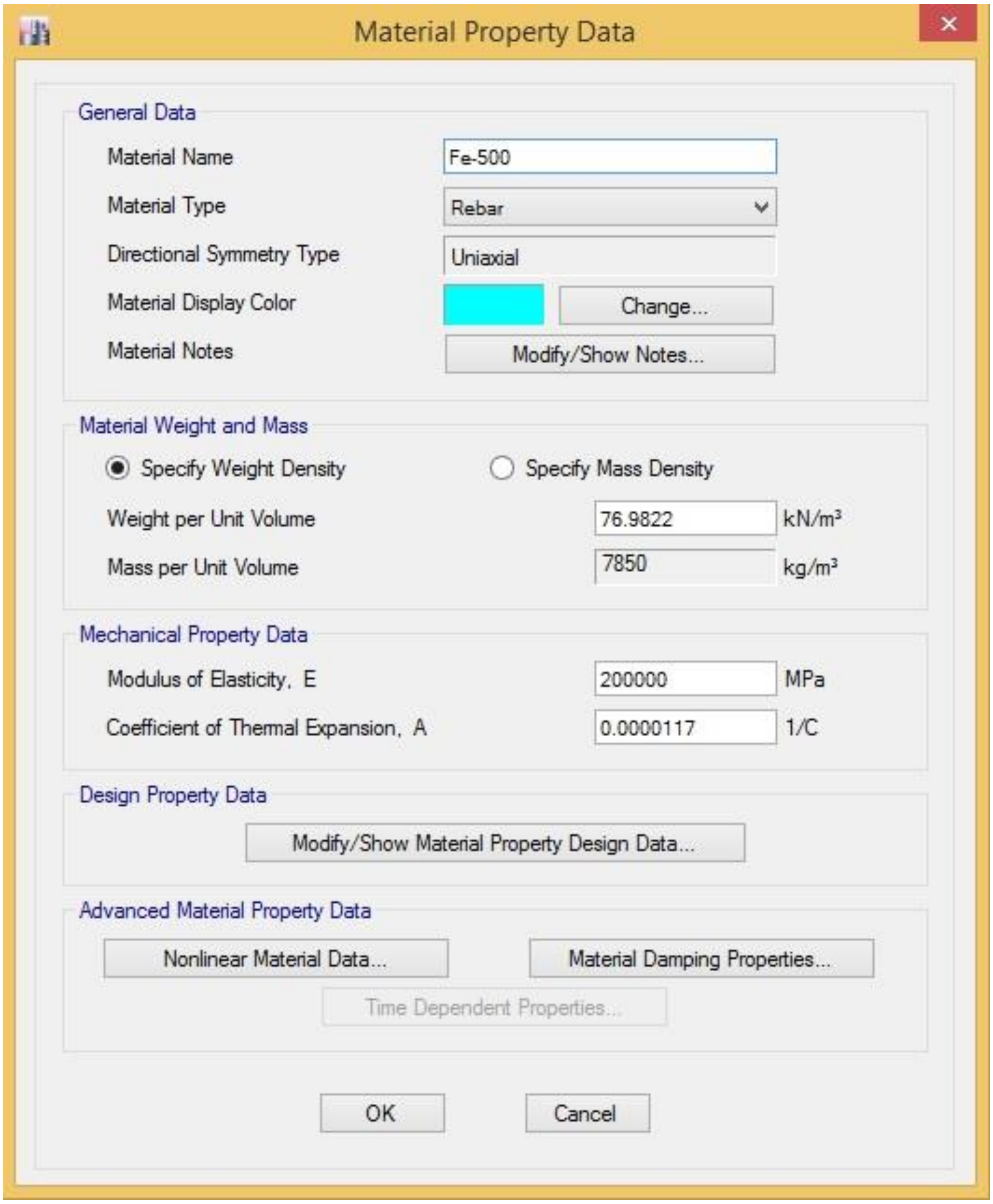


Figure-22. Sample Material Property – Steel Fe500

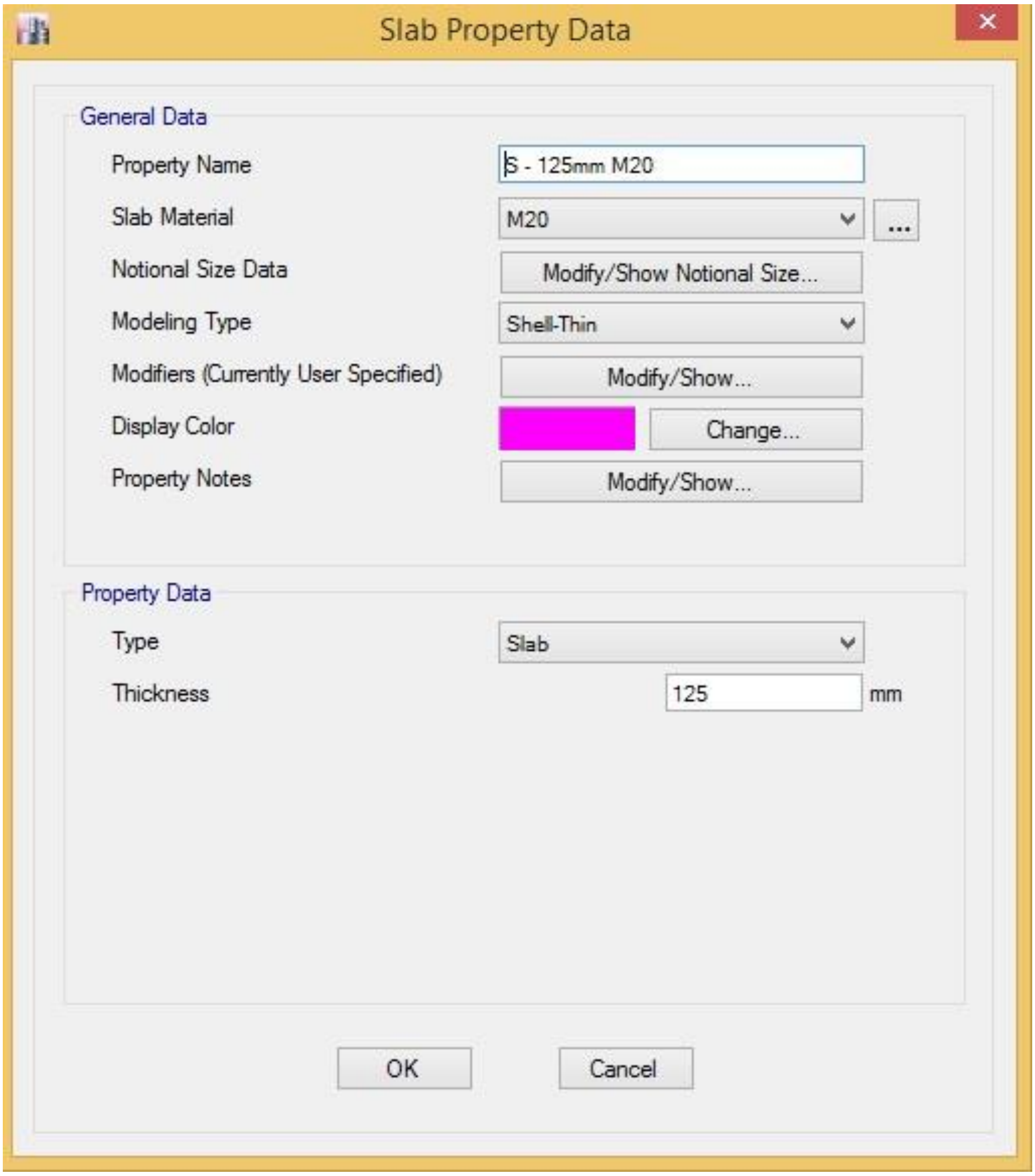


Figure-23. Sample Section Property – Slab

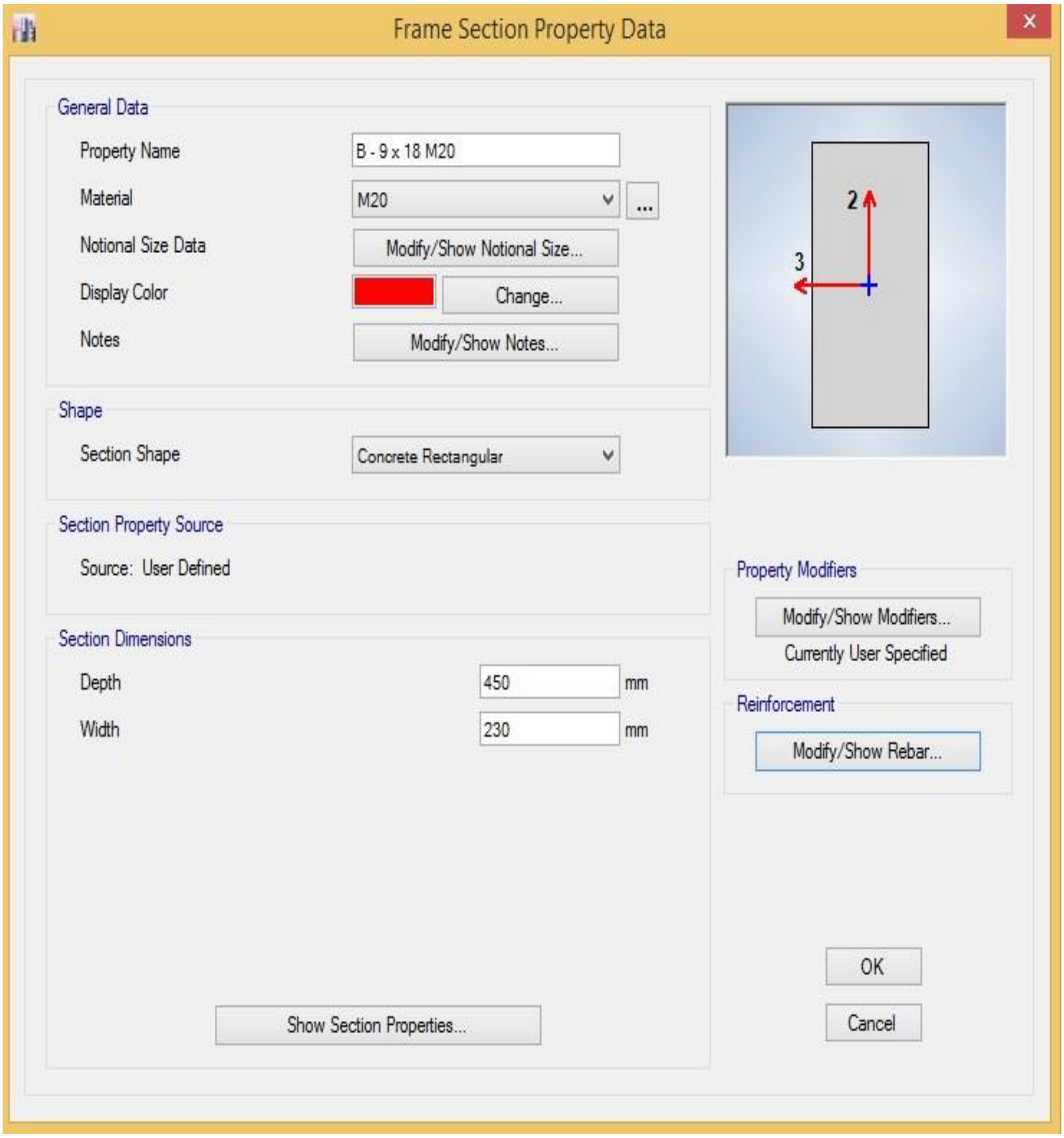


Figure-24. Sample Section Property – Beam

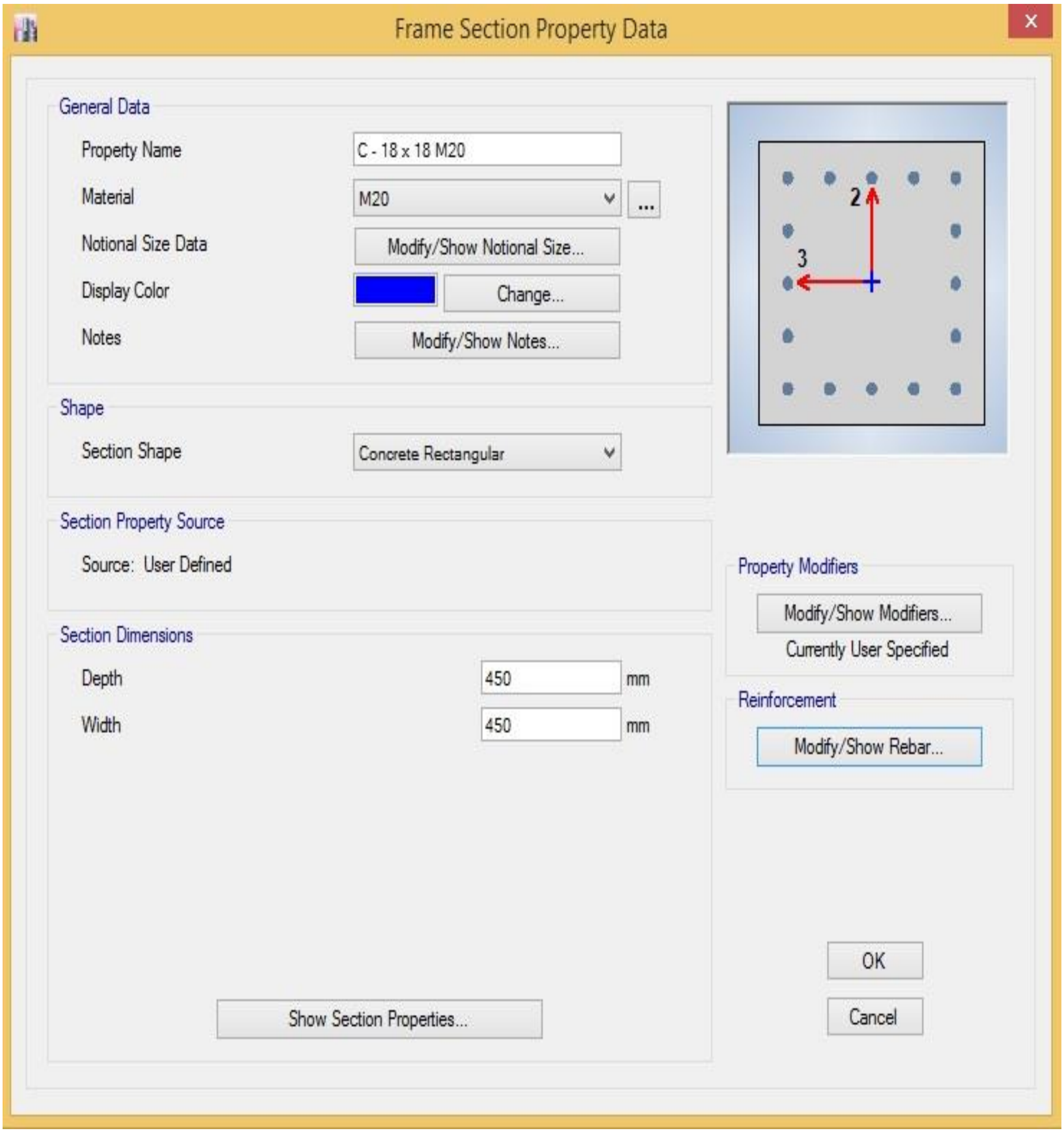


Figure-25. Sample Section Property – Column

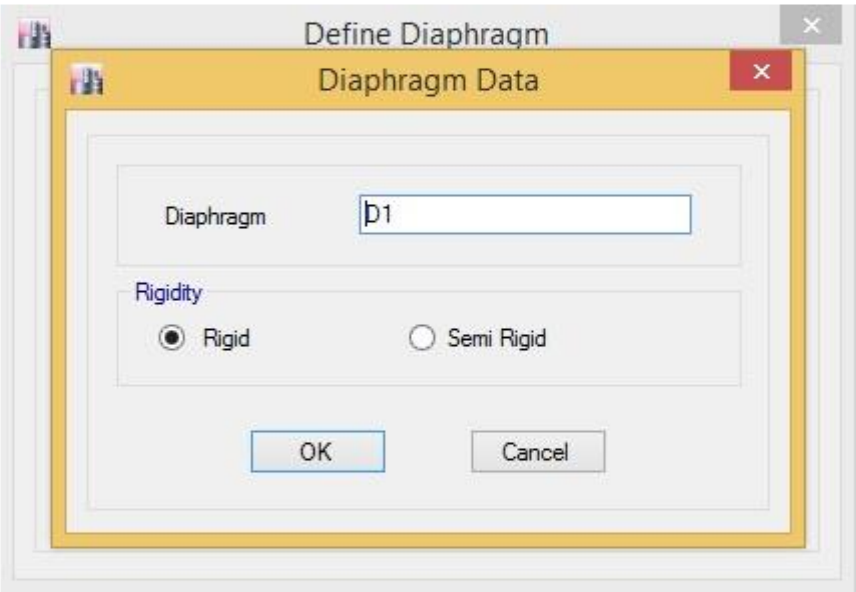


Figure-26. Sample Diaphragm Data

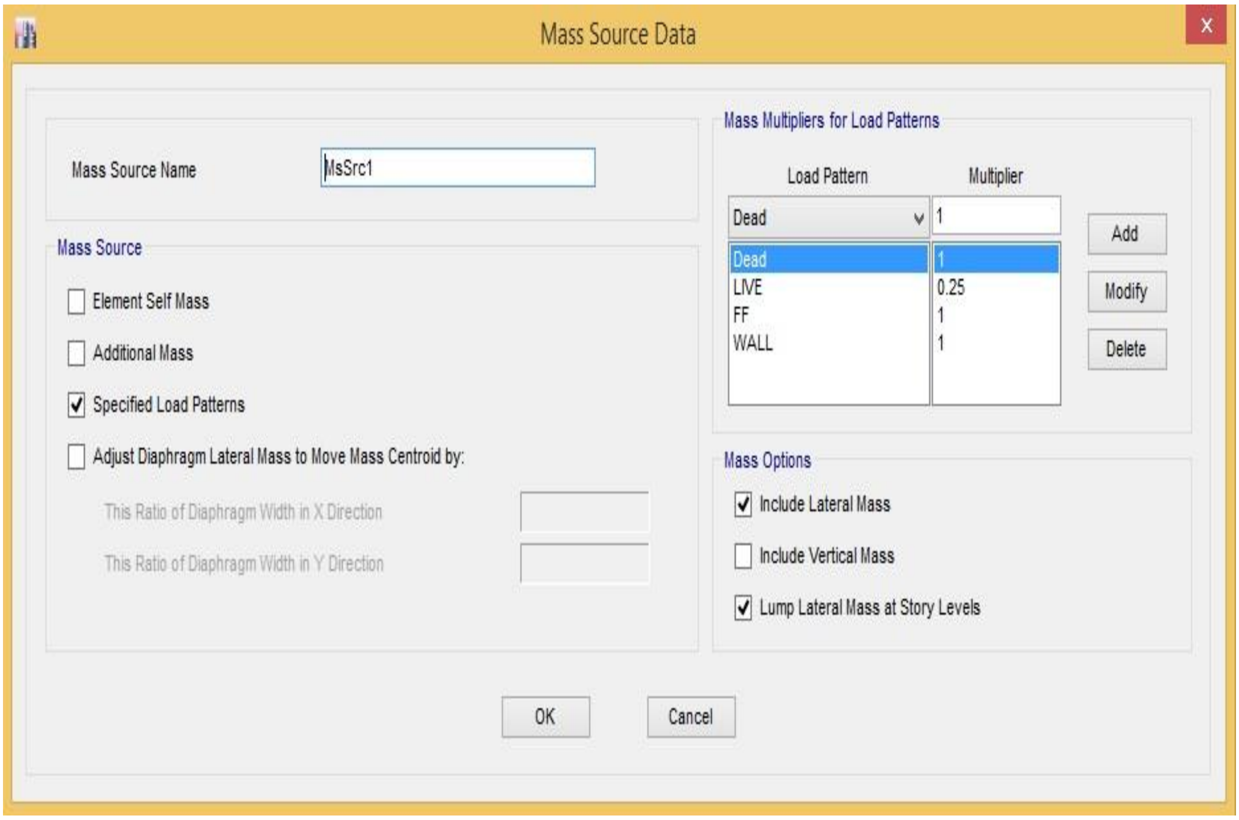


Figure-27. Sample Mass Source Data

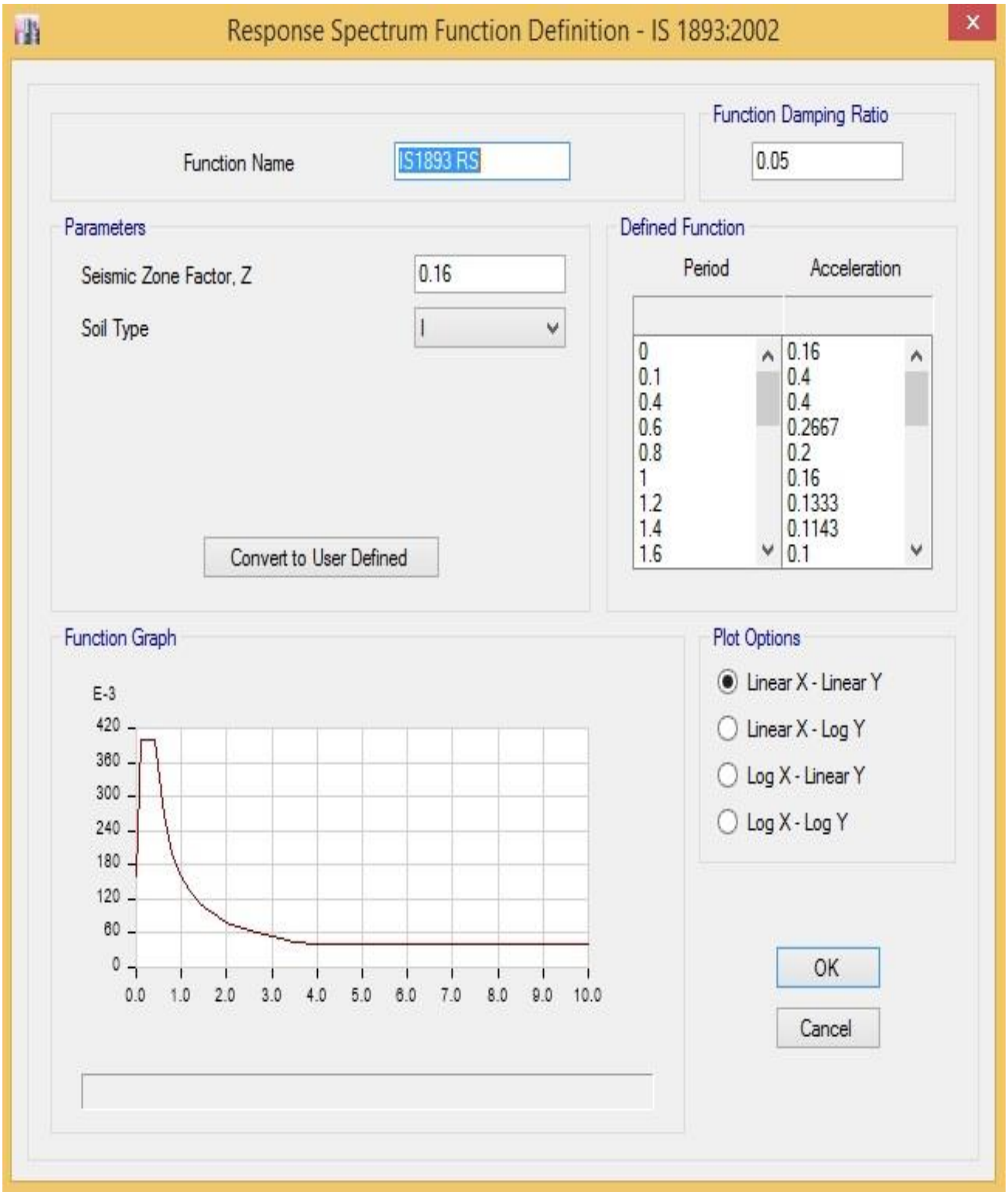


Figure-28. Sample Response Spectrum Function Property

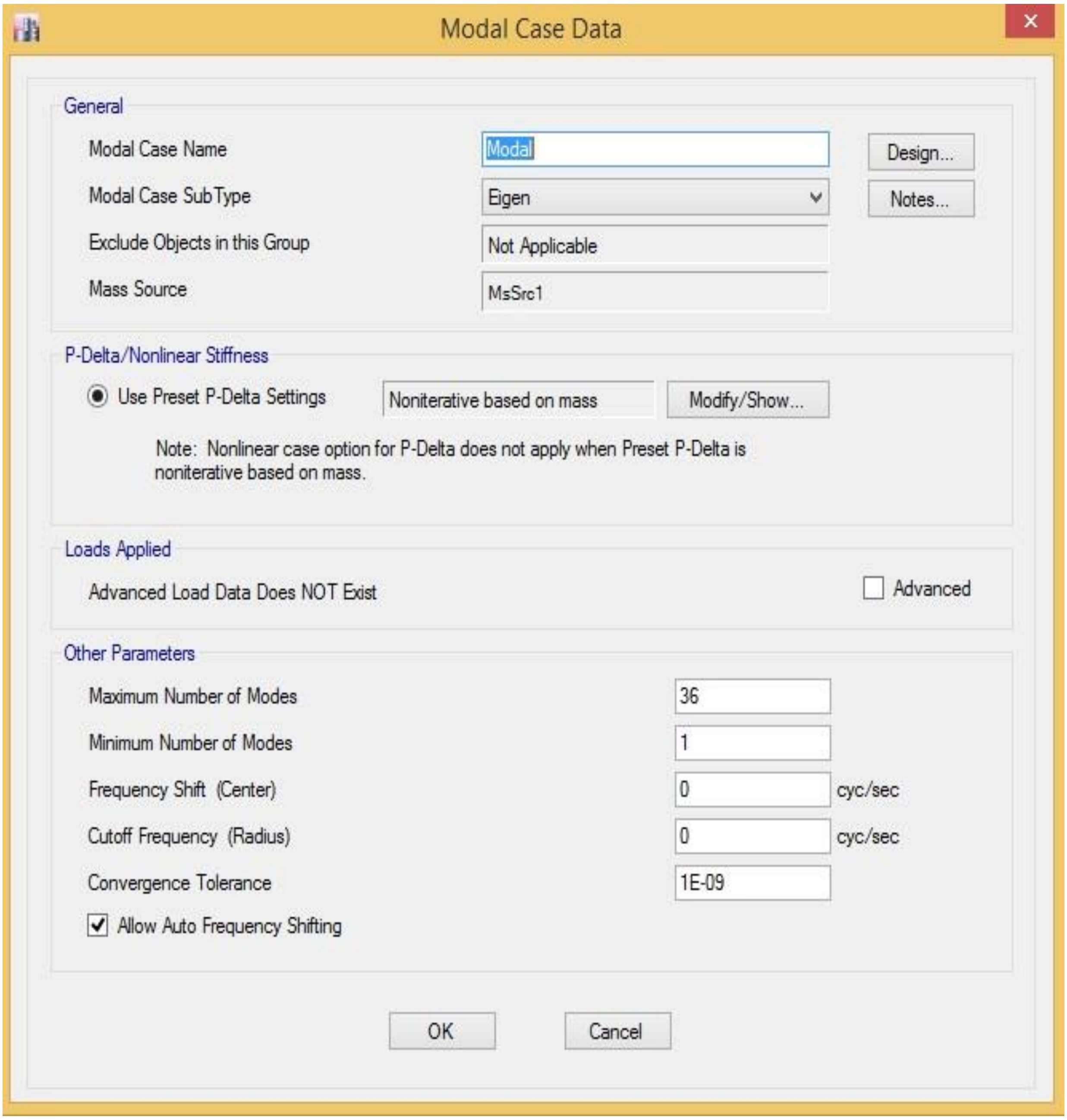


Figure-29. Sample Modal Case

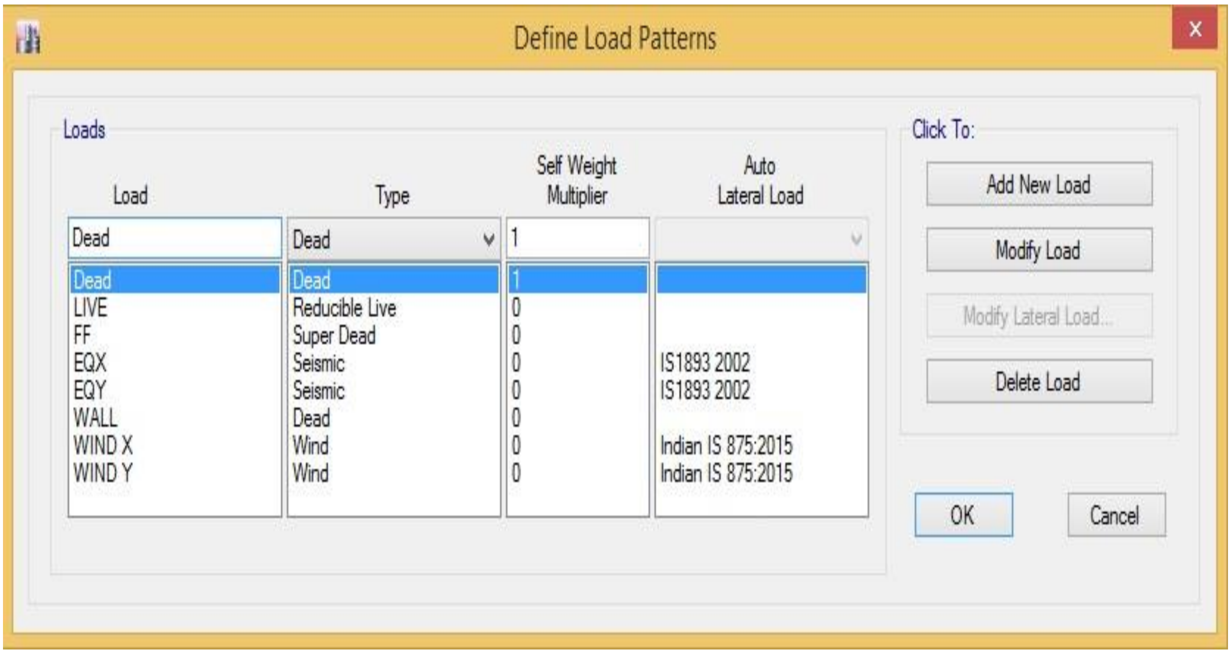


Figure-30. Sample Load Patterns

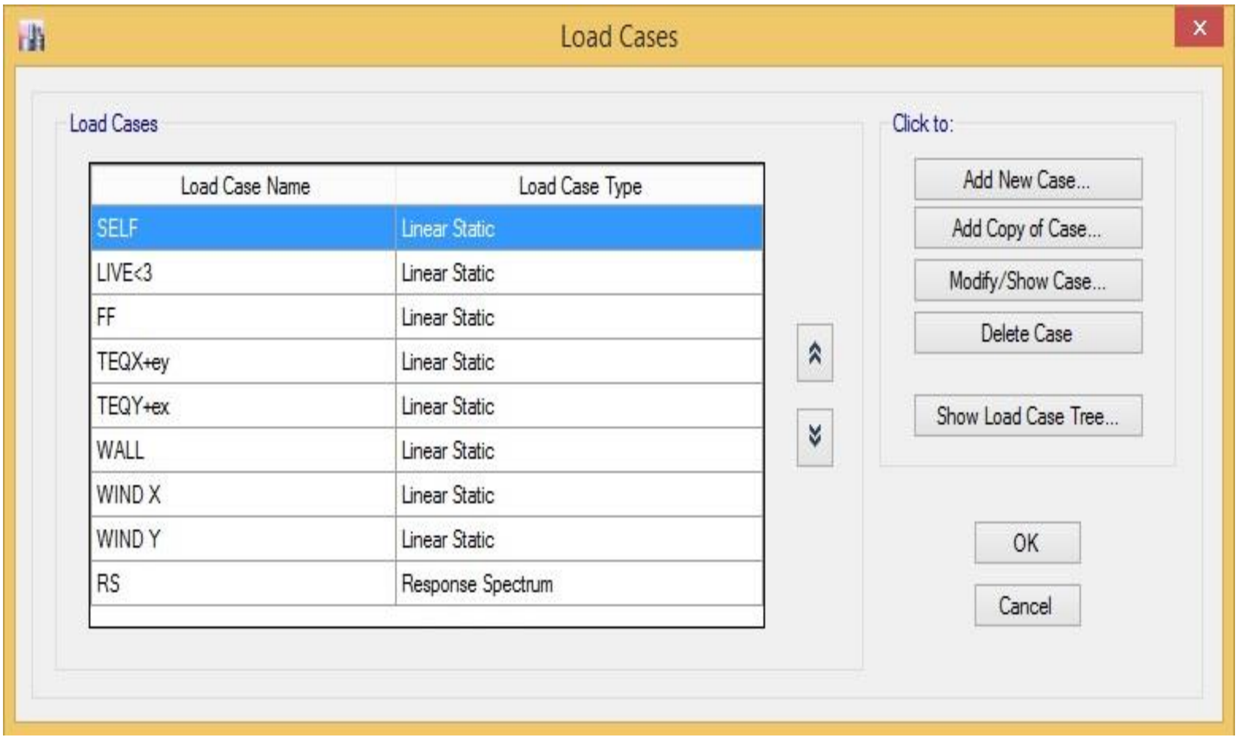


Figure-31. Sample Load Cases

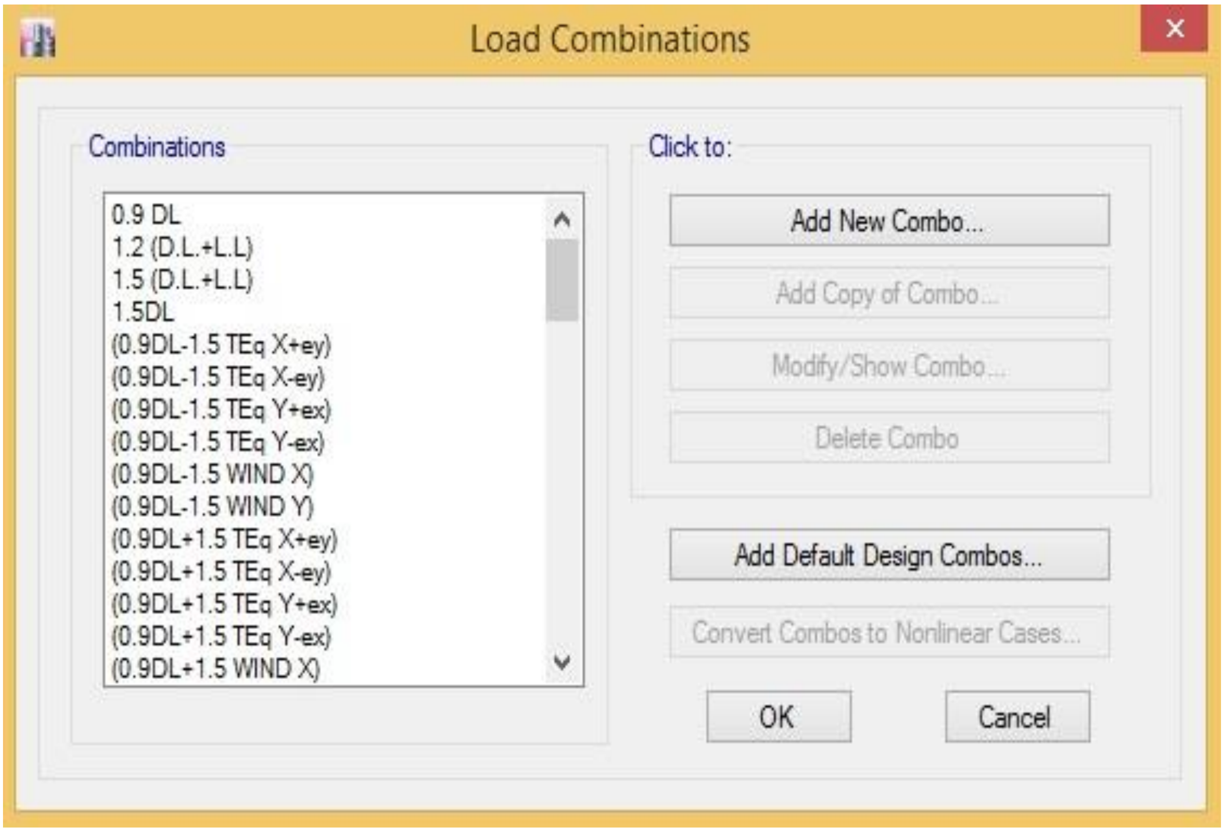
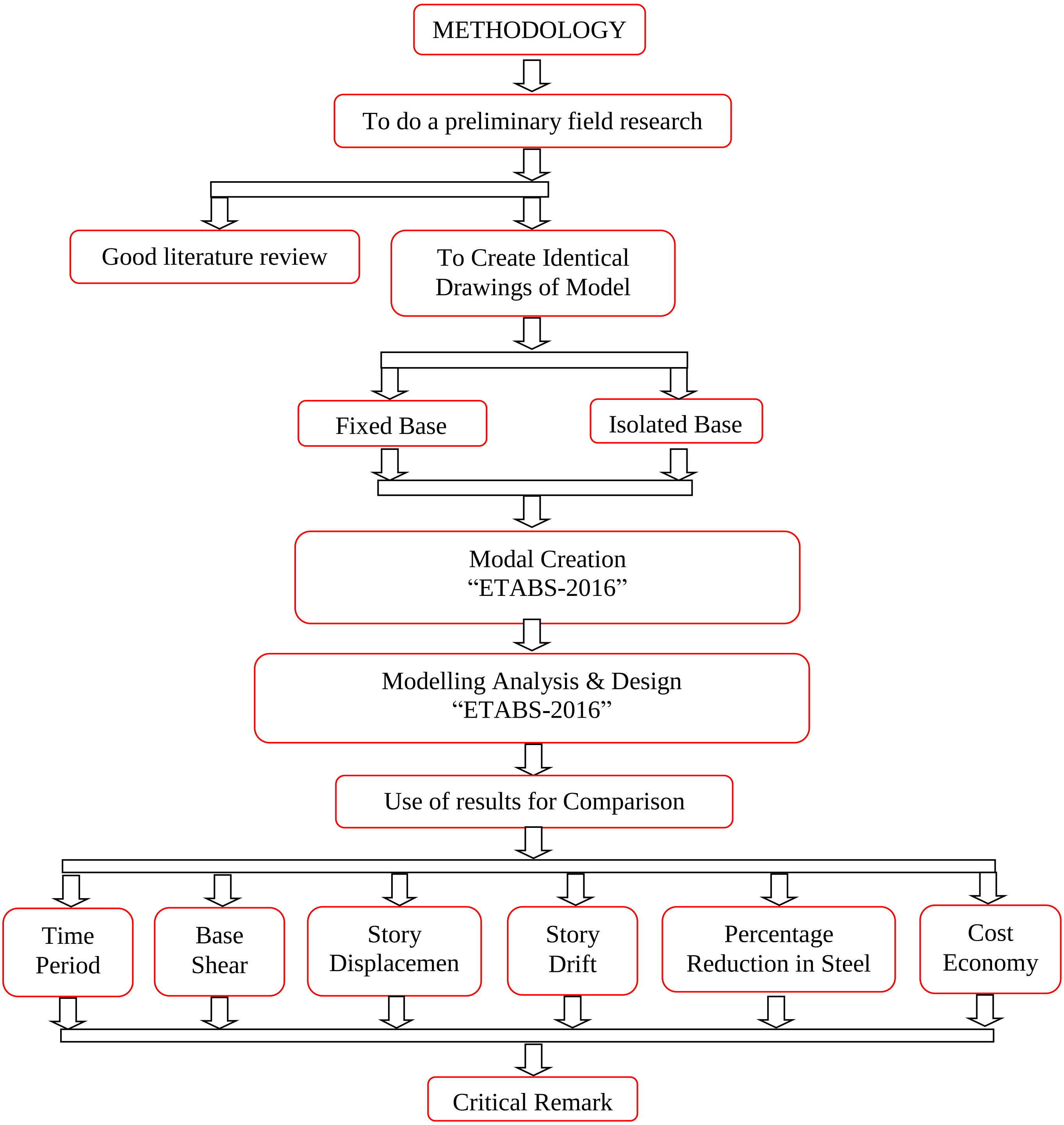


Figure-32. Sample Load Combination

4.9 Research Methodology



- From preliminary field study & healthy literature review, Sample Model is created using CAD tools.
- Validation of computer aided structure designing software “ETABS-2016”.
- Fixed base Model generation in “ETABS-2016”.
- Analysis & design of fixed base Model in “ETABS-2016”.
- Design of Base isolator using cumulative load of fixed base Model.
- Base isolator Model generation in “ETABS-2016”.
- Result obtained from all the above sample Model cases (4.6) are compared.

4.10 Summary

In the current chapter, the objectives of the study are defined from the identification of the gap in existing research by means of the literature survey. With the formulated objectives, Hypothesis are identified and to fulfill the same, sample models with different case are prepared and presented in this thesis.