A STUDY OF EFFECTIVENESS OF DAMPING SYSTEM CONSIDERING SSI IN COMMERCIAL BUILDING

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Abstract

Steel-concrete composite construction is the structure in which steel section encased in concrete for columns & the concrete slab or profiled deck slab is connected to the steel beam with the help of mechanical shear connectors so that they act as a single unit. This study is aimed to compare the seismic behaviour of different damping systems in steel concrete composite buildings. This study presents the analysis of G+9,G+3 and G+14 building considering soil structure interaction. A three dimensional modelling and analysis of the structure are carried out with the help of SAP 2000 software. Equivalent static analyses are carried out on all structures. In this work base isolation & single bracing system are consider in analysis.

Keywords—*seismic behavior, damping systems, base isolation, single bracing, SSI, SAP 2000.*

1. INTRODUCTION

1.1 General:

Earthquakes are the most unpredictable and devastating of all natural disasters, which causes shaking of the ground and failure of the structure. As results of past earthquake we seen its affect the loss of property as well as loss of life.so it is necessary to construct a structure which withstand against the earthquake and reduce this effect soil structure analysis by static and dynamic method help us to find out various damping technique which help to solve this problem. By determining the earthquake forces and SSI effect possible Resisting system to structure we can suggest .By providing Suitable Damping system we can provide strength to structure against the earthquake forces

The process in which the response of the soil influences the motion of the structure and the motion of the structure influences the response of the soil is termed as SSI. In this case neither the structural displacements nor the ground displacements are independent from each other. The phrase 'soil-structure interaction' is defined as "The process in which the response of the soil influences the motion of the structure and the motion of the structure influences the response of the soil is termed as SSI." As we know lateral force that is earthquake causes the effect of soil structure interaction that may result into damage to the structure or failure of the structure.The foundation designer must consider the behavior of both structure and soil and their interaction with each other. The interaction problem is of importance to many civil engineering situations and it covers a wide spectrum of problems. These include the study of shallow and deep foundation, floating structure, retaining wall-soil system, tunnel lining, earth structure etc So, it is necessary to find out various techniques to reduce the effect of soil structure interaction Seismic base isolation & Viscous Damper Bracing system is the most developed system at the present time. The basic concept of seismic isolation is to reduce the response to earthquake motion by, (i) reducing stiffness, (ii) increasing the natural time period of system (iii) provision of increased damping to increase the energy dissipation in the system find out the structural behavior of composite steel building using combination of various damping system and find out the conclusion.

1.2 Composite structure:

A composite member is the member constructed by combining concrete member and steel member so that they act as a single unit. As we know that concrete is strong in compression and weak in tension on the other side steel is strong in tension and weak in compression. The strength of concrete in compression is complemented by strength of steel in tension which results in an efficient section. By the concept of this composite member the concrete and steel are utilized in a well-organized manner. The structural elements which are comprised in a composite construction are given below.

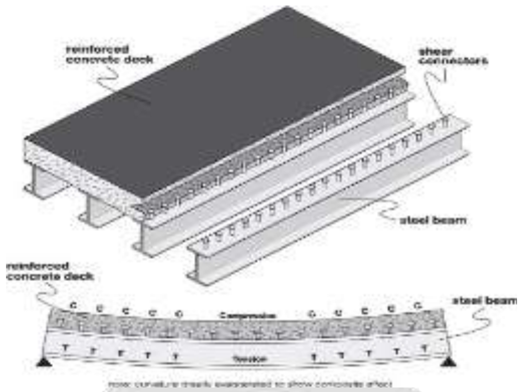


Fig 1.1: Composite deck slab and beams

1.2.1 Composite deck slab:

Composite floor system comprises of steel beams, metal deck and concrete slab. In general a steel beam for example I section is coupled with steel deck over which a concrete slab is laid. The metal deck rests between two steel sections which also serve as operational stand for concrete work. This composite floor system acts as a diaphragm due to which the composite floor system produces a rigid horizontal diaphragm, providing solidity to the structure in addition to that it distributes wind loads and earthquake loads to the composite frame system.

1.2.2 Composite beam:

A composite beam is produced by placing a concrete slab over steel beams mostly I section. When loads are applied on this member these rudiments have a tendency to perform in a self-regulating way which results in occurrence of slip among them. This relative slip can be eliminated when we provide an appropriate connection between steel beam and concrete slab, by providing connections the steel beam and concrete slab is made to act as a single unit. The steel which is weak in compression buckles under compression loads and concrete which is weak in tension develops cracks due to tensile loads. By providing above mentioned arrangement concrete and steel elements act together in order to resist both tensile and compression loads in an efficient way. Due to higher stiffness than steel members composite members deflect less than them. For same loading, employing composite beam results in thin, effective and economic cross sections than RCC structures.

1.2.3 Composite columns:

A compression member consisting of both steel and concrete elements can be termed as steel concrete composite columns. There are two types of composite columns

1. Concrete section with embedded steel section
2. A hallow steel section with concrete infill

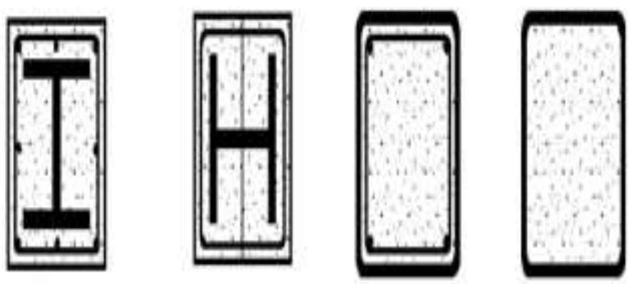


Fig 1.2: Types of composite columns

Friction and bond are the two parameters which makes both steel and concrete elements to act as a single unit in composite columns. The general process of construction of composite column includes erection of hallow steel section or I section which takes the initial construction loads then it is filled with concrete or concrete is casted around I beam. Lateral deflections and buckling of steel members are prevented by concrete member. In addition to that composite columns have less cross sectional area and light weight when compared with RCC columns.

1.2.4 Shear connectors:

This is the main component which is responsible for the development of composite action between concrete slab and steel beam by shear transfer. This helps the composite system to take up large amounts of flexural stresses and to transfer horizontal loads to the lateral load resisting system. The purpose of shear connectors is to avoid partition of concrete slab and steel beam and to transmit the lateral shear at the concrete and steel interface.

2. METHODOLOGY

2.1 General:

Soil – structure interaction plays an important role in the behaviour of foundations and structure. For structures like beams, piles, mat foundation, Retaining Structure, dam box cells it is very essential for consider the deformation characteristics of soil and flexural properties of foundations. It can be seen that when interaction is taken into account, the true design values arrived-at may be quite different from those worked out without considering interaction. In general in most of the case interaction causes reduction in critical design values of the shear and moments etc. However, there may be quite a few locations where the values show an increase. Because of these possibilities have their own roles to play in economy and safety of structure.

2.2 Soil Foundation Interaction Problem:

The study of the interaction between foundation and supporting soil media is of fundamental importance to both geotechnical and structure engineers. Results of such study can be used in the structural design of the foundation and in the analysis of the stresses and deformations with the supporting soil medium.

In-situ soils are commonly anisotropic and non-homogeneous and display markedly non-linear, irreversible and time dependant characteristics. The behaviour of such soils is expected to be influenced by following factors.

(i) The shape, sizes and mechanical properties of the individual soil particles.
(ii) The configuration of the soil structure.
(iii) The inter-granular stresses and stress history
(iv)The presence of soil moisture, the degree of saturation and the soil permeability

The solution of any interaction problem on the basis of all above factors is very difficult, laborious and impracticable, realistic and purposeful solutions can achieved by idealizing the behaviour of the soil by considering specific aspects of its behaviour. The simplest idealization of response naturally occurring soils assumes linear elastic behaviours of the supporting soil medium. This idealization also assumes the surface of the soil medium to form the soil-foundation interface and the soil medium is represented by elastic medium occupying a half-space region. Though these assumptions are not always satisfied by in-situ soils, these considerably simplifying the solution and provide useful information to number of practicable problems in geotechnical engineering. Various idealization soil behaviour models will be introduced afterwards.

3. MODELLING

3.1 General:

The objective of this study is to develop efficient building models by using combination of braced frames. Five types of multi storied braced frame models are developed in seismic zone and evaluated its structural performance with respect to member strength, ductility and inter storey drift. Equivalent static method used for seismic analysis and the results are verified by software. The results of all five models are analysed and selected an efficient structural model for design of eight storied commercial building.

The steelconcrete composite building used in this study is ten storied (G+9). building have same floor plan with5 bays having 4m distance along longitudinal direction and 3 bays having 4m distance along transverse direction as shown in figure.

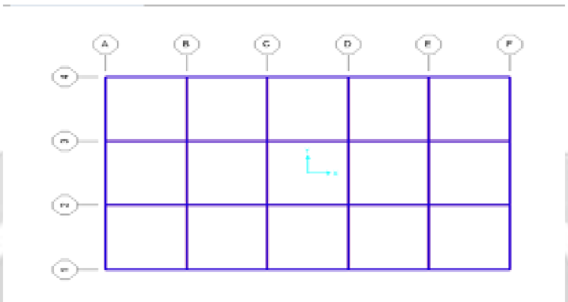


Fig 3.1: Building Plan

3.2DESIGN DATA

Model 1-Composite floors are designed based on limit state design philosophy. Since IS 456:2000 is also based on limit state methods, the same has been followed wherever it is applicable. The design should ensure an adequate degree of safety and serviceability of structure. The structure should therefore be checked for ultimate and serviceability limit states.

(a) Design data

Model: G+9 Seismic zone: III
Zone factor: 0.16 Importance factor: 1
Height of building: 31.5 m Floor height: 3.00m
Depth of foundation: 1.5 m Plan size: 20 m X 15 m
Type of soil: Medium Slab depth: 120 mm thick for R.C.C. Wall thickness: 230 mm.

(b) Material Properties

Unit weight of masonry: 20kN/m^3
Unit weight of R.C.C.: 25kN/m^3
Unit weight of steel: 79kN/m^3
Grade of concrete: M20 for R.C.C and Steel.
Grade of steel: HYSD bars for reinforcement Fe 415
Modulus of Elasticity for R.C.C.: $5000 \text{ X}\sqrt{f_{ck}}$ N/mm^2
Modulus of Elasticity for Steel: 2.1×10^5N/mm^2

(c) Load Consideration

Dead load: Self Weight
Live load
Floor finish load
Seismic load

(d) Load Combination Consideration:

Load combinations as per IS 1893-2002

(e) Dimensions consideration for design:

For steel frame

Beam size: ISMB 300 @ 54.4 kg
Column size: ISHB 500 @49.4kg
The steel damping used is ISA 110X110X10.

Codes for analysis
RCC design: IS 456:2000
Composite design: IS 11384

Table 3.1 Dynamic Properties of Soil

Soil Type	G(kN/m^2)	E(kN/m^2)
Soft Soil	11500	32000
Medium Soil	21500	60000
Hard Soil	28500	80000

G=Shear Modulus; E = Elastic Modulus; E=Gx2 (1+μ), μ=Poisson's ratio of soil.

3.3 MODELLING

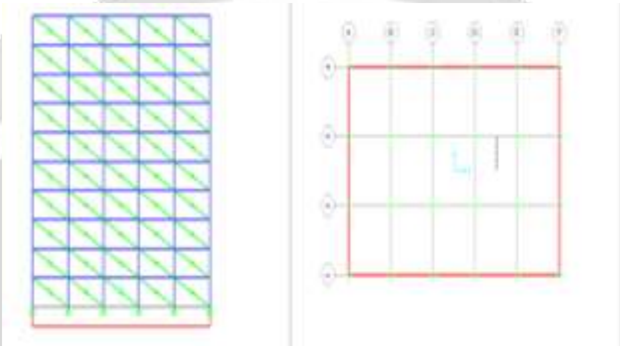


Fig 3.2 Plan and Elevation on sap 2000

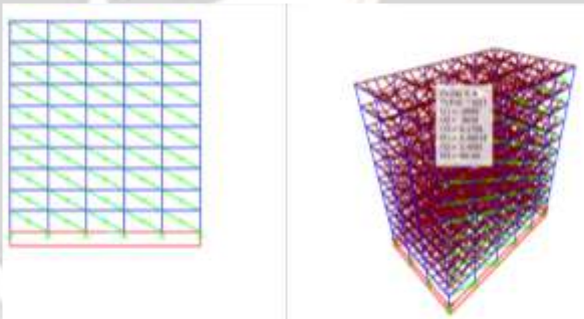


Fig 3.3 2d and 3d modeling

Model 2-

Model: G+3 Seismic zone: III
Zone factor: 0.16 Importance factor: 1
Height of building: 12 m Floor height: 3.00m
Depth of foundation: 1.5 m Plan size: 5 m X 5 m
Type of soil: Medium Slab depth: 120 mm thick for R.C.C. Wall thickness: 230 mm.

(a)Load Consideration

Dead load: Self Weight
Live load
Floor finish load
Seismic load

(b)Load Combination Consideration:

Load combinations as per IS 1893-2002

(c) Dimensions consideration for design:

For steel frame
Beam size: ISMB 300 @ 54.4 kg

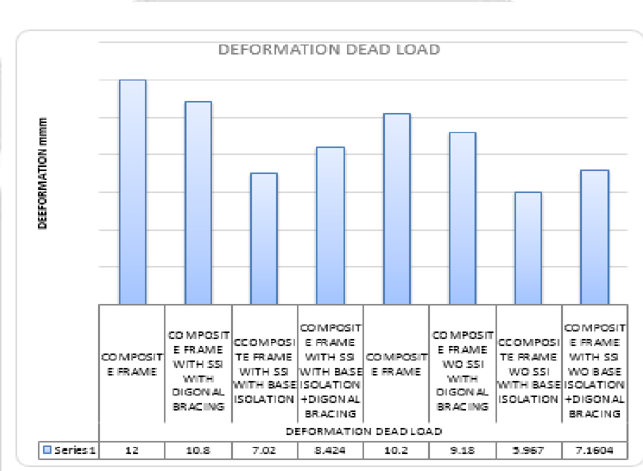
Column size: ISHB 500 @49.4kg
The steel damping used is ISA 110X110X10.
Codes for analysis
RCC design: IS 456:2000
Composite design: IS 1138

4. RESULTS AND DISCUSSIONS

The result of analytical parameter such as story drift, base shear, and time history analysis of Composite frame are carried out. These results are shown in tabular form. The interpretations of this result are compared graphically. Also soil structure interaction comparison of composite element with element are done by tabular form

Model 1 Results And Discussions(G+9)

Deformation Dead Load G+9

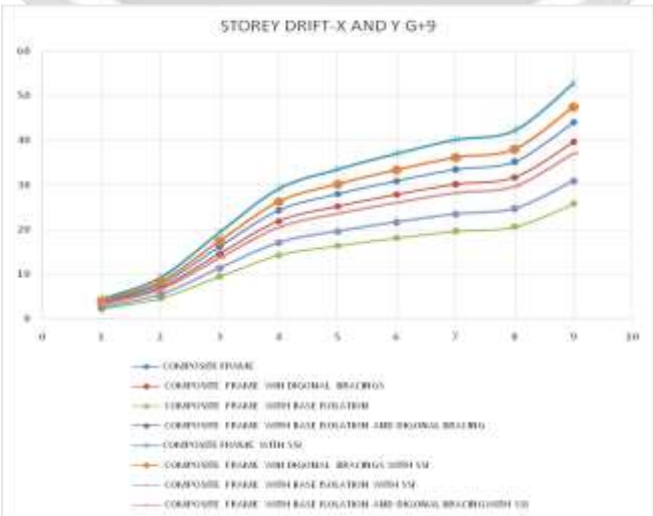


Graph 4.1: Deformation Dead Load G+9

In this graph maximum deformation dead load is 12 in composite frame with ssi. The difference between composite frame and composite frame with SSI is 15%.

Deformation due to self-weight is decreased up to 30-35% in damper system but 15% in base isolation. Hence it is Observed that base isolation will only contribute to reduction in storey drift

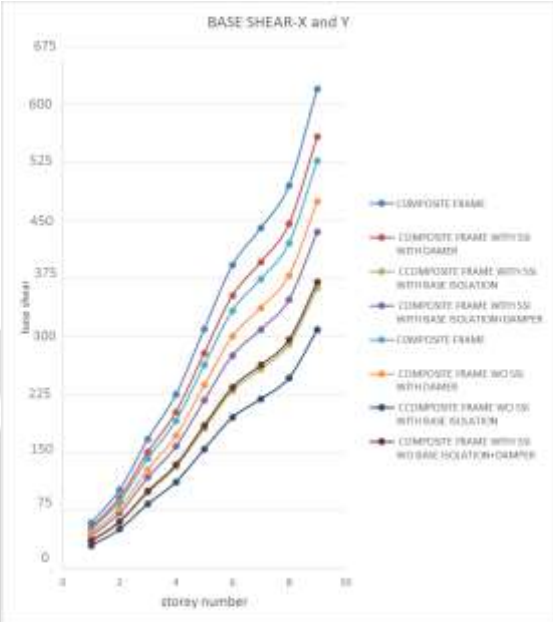
Storey Drift-X & Y Direction



Graph 4.2- Storey Drift-X & Y Direction

In this graph maximum story drift- x is 52 in composite frame. The difference between composite frame and composite frame with SSI with damper is 30%.
Storey drift is observed to decrease 30% in base isolation & viscous damper.

Base shear along x and y direction



Graph 4.3: Base shear along x and y direction

In this graph maximum base shear is 630 in composite frame. The difference between composite frame and composite frame with SSI with damper is 30%.

Model 2 Results and Discussions (G+3)

Deformation Dead Load

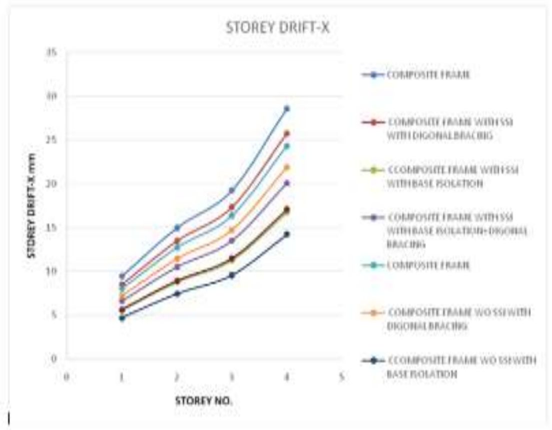
Graph 4.4: Deformation Dead Load

In this graph maximum deformation load is 7.392 in G+3 composite frame with SSI without damper. The difference between G+3 composite frame with SSI without damper and G+3 composite frame with SSI without is 16%.

Deformation due to self-weight is decreased up to 30-35% in damper system but 10% in base isolation. Hence it is observed that base isolation will only contribute to reduction in storey drift

Storey Drift-X and Y Direction

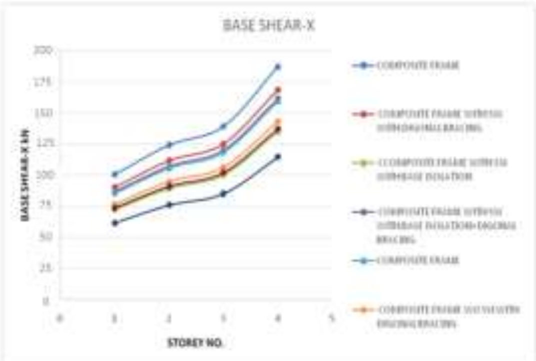
STOREY DRIFT-X and Y							
STOREY NO.	COMPOSITE FRAME	COMPOSITE FRAME WITH SSI WITH DIGONAL BRACING	CCOMPOSITE FRAME WITH SSI WITH BASE ISOLATION	COMPOSITE FRAME WITH SSI WITH BASE ISOLATION+ DIGONAL BRACING	COMPOSITE FRAME	COMPOSITE FRAME WO SSI WITH DIGONAL BRACING	CCOMPOSITE FRAME WO SSI WITH BASE ISOLATION
1	9.5	8.55	5.5575	6.669	8.075	7.2675	4.723875
2	15	13.5	8.775	10.53	12.75	11.475	7.45875
3	19.27	17.343	11.27295	13.52754	16.3795	14.74155	9.5820075
4	28.59	25.731	16.72515	20.07018	24.3015	21.87135	14.2163775



Graph 4.5- Storey Drift-X and Y Direction G+3

In this graph maximum story drift- x is 28.5 in G+3 composite frame with SSI without damper. The difference between G+3 composite frame with SSI without damper and G+3 composite frame with SSI with damper is 15%.

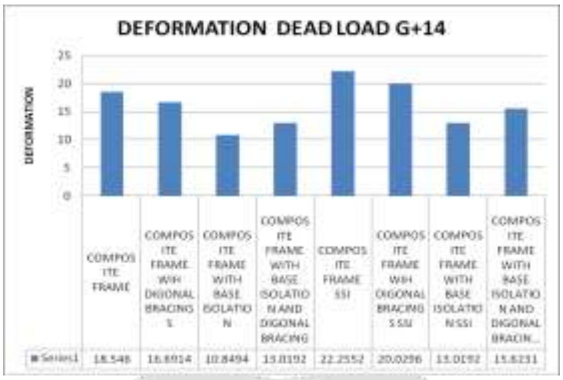
Base shear along x And y direction



Graph 4.6: Base shear along x and y direction

In this graph maximum base shear- x is 185 in composite frame. The difference between composite frame and composite frame with SSI with damper is 25%.

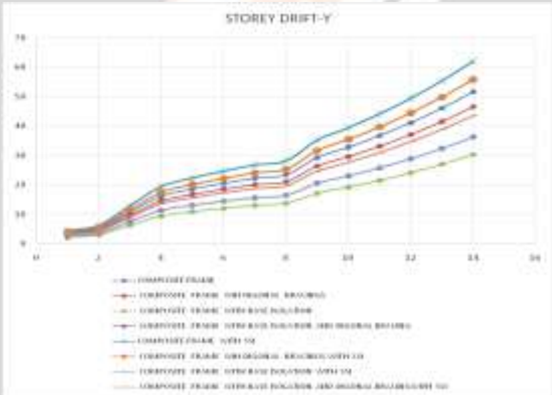
Model 3 Results and Discussions (G+14)
Deformation Dead Load



Graph 4.7: Deformation Dead Load

In this graph maximum deformation dead load is 22.25 in composite frame with ssi. The difference between composite frame and composite frame with SSI is 16.5%.
Deformation due to self-weight is decreased up to 30-35% in damper system but 15% in base isolation. Hence it is observed that base isolation will only contribute to reduction in storey drift.

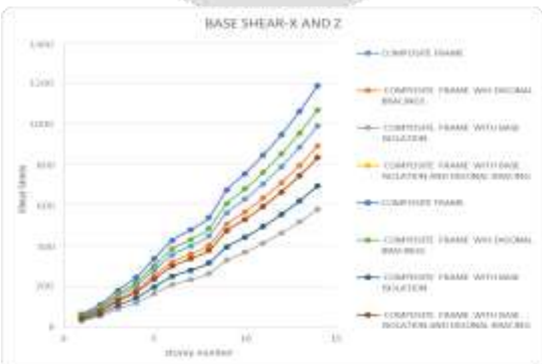
Storey Drift-X and Y Direction



Graph 4.8- Storey Drift-X And Y Direction G+14

In this graph maximum story drift- x is 66 in G+14 composite frame with SSI without damper. The difference between G+14 composite frame with SSI without damper and G+14 composite frame with SSI with damper is 40%.

Base shear along x and y direction



Graph 4.9: Base shear along x and y direction

In this graph maximum base shear- x is 1200 in composite frame. The difference between composite frame and composite frame with SSI with damper is 30%.

5. CONCLUSION

From above study following conclusion are drawn

- Storey drift is observed to decrease 30% in base isolation & viscous damper.
- Deformation due to self-weight is decreased up to 30-35% in damper system & 15% in base isolation. Hence it is Observed that base isolation will only contribute to reduction in storey drift
- After comparison with and without soil structure interaction for story drift along X and Y direction it was observed that Story drift Varies between 15%-40% for different storey. Hence it can be concluded that SSI need to be considered for higher zone, multi storey building and weak soil
- Deformation due to self-weight is observed 16% more in with considering soil structure interaction
- Storey drift is observed double in G+9 building (30%) than G+3 Building (15%).

The combination of viscous damper + base isolation system will reduce the effect of earthquake force. This system provide lesser storey drift and deformation than other systems.

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