Seismic Comparison of Steel, R.C.C and Steel-Concrete Composite Structure

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***Abstract*- Composite construction, in the general sense, is the use of different materials or methods of construction within one structural element in a way that utilizes the properties of each to the best advantage. The term 'composite construction' has, within the construction industry, become accepted as meaning the juxtaposition of structural steel and concrete with some shear connection between the two materials to enable composite action within the resulting structural member. There are many advantages in composite structures which could make the two different materials, steel and concrete fully composed, so the disadvantages of traditional concrete structures or steel structures, such as high self weight, cracking, stability problem, could be overcame due to the composite action. Especially in high-rise buildings, steel concrete composite structures will be the first choice due to the high seismic performance. A G+ 5 Storied frame system of R.C.C.,Steel and steel-concrete composite building is taken under consideration for seismic performance for earthquake zone III with medium soil. Total 3 Models are analyzed using Equivalent static method of analysis (IS : 1983 2002). Section is selected by optimization technique for efficient and economical design.**

***Keyword*—thermal insulation, optimization, Equivalent static analysis, composite strucutre, STAAD Pro.**

I INTRODUCTION

The word composite general in construction industry refers to steel-concrete composite structure. The most important and most frequently encountered combination of construction materials is that of steel and concrete, it has applications in multi-storey commercial buildings and factories, as well as in bridges. These materials can be used in mixed structural systems, for example concrete cores encircled by steel tubes, as well as in composite structures where members consisting of steel and concrete act together compositely. These different materials are completely compatible and complementary to each other; they have almost the same thermal expansion, they have an ideal combination of strengths with the concrete efficient in compression and the steel in tension, concrete also gives corrosion protection and thermal insulation to the steel at elevated temperatures and additionally can restrain slender steel sections from local or lateral- torsional buckling. In multi-storey buildings, structural steelwork is typically used together with concrete; for example, steel beams with concrete floor slabs. It also applies to road bridges, where concrete decks are normally preferred. Designing composite systems of structural steel and reinforced concrete produces more efficient structures when compared to designs using either material alone. The combination of concrete cores, steel frame and composite floor construction has become the standard construction method for multi-storey commercial buildings in several countries. Much progress has been made, for example in Japan, where the structural steel/reinforced concrete frame is the standard system for tall buildings.

In this paper attemed has been made to study effect of composite steel-concrete structural frame system. Wherein beams are of Steel and columns are replaced by Reniforced concrete section. Comparison of various parameters for R.C.C., Steel and this type of composite structure is been tried to study in this paper. The objective of this study is to incorparate the advantages and eliminate the disadvantages of R.C.C. & Steel Structure in the composite structure.

II LITERATURE REVIEW

A. T. Kassem el.al [1] studies the flexural behavior of steel-concrete composite simply supported girders in fire condition. A three dimensional nonlinear thermal structural finite element model has been established using COSMOSM software package to evaluate both girder structural and thermal responses in fire condition. A parametric study based on the outputs of this model has been performed to study effects of variations in various structural parameters on the behavior of composite girders. Practical conclusions about fire endurance, recommended load ratios, and best composite configurations have been extracted. Composite girders restrained near the neutral axis behave much better than girders restrained at the steel soffit. The more the concrete stiffness relative to steel the more the fire endurance even after a subjective failure criterion. Steel grade does not affect structural behavior in fire condition. Concrete slab configuration is an insignificant parameter for a problem of a composite girder in fire condition.

Prof. Dr. A. Q. Melhem [2] work on the effect of high strength steel (HSS) versus ordinary strength steel (OSS) on the performance of composite girder models theoretically and experimentally. It shows how the HSS can be used to its greater benefit in hybrid composite structures. Two set of composite girder models studied implementing fabricated hybrid HSS and homogeneous OSS I-section connected via stud shear connectors to concrete slab. The models are identical; having the same cross section, span length, slab dimensions and concrete compressive strength. They are different in yield and ultimate stress of steel section and composite action by means of shear connection.

Prospective advantages has been gained from utilizing HSS versus OSS in composite members, such as reducing the structural depth, weight and safety design for strength. The presence of full shear connection (in comparison with partial shear connection) has reduced the slip between the steel beam and concrete slab in roughly of ten times at ultimate case for HSS situation. Additionally, full shear connection has reduced the deflection to ten percentages. Impending inconvenience of using HSS includes reducing ductility. The application of HSS can lead to noteworthy material-cost savings particularly for lighter weight members. The weight reduction obtained from using HSS has no effect on the applied loads for short spans.

B. Uy [3] This paper provides an overview of the design codes, innovative construction applications and maintenance issues for steel-concrete composite members in Australia. It has been found that the national codes of practice have been lacking in guidance. The paper concludes with research that is being carried out which considers materials and solutions in composite structural forms which promote the concepts of sustainability and will inevitably be prominent in improved maintenance system of steel-concrete structures in the future. The use of high performance steels in composite steel-concrete structures essential for better Performance.Major tubular members filled with hot water to act as a discrete heater and Chilled beams to provide air conditioning. Research necessary for Rehabilitation and retrofitting techniques of composite steel-concrete structures.

Enrico Spacone el. at [4] The paper presents the current state of the art of nonlinear analysis of steel-concrete composite structures. The focus was on frame elements, which are computationally faster than continuum finite element models. Models with lumped and distributed inelasticity, as well as models with perfect and partial connections are covered. Rigid and partially restrained joints are then reviewed and discussed at length. A discussion of the analysis of structural walls completes the presentation of the models.

Min Ding el.al [5] The theoretical model to compute the long-term stress of simply supported steel-concrete composite beam was deduced. The results show that the additional stress at the top of concrete slab is tensile stress and that at the bottom of steel beam is compressive stress. The ratio of steel beam to concrete slab thickness, as well as concrete slab width and the longitudinal reinforcement ratio in concrete slab can not be ignored. Concrete strength, external load value and concrete age to loading have relatively bigger effect as well, But the environmental yearly average relative humidity has less impact. The fruits are useful to the design and application of steel-concrete composite beams.

III MODELLING

A 3D model of composite building of G+5 storied frame is anlaysis under seismic forces. The typical plan of composite framed building (beams are of Steel and columns are of Reniforced concrete) is shown in figure 1. Model is prepared using STAAD Pro. V8i Software.Connections are considered as rigid connections. For analysis below three types of frame structure is taken into study.

1) R.C.C. Frame with R.C. Slab
2) Steel Frame with Steel plate Slab
3) Steel Beam and R.C. Column with R.C. Slab

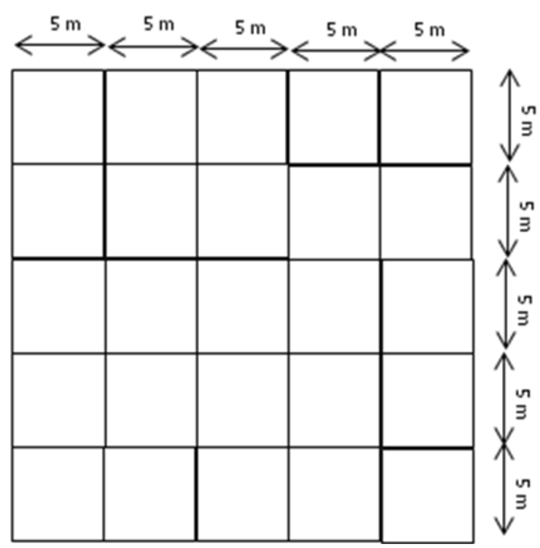

Figure -1 The typical plan of framed building

IV DATA FOR G+5 STOREY BUILDING

Geometry

Type of building : Commerical
Height of building : 18.6 m
Typical storey height : 3.1 m
Width of building : 20 m
Depth of building : 20 m

Material

Grade of concrete : M 30
Yield strength of steel section : 250 N/mm^2
Yield strength of reinforcement : 415 N/mm^2

Loading

Dead load at any floor including floor finish : 4.0 kN/ m^2
Live load at any floor level : 2.0 kN/ m^2
Wall load at peripherial beams : 12.5 kN / m^2
Wall load at interial beams : 5.0 kN / m^2
Wall load at peripherial beams at roof level : 2.5 kN / m^2

Earthquake load

Zone : III
Important factor : 1.0

V ANALYSIS AND CONCLUSION

Analysis has been carried out using the software STAAD Pro.V8i for evaluating the performance of Composite structure comparing support reaction, support moment & nodal displacement for R.C.C. & Steel. It is analyzed for medium soil for earthquake zone III using Equivalent static method of analysis and Response spectrum method of analysis. For designing Limit state method is used.

Table 1 shows maximum and minimum nodal displacement of R.C.C. frame,Steel Frame and Composite frame. It can be observed that the nodal displacement value of composite frame is comparatively less as compare to R.C.C. and Steel Frame.

Table2 shows maximum and minimum support reactions , it can be observed that the value of Fy is Considerably less in Composite frame as compare to R.C.C. which will affect the design of foundation.

Table 1 Nodal displacement for RCC Frame , Steel Frame and Composite Frame

NODAL DISPLACEMENT									
	R.C.C.Frame			**SB-RCC**			**STEEL**		
	Hori.	**Vertical**	**Hori.**	**Hori.**	**Vertical**	**Hori.**	**Hori.**	**Vertical**	**Hori.**
	X mm	**Y mm**	**Z mm**	**X mm**	**Y mm**	**Z mm**	**X mm**	**Y mm**	**Z mm**
Max X	**25.109**	-4.576	22.293	**22.593**	-4.173	20.472	**38.234**	-1.47	0.012
Min X	-25.108	-3.302	-22.293	-22.593	-3.006	-20.472	-38.238	-1.904	-0.011
Max Y	16.739	**0.35**	17.293	15.062	**0.319**	15.561	25.453	**0.145**	0.007
Min Y	0	-5.485	0	0	-5.048	0	-35.786	-2.866	-0.01
Max Z	24.563	-2.607	**25.939**	22.572	-2.379	**23.341**	2.122	-2.58	**18.349**
Min Z	-24.563	-5.272	-25.939	-22.572	-4.801	-23.341	2.122	-2.58	-18.349

Table 2 Support reaction for RCC Frame , Steel Frame and Composite Frame

SUPPORT REACTIONS									
	R.C.C.Frame			**SB-RCC**			**STEEL**		
	Hori.	**Vertical**	**Hori.**	**Hori.**	**Vertical**	**Hori.**	**Hori.**	**Vertical**	**Hori.**
	Fx kN	**Fy kN**	**Fz kN**	**Fx kN**	**Fy kN**	**Fz kN**	**Fx kN**	**Fy kN**	**Fz kN**
Max Fx	**180.889**	2564.668	162.759	**164.5**	1485.172	170.134	**41.848**	1085.583	0.183
Min Fx	-180.889	2157.113	-162.759	-164.5	1981.037	-170.134	-41.806	963.75	0.05
Max Fy	177.874	**2669.331**	162.759	0	**2470.985**	0	35.005	**1354.173**	4.833
Min Fy	-8.731	-147.404	-107.813	-8.112	-134.866	-99.437	-1.26	-37.559	-7.534
Max Fz	177.874	2564.647	**187.605**	164.5	2351.724	**170.134**	-3.243	1281.162	**17.69**
Min Fz	-177.874	2157.133	-187.605	-164.5	1981.037	-170.134	-3.245	1281.385	-17.692

Table 3 shows maximum and minimum support moments ,good amount of reduction is noticed in Composite frame as compare to R.C.C.. The size of member is less than that of R.C.C. frame as forces induced are less in composite frame.

Efficient properties of composite structure compare to R.C.C. & Steel are due to lighter weight of members, smaller section required & good load carrying capacity following the design concept of Strong Column & Weak Beam theory.

Thus Composite structure provides the effective solution in designing structures for earthquake resistance compare to R.C.C structures. As steel frame is economically not viable but composite frame can be economicall as well as faster in construction compare to R.C.C.. Now-a-days there is vital use of Composite structures in commercial industry, but there is less awareness regarding the same in India. This paper attempts to aware the benefits of composite construction.

Table 3 Support Moments for RCC Frame , Steel Frame and Composite Frame

SUPPORT MOMENTS									
	R.C.C.Frame			**SB-RCC**			**STEEL**		
	Mx kNm	**My kNm**	**Mz kNm**	**Mx kNm**	**My kNm**	**Mz kNm**	**Mx kNm**	**My kNm**	**Mz kNm**
Max Mx	**291.093**	6.231	276.014	**263.988**	5.648	255.262	**30.335**	-1.017	1.904
Min Mx	-291.092	-6.231	-276.013	-263.986	-5.648	-255.261	-30.337	1.017	1.906
Max My	291.093	**6.231**	276.014	263.988	**5.648**	255.262	-14.623	**1.017**	-1.892
Min My	-291.092	-6.231	-276.013	-263.986	-5.648	-255.26	24.38	-1.017	-7.864
Max Mz	252.56	6.231	**280.689**	263.988	5.648	**255.262**	0.171	0.07	**72.823**
Min Mz	-252.559	-6.231	-280.688	-263.986	-5.648	-255.261	-0.085	-0.068	-72.858

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