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Research Paper Engineering

Comparision of Structural Systems For Composite Construction in High Rise Building

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ABSTRACT

In the present study, analysis and design of three structural systems i.e. RCC frame tube, steel frame tube and composite megaframe with supercolumn is presented. For comparison of structural performance of these systems, 30 storey building with plan dimensions 60.96m 36.576m and height 118.8m is considered. In addition to gravity loading, lateral loading due to earthquake and wind are considered. Wind forces are calculated using Gust factor method as per IS875-III and earthquake forces are estimated as per dynamic method of IS1893. ETABS software is used for modelling and design of structural elements. Analysis results in terms of natural time period, storey shear, overturning moment, lateral drift, storey displacement, forces in critical members are compared for all the three structural systems. For the design of composite structure, specifications of Euro Code 4 are followed. Based on the design of structural systems, consumption of basic materials like concrete and steel is com-pared for all the three structural systems. Cost of the building with three structural systems is also presented. Gravity load intensity per unit floor area is also calculated to understand variation in dead load.

KEYWORDS Structual Systems ,highrise building Megaframe with super column

I Introduction

steel-concrete composite systems have become quite popular in recent times because of their advantages against conventional construction. Composite construction combines the better properties of the both i.e. concrete in compression and steel in tension, they have almost the same thermal expansion and results in speedy construction. The use of Steel in construction industry is very low in India compared to many developing countries. Experiences of other countries indicate that this is not due to the lack of economy of Steel as a construction material. There is a great potential for increasing the volume of Steel in construction, especially the current development needs in India. Engineers are familiar with the problems involved in constructing either steel or concrete building, as each of these materials has its own peculiarity. Steel structural members are generally fabricated as component consisting of thin plate elements, so they are prone to local and lateral buckling. Therefore, they are checked for the failure due to buckling and instability, while concrete structural members are generally thick and unlikely to buckle; but they are inclined to creep and shrinkage with time. Therefore, a system comprising steel-concrete-composite structure was developed to take benefit of both the material. For building systems, steel-concrete composite structures are known as the most economical solution to the diverse engineering design requirements of stiffness and strength. The strength and behavior of composite slabs are governed by the shear interaction between the concrete and the steel deck. By the composite action between the two, one can utilize their respective advantages to the fullest extent. Structurally robust and aesthetically pleasing buildings are being constructed now-a-days by composite steel concrete construction meeting the specific requirements of large span, building height, soil condition, time, flexibility and economy. The main benefits from the use of composite steel concrete construction are in terms of construction time and cost. The use of rolled steel section and prefabricated component makes the composite construction fast track construction compared to the cast in situ concrete

II. OBJECTIVE

Steel-concrete composite systems have become quite popular in recent times because of their advantages against conventional construction. Composite construction combines the better properties of the both i.e. concrete in compression and steel in tension, they have almost the same thermal expansion and results in speedy construction. The objectives of the study are

To provide a brief description to various components of steel concrete framing system for buildings.

To investigate major parameters like cost, time, seismic response of steel-concrete composite frames over traditional reinforced concrete frames and steel frames for building structures

III. COMPOSITE CONSTRUCTION

Steel-concrete composite construction means 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. In India, many consulting engineers are reluctant to accept the use of composite steel-concrete structure because of its unfamiliarity and complexity in its analysis and design. But literature says that if properly configured, then composite steel-concrete system can provide extremely economical structural systems with high durability, rapid erection and superior seismic performance characteristics.

IV. BUILDING DETAILS

The plan of the building is 60.96 X 36.57.Height of building is 118.8m .Bay in X direction 10 bay in Y direction 7.The centre to centre distance between two grids is 6.1m and 5.25m respectively

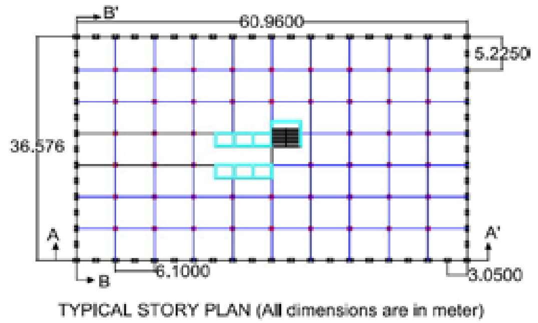

Fig.1 Plan showing typical floor

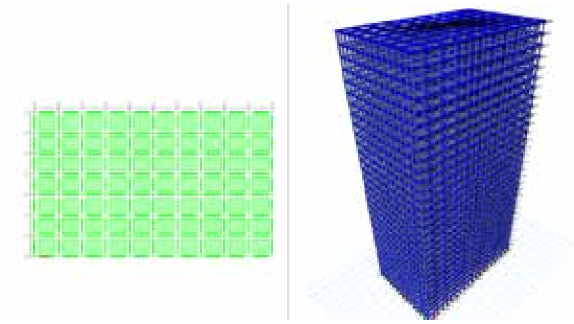

Fig.2 3-D and plan ground level view from E-TABS

Table 1: Data for Analysis of RCC Structure

S.I No	Particulars	Dimension/Value
1	Plan Dimension	60.96 X 36.57
2	Total height of the building	118.8m
3	Height of each storey	3 .96m
4	Height of parapet	1 m
5	Depth of foundation	4 m
6	Size of beams 6.0m span	450x600
	Size of beams 4.0m span	
		300x450
7	Size of outer columns	450x1000
	Size of internal columns	450x850
8	Thickness of slab	140mm
	Thickness of walls	230mm
9	Seismic zone	IV
	Wind speed	50 m/s
	Importance factor	1.0
	Zone factor	0.16
	Damping ratio	5%
10	Floor finish	4.0kN/m2
	Live load at all floors	1.0 kN/m2
	Density of concrete	25 kN/m 3
	Density of brick	20 kN/m 3
11	Grade of concrete	M30
	Grade of reinforcing steel	Fe500
	Soil condition	
		hard soil

Table 2: Data for Analysis of Steel Structure

S.I NO	Particulars	Dimension/Value
1	Plan Dimension	60.96 X 36.57
2	Total height of the building	118.8 m
3	Height of each storey	3.96 m
4	Height of parapet	1 m
5	Depth of foundation	4 m
6	Size of beams 6.0m span	ISMB 450
	Size of beams 4.0m span	
		ISMB 300
7	Size of columns	ISMB 450
8	Thickness of slab	140mm
	Thickness of walls	230mm
	Thickness of bracing	
9	Seismic zone	IV
	Wind speed	50 m/s
	Importance factor	1.0
	Zone factor	0.16
	Damping ratio	5%
10	Floor finish	1.0 kN/m2
	Live load at all floors	4.0 kN/m2
	Density of steel	7850 kg/m3
	Density of brick	20 kN/m3
11	Grade of concrete	M20
	Grade of reinforcing steel	Fe415
	Soil condition	hard soil

Table 3: Data for Analysis of Composite Structure

S.I NO	Particulars	Dimension/Value
1	Plan Dimension	60.96 X 36.57
2	Total height of the building	118.8 m
3	Height of each storey	3.96 m
4	Height of parapet	1 m
5	Depth of foundation	4 m
6	Size of beams 6.0m span	ISMB 450
	Size of beams 4.0m span	ISMB 300
	Cold form Deformed bars	Based on requirements
7	Size of columns	ISMB 450
8	Thickness of slab	140mm
	Thickness of walls	230mm
	Thickness of bracing	
9	Seismic zone	IV
	Wind speed	50 m/s
	Importance factor	1.0
	Zone factor	0.16
	Damping ratio	5%
10	Floor finish	1.0 kN/m2
	Live load at all floors	4.0 kN/m2
	Density of steel	7850 kg/m3
	Density of brick	20 kN/m3
11	Grade of concrete	M20
	Grade of reinforcing steel	Fe415
	Soil condition	hard soil

V. MODELING & ANALYSIS

The explained 3D building model is analyzed using Equivalent Static Method. The buildings models are analyzed by using ETABS software. In composite structure the beam is modeled as composite beam element and column is modeled as RCC beam element and shear wall is modeled as RCC plate element. In RCC structure the beam and column is modeled as RCC beam element and shear wall is modeled as RCC Plate element .The different parameters such as maximum shear forc,e axial force ,maximum bending moment and time period

VI. RESULTS

Storey Maximum Drift

Structural System	Max. drift	
	X direction	Y direction
RCC frame tube	0.000009	0.00043
Steel frame tube	0.000468	0.00075
Megaframe with Supercolumn	0.00043	0.00034

Maximum Displacement

Structural System	Max. displacement(m)		
	X direction	Y direction	Permissible
RCC frame tube	0.0492	0.132	0.237
Steel frame tube	0.119	0.217	0.237
Megaframe with Supercolumn	0.134	0.096	0.237

Weight of Structure

Weight of Structure in KN		
RCC	144388	
STEEL	128591	10.94 % reduced
Composite	136718	5.31 % reduced

Base Shear Due Earthquake and Wind

Structural System	Direction	Base shear due to static EQ(kN)	Base shear due to Dynamic EQ(kN)	Base Shear due to wind(kN)
RCC Frame Tube	X direction	6998	5555.31	6271.25
	Y direction	6998	5410.31	9256.25
Steel Frame Tube	X direction	3703	2834	6171
	Y direction	3703	2967	9012
Megaframe with super column	X direction	4664	3600	5565
	Y direction	11850	3608	8451

Modes and Time Periods

Mode	RCC frame tube	Steel frame tube	Megaframe with supercolumn
Mode 1	3.66 UY)	3.29(UY)	2.83(UX)
Mode 2	2.80(UX)	3.01(UX)	2.6(UY)
Mode 3	2.06(RZ)	2.24(RZ)	0.95(RZ)
Mode 4	1.11(UY)	1.00(UY)	0.82(UX)
IS1893(Part III):2002	2.01	2.28	2.28

Property	RCC	Steel	Composite	Reduction %(Steel)	Reduction% (Composite)
Maximum Axial Force(kN)	11980	10272	9025	14.25	24.66
Maximum Shear force(kN.m) X axis Y axis	250.35 196.65	217.8 180.67	170.17 150	13 8.12	32.02 23.72
Maximum B.M(kN.m) X axis Y axis	765.6 878.8	707.4 684	652.05 661.5	7.60 22.16	14.83 24.72

Forces and Moments

VII CONCLUSION

Composite structural system gives lesser displacement and drift providing more human comfort for higher stories

Axial forces in column have been reduced by 14.25% in steel structure and reduced by 24.66 % in Composite structure as compared to R.C.C.framed structure

Megaframe with supercolumn has minimum base shear due to wind and steel frame tube has minimum base shear due to earthquake as its lighter structure than other two systems

It is clear that the weight of Composite structure is reduced by 5.31% as compared with

RCCStructure. Hence cost of foundation is also reduced

Steel and composite structure gives more ductility to the structure as compared to the R.C.C. which is best suited under the effect of lateral forces

Research Papers

[1] Smith B.S. and Coull Alex. “Tall Building Structures:Analysis And Design”. AWilly- Interscience Publication, pg 283-285.
[2] Xia Jun, Dennis Poon and Mass Douglas C. “Case Study:Shanghai Tower”.CTBUH Journal,2010 Issue II,pg 355-366.
[3] Sheih Shaw-Song, Ching-Chang Chang and Jong Jiun-Hong. “Structural Design Of Super-composite Column For The Taipei 101 Tower”. Second Conference on Structural Steel Technology for Taiwan Strait Region.
[4] Sarkisian M, Mathias N, Long E, Mazeika A, Gordon J and Chakar J. “Jin Mao Tower Inuence On China’s New Innovative Tall Building”. Shanghai International Seminar Of Design And Construction Technologies Of Super High-rise Building,2006.
[5] Wijanto Sugeng, Prasetyoad Tiyoki and Sengara Wayan. “The SignatureTower:Reaching High In The Sky Of Indonesia”. Ninth World Congress, 2012 journal, pg 563-574.
[6] Malott David and Poon Dennis . “Pioneering China’s Tallest:Form And Structure Of The Ping An Finance Center”. Ninth World Congress, CTBUH 2012 journal,pg122-134..
[7] Shrinivasan N. “Composite Column Design With Eurocode 4”. INSDAG Publication.
[8] Shrinivasan N. “Composite Beam Design With Eurocode 4”. Chapter 1 and 2,INSDAG Publication.
[9] Shrinivasan N. “Composite Deck Design With Eurocode 4”. INSDAG Publica-tion.
[10] Liu Peng, Ho Gumanx, Lee Alex, Yin Chao. “Tiajin Golden Finance 117 tower”. Ninth World Congress, CTBUH 2012 journal, pg 234-249.
[11] Spectar Mark. “Structural Systems For Tall Buildings”. Council On Tall Buildings And Urban Habitat, McGraw-Hill International editions.
[12] IS800:2007. General Construction In Steel- Code Of Practice.Bureau of Indian Standard, New Delhi.
[13] IS 1893 (Part I) :2002. Criteria For Earthquake Resistant Design Of Structure: Part 1 General Provisions And Buildings. Bureau of Indian Standard, New Delhi.
[14] IS875(Part III):1987. Code of Practice for Design Loads(Other than Earthquake For Buildings And Structures).Bureau of Indian Standard, New Delhi.
[15] IS456:2000.Plain And Reinforced Concrete- Code Of Practice.Bureau of Indian Standard, New Delhi.
[16] Dr. Shah V. L. and Dr. Karve S.R. “Illustrated Reinforced Concrete Design”. Structures Publication,Third Edition,pg 52-204.
[17] Iyengar Hal. “Reections on The Hancock Concept”. CTBUH Journal (Volume 1), May 2000,pg213-227.
[18] Kobielak S., Tatko R. and Piekaez R. “Method for approximate analysis of Cracking effect on lateral stiffness of reinforced concrete framed-tube structures”. Archieves of civil and mechanical engineering (Volume 10),2010,pg 230-241.
[19] Lee David and Ng Martin. “Application of Tuned Liquid Dampers for the Efficient Design of Slender Tall Buildings”. CTBUH Journal,2010 Issue IV,

WEBSITES

http://www.Sciencedirect.com – A website for downloading technical papers.
http://www.google.com – A website help for any type of search.
http://www.iit.ac.in/libarary.com - A website for searching articles in library.
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