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Comparative Study of Different Structural System with Steel Staggered Truss System

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Abstract

Staggered Truss System (STS) is a prospective steel structure system for high-rise buildings and staggered truss framing system is one of the effective design techniques to improve the efficiency of building. In addition, cost reduction arise from reduction in steel tonnage using this framing method. The purpose of this study is to carryout comparative analysis of moment resisting system, moment resisting system with shear wall, staggered truss system and staggered truss system with shear wall. In this analysis, different time histories are used. For the analysis, these structures are modeled in SAP2000 v18 and various displacement data are achieved for different types of system. After analysis of these four models, some outcomes are observed and it is concluded that displacement in staggered truss system reduced by 28% to 76% in transverse direction compared to moment resisting system. It is observed that the reduction in displacement for STS with shear wall is 7% to 43% in longitudinal direction but in transverse direction, the reduction of displacement is almost same as STS system. As per result Staggered truss with shear wall gives 46% to 76% less displacement in longitudinal direction & 28% to 77% less displacement in transverse direction for different near fault ground motion. After analyzing all data, it seems that staggered truss system with shear wall is more efficient than moment resisting system and moment resisting system with shear wall and staggered truss system.

1 Introduction

Staggered truss system was developed by Massachusetts institute of technology in USA. It is a new concept in structural steel framing system for high rise building. In this system column are located only at exterior faces of the building for achieving large column free area. For large scale building staggered truss system is successfully applied. STS is not considered as a basic seismic-force-resisting system so some research work should be carried out for STS system. In Indian standard there is no any guideline for staggered truss system but AISC gave guidelines for staggered

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truss system in "Design Guide 14" [1]. The STS should be provided at alternate floor level for achieving large column free area twice than column spacing. Staggered truss system is generally suitable for rectangular building [1]. Staggered truss system must be provided in shorter direction. For the connectivity between two corridors, one central opening is provided called vierndeel. Previous research work was carried out only for vierndeel truss, angle of incline truss [2], comparison between staggered truss and open web truss [3], comparison between gusset plate welding and direct welding [4]. But the use of steel plate shear wall in STS may be new direction of research work.

Table 1Standard properties of steel

Sr. No.	Property	Value
1	Yield strength of Fe 410 A	250 N/mm^2
2	Yield strength of Fe 490 A	350 N/mm^2
3	Density	7850 kg/m^3
4	Young's Modulus	2.1×10^5 N/mm^2
5	Poisson Ratio	0.3

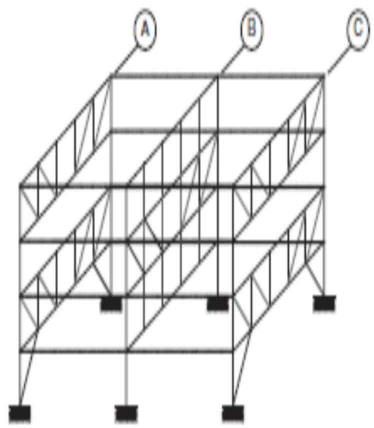


Figure. 1staggered truss system

MATERIAL PROPERTIES

Two materials are used Fe410 A and Fe490 B. For beam, column and incline truss Fe490 B is used. For shear wall Fe 410 A is used.

1.1 Problem formulation

One G + 7 storey building having plan dimension of 60 x 45m is modeled in SAP2000. All columns are fixed at the base. Staggered truss system is provided in shorter (y-direction) direction and in longer direction moment resisting system is provided. Strong axis of columns are oriented parallel to longitudinal direction. Material nonlinearity is considered for analysis in SAP2000. Indian Standard Wide Parallel Flange Beam (WPB) are used as columns. Aspect ratio for the shear wall is taken as one. For consideration of large column free area for STS system, columns areprovided in transverse direction at interval of 10 m and 5m for MR system.

Table 2 Section properties

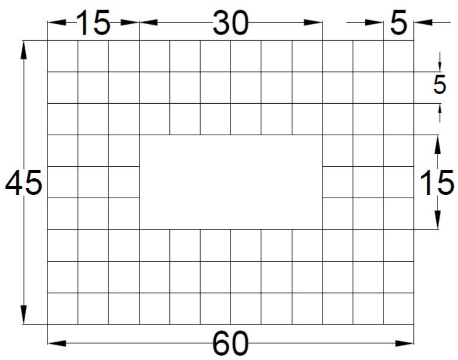


Figure. 2 Plan of building

Sr. No.	Name	Model 1 & Model 2
1	Dimension	60 × 45 m
2	Number of storey	8
3	Height of each storey	3 m
4	Column	WPB250× 250
5	Beam	ISMB 250, ISMB 200 ISMB 150
6	Type of floor slab	Concrete
7	Thickness of floor	0.19 m

Model 1: Structure with moment resisting system

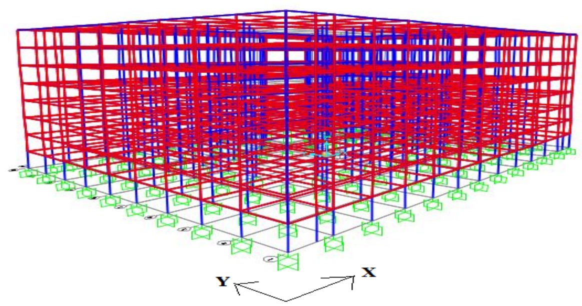


Figure. 3 Model 1:Moment resisting system

Model 2: Moment resisting system with 6 mm thick and 3 m wide steel shear wall at four corner in x-direction

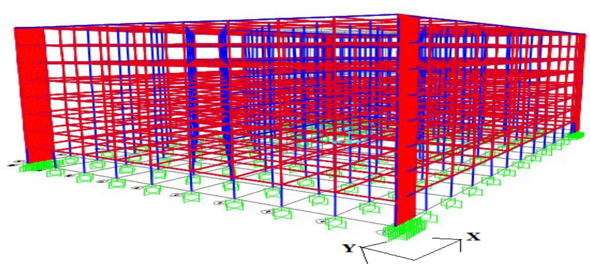


Figure. 4 Model 2: Moment resisting system with shear wall

Table 3 Section properties

Sr. No.	Name	Model 3& Model 4
1	Dimension	60 x 45 m
2	Number of storey	8
3	Height of each storey	3 m

4	Column Storey 1 to 3 Storey 4 to 5 Storey 6 to 8	WPB 400 × 400 WPB 250 × 250 WPB 200 × 200
5	Beam In transverse direction (*y*) In longitudinal direction (*x*)	ISWB 250 ISMB200,ISMB175
6	STS member	ISA 40 × 40 × 6
7	Type of floor slab	Concrete
8	Thickness of floor	0.19 m

Model 3: Structure with staggered truss system

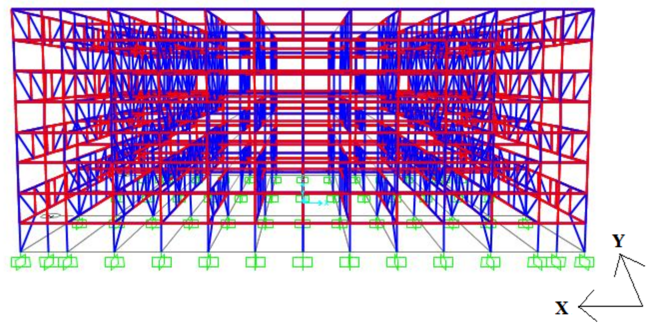


Figure. 5 Model3:Staggered truss system

Model 4: Structure with staggered truss system with 6mm thick and 3 m wide steel shear wall at four corner in x-direction.

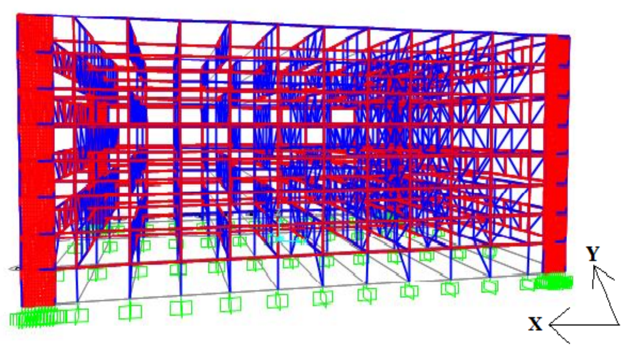


Figure. 6 Staggered truss system with shear wall

1.2 Loading Scheme

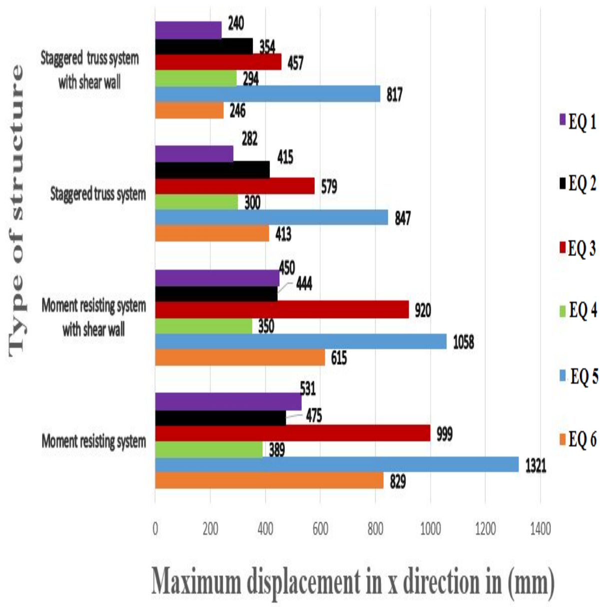
As per IS codal provision floor finishing, Live Load, Roof live load is 1 kN/m^{2,} 2 kN/m^2 & 1 kN/m^{2}respectively. Nonlinear dynamic time history analysis is carried out to investigate maximum displacement in *x&y* direction under different Near-fault ground motions.

1. October 15,1979 Imperial Valley, California (El centro Array #5) (EQ 1)
2. October 15,1979 Imperial Valley, California (El centro Array #6) (EQ 2)
3. January 17,1994 Northridge, California (Newhall) (EQ 3)
4. June 28, 1992 landers, California (Lucerne Valley) (EQ 4)
5. January 17,1994 Northridge, California (Rinaldi) (EQ 5)
6. January 17,1994 Northridge, California (Sylmar) (EQ 6)

Load combination is taken as per IS 1893-2002 Clause no 6.3.1.1

2 Result Data

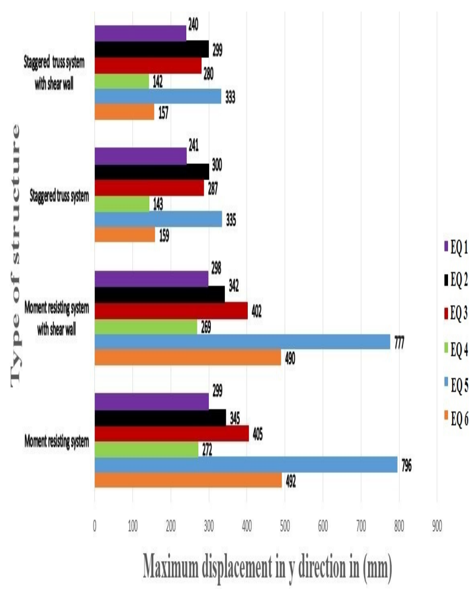
Table 4Maximum displacement in x direction (mm)



Near-fault ground motion	MR system	MR system with Shear wall	STS System	STS system with shear wall
EQ 1	531	450	282	240
EQ 2	475	444	415	354
EQ 3	999	920	579	457
EQ 4	389	350	300	294
EQ 5	1321	1058	847	817
EQ 6	829	615	413	246

Figure. 7 Maximum displacement in x direction in (mm)

Table 5Maximum displacement in y direction (mm)



Near-fault ground motion	MR system	MR system with Shear wall	STS System	STS system with shear wall
EQ 1	299	298	241	240
EQ 2	345	342	300	299
EQ 3	405	402	287	280
EQ 4	272	269	143	142
EQ 5	796	777	335	333
EQ 6	492	490	159	157

Figure. 8 Maximum displacement in y direction in (mm)

3 Conclusion

After analysis of these four models some outcomes are observed and it is concluded that displacement in staggered truss system reduced by 28% to 76% compared to moment resisting system in y direction. It is observed that the reduction in displacement in x direction for STS with shear wall is 7% to 43% but in y direction the reduction of displacement is almost same as STS system. As per result Staggered truss with shear wall gives 46% to 76% less displacement in x direction 28% to 77% less displacement in y direction for different near fault ground motion. After analysing all data, it seems that staggered truss system with shear wall is more efficient than moment resisting system and moment resisting system with shear wall and staggered truss system.

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