Comparative Study on Seismic Analysis of Light Gauge Cold Formed Steel and RC Building For Severe Seismic Zone

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Abstract- *Light gauge steel (LGS) frames are formed by framing thin cold-formed steel (CFS) sections into different elements such as floors, walls and trusses. LGS frames are usually combined with steel, gypsum, wood and fibre cement-based panels to form structural systems. A past research suggests the cost effectiveness of LGS construction with various other advantages for single storied building. This paper works out the cost effectiveness of the two storied LGS construction in seismic zone V (severe seismic zone). For comparison with RC construction, a two storied residential building was considered as a unit scale. Structural analysis, design and cost estimation was carried out for both techniques. The result shows that LGS construction is 22% cheaper and 4.45 times lighter than RC construction.*

Keywords- Cold formed steel, Light gauge steel framing (LGS), RC construction, severe seismic zone.

I. INTRODUCTION

The use of Light gauge cold formed steel members in building construction began in about the 1850s in both the United states and Great Britain. However, such steel members were not widely used in buildings until around 1940. After 1946 development and use of light gauge steel construction gained acceleration. Gradually, LGS is gaining acceptance and popularity all over the world. (1)

In LGS framing, Lipped C-sections are used for studs (i.e. vertical compression member of a wall assembly that supports vertical and/or transfers lateral loads) and joists (i.e. that supports the lateral loads on floor), blocking, web stiffeners etc. While C-sections without lips are used as for wall tracks, floor tracks and framed openings. General size used are shown in table 1. For rust protection galvanising is done. Different members are connected using self-drilling screws.

Web (mm)	Flange (mm)	Lips (mm)	Thickness (mm)
100	50	10-25	1, 1.2, 1.6, 2
150	50	10-25	
200	50	10-25	
250	50	10-25	

Table 1Seismic performance of a structure is the ability to withstand to lateral loads. A standard LGS panel alone is incapable of withstanding lateral loads. While close spacing of vertical members provide efficient gravity load carrying capacity. Lateral force resisting systems (LFRS) is defined as the structural elements and connections required to resist racking and overturning actions, because of wind, earthquake, or other predominantly horizontal force, and/or combinations thereof, imposed upon the structure in accordance with the applicable code. LFRS for LGS falls into the following categories (a) shear walls clad with face sheathings such as plywood, plasterboard or steel sheets; (b) CFS frame strap-braced wall systems; (c) some frame-connection systems such as special bolted moment frames; (d) podium-type structures, where a complete load bearing LGS frame is built atop lower levels of other structures; and (e) mixed (hybrid) systems. (2)

II. PROBLEM STATEMENT

For comparison between LGS and RC construction, a two storied residential building was selected a unit scale with the following geometrical properties

Length = 12 m
Width = 9.5 m
Storey height = 3 m
Total height = 6 m
Plinth area = 114 sqm (1226.5 square ft.)

The LFRS system used in this work is LGS frame strap braced wall systems in which steel straps are diagonally attached to the flanges of studs forming X bracing along with horizontal straps (bridging or noggins).

III. ANALYSIS AND DESIGN

3.1 *Design parameters*

Following loads were taken from the respective Indian codes

(a) Dead load (IS: 875 PART 1 -1987)
(b) Imposed load (IS: 875 PART 2 -1987)
(c) Seismic load (IS: 1893 PART 1 -2002)
(d) Wind load (IS: 875 PART 3 -2015)

3.2 *Seismic parameters*

Following parameters were used for seismic analysis and design as per IS: 1893 (part 1): 2002

(a) Seismic zone V
(b) Zone factor, Z = 0.36
(c) Importance factor, I = 1
(d) Response reduction factor, R = 4
(e) Soil type, ST = Type 2 (Medium soil)
(f) Damping ratio, DM = 5%

3.3 *Wind parameters*

(a) Basic wind speed, Vb = 55 m/s
(b) Design life = 50 years
(c) k1, k2, k3, k4=1
(d) Height factor = 0.8
(e) kd, kc = 0.9
(f) ka = 0.8
(g) External pressure coefficients, Cpe

Transverse winds
Sidewall: 0.7 (Windward), 0.2 (Leeward)
Endwall: 0.5
Longitudinal winds
Endwall: 0.7 (Windward), 0.2 (Leeward)
Sidewall: 0.5
(h) Internal pressure coeff, Cpi =+/- 0.5

3.4 *Analysis and design of LGS structure*

For analysis of LGS structure STAAD Pro. V8i (Select series 6) was used. For design, IS 801: 1975 (Indian standard code of practise for use of cold-formed light gauge steel structural members in general building construction). Indian code includes allowable stress design (ASD) method.

3.5 *Analysis and design of RC structures*

Analysis and design of RC building was performed using STAAD Pro. V8i (Select series 6) by using Indian standard codes IS 456: 2000 (Limit State Method) and IS 13920: 1993 for ductile detailing. STAAD foundation 5.3 was used for analysis and design of foundation.

Grade of concrete – M25
Grade of steel reinforcement – Fe415
Figure 3,4 shows the model of RC structure.

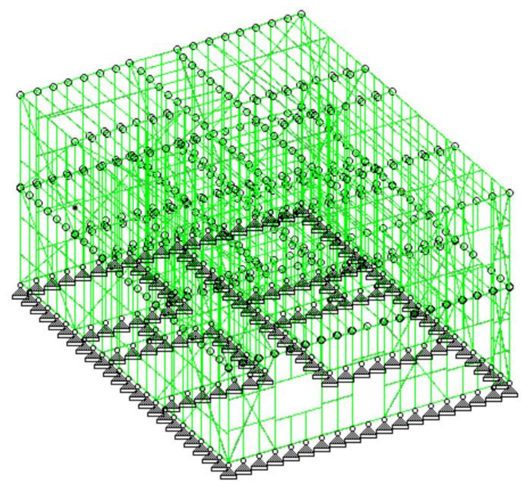

FIGURE 1

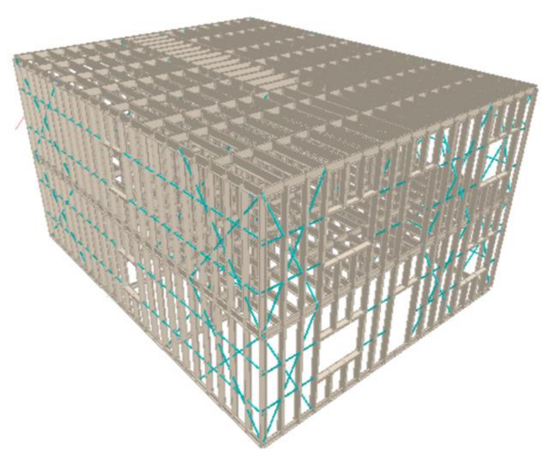

FIGURE 2

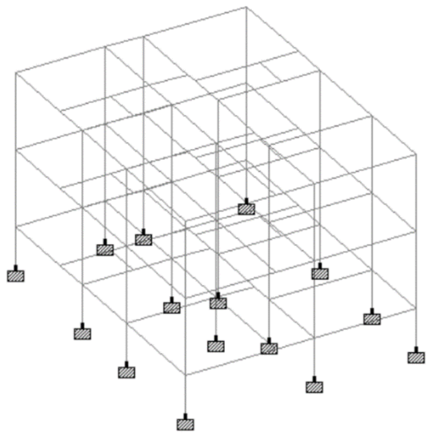

FIGURE 3

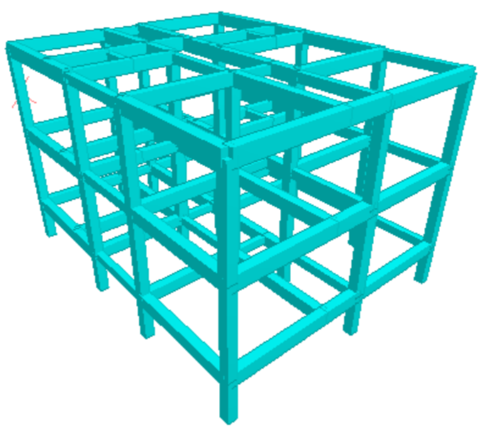

FIGURE 4

III. RESULTS

Table 2 exhibits detailed comparison of design outputs for two technologies. It can be observed from Table 2 that the depth of the footing for RC structure is large as compared to that for LGS. It means that there is much saving in excavation for foundation. Size of beams for RC structure is 300 mm x 450 mm while that for LGS is C200mm x 50mm x 10 mm x 1.2 mm. Size of column for RC structure is 300 x 300 mm while that for LGS structure is C150mm x 50mm x 1 mm.

TABLE 2

TYPE	RC STRUCTURE	LGS STRUCTURE	
A	BEAMS	JOISTS	FLOOR TRACKS
	WIDTH DEPTH THK	WEB FLANGE LIP THICKNESS	WEB FLANGE THICKNESS
1	300 MM × 300 MM	C200mm x 50mm x 10 mm x 1.2 mm	C200mm x 50mm x 1.2 mm
2	300 MM × 400 MM	C200mm x 50mm x 10 mm x 1.6 mm	C200mm x 50mm x 1.6 mm
3	300 MM × 450 MM		
B	COLUMNS	STUDS	WALL TRACKS
1	300 MM × 300 MM	C150mm x 50mm x 10 mm x 1 mm	C150mm x 50mm x 1 mm
1	300 MM × 400 MM	C150mm x 50mm x 10 mm x 1 mm	C150mm x 50mm x 1 mm
C	SLAB	DECK SLAB	DECK SHEETING
	100 MM	100 MM	0.5 MM
D	FOUNDATION	FOUNDATION	
	ISOLATED FOOTING	RAFT	
	2 M 2 M 250 MM	125 MM	
E	WALL		
	BRICK WALL	WALL SHEETING	WALL INSULATION
EXTERIOR	230 MM	6 MM	
INTERIOR	150 MM	12.5 MM	75 MM

IV. COST ESTIMATION AND WEIGHT CALCULATION

Quantities of material were calculated using design results and geometry of the structure in detail. To estimate the cost of the project:" Central public works department Delhi schedule of rates 2018". Table 3 shows cost estimation of RC building. Table 4 shows cost estimation of LGS building Figure 5 shows the unit cost per square feet of building.

TABLE 3

COMPONENTS	MATERIALS	QUANTITY	UNIT	UNIT RATE	COST (Rs.)
COLUMNS+BEAMS	CONCRETE	46	M3	9500	437000
	STEEL	4400	KG	82.2	361680
WALL	BRICKWORK	80	M3	7500	600000
FOUNDATION	CONCRETE	11	M3	9500	104500
	STEEL	780	KGS	82.2	64116
	EXCAVATION	90	M3	300	27000
SLABS	CONCRETE	29	M3	9500	275500
	STEEL	1800	KGS	82.2	147960
				TOTAL	2017756
				AREA	1226.5
				Rs. /SQft	1645

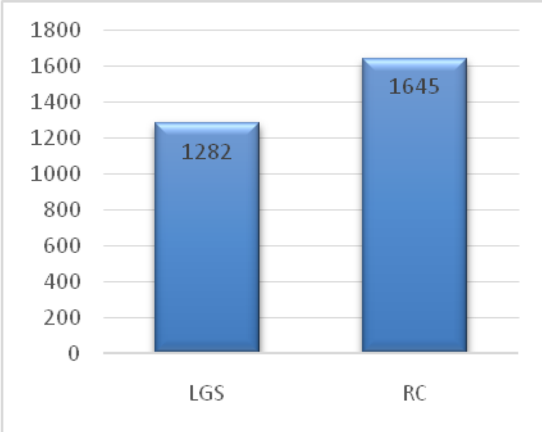

Figure 5.

TABLE 4

COMPONENT	MATERIAL	QUANTITY	UNIT	UNIT RATE	COST (Rs.)
JOISTS& STUDS	LGS	4880	KGS	147	717360
BRACINGS	HRS	770	KGS	70	53900
DECK SLAB	CONCRETE	23	M3	9500	218500
DECK SHEET	STEEL	1100	KGS	70	77000
SELF DRILLING SCREWS	STEEL	75	KGS	180	13500
ANCHOR BOLTS	STEEL	50	KGS	80	4000
WALL SHEETING	FIBRE CEMENT BOARDS	260	M2	320	83200
	GYPSUM BOARDS	720	M2	200	144000
WALL INSULATION	GLASSWOOL	360	M2	280	100800
FOUNDATION	CONCRETE	14.25	M3	9500	135375
	STEEL	300	KGS	82.2	24660
				TOTAL	1572295
				AREA	1226.5
				Rs. /SQft	1282

The total cost of constructing the same facility by RC, LGS techniques was found to be 15,72,295 and 2,017,756 in Indian rupees respectively. It implies that LGS technique is 22% cheaper than RC construction. The total weight of RC and LGS superstructure is 338.2 tons and 76.375 tons respectively.

V. CONCLUSION

1. LGS building is 22% cheaper than RC building in a severe seismic zone V.
2. LGS structures are 4.45 times lighter than RC structures.
3. LGS structures require 2-3 weeks while RC structures require 2-3 months for completion.

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VI. FUTURE SCOPE

Hence, LGS structures are recommended for two storied buildings over RC constructions. Further research is required to check suitability and cost effectiveness of 3-4 storied LGS structures in high seismic areas.

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