SEISMIC PERFORMANCE OF LIGHTWEIGHT CONCRETE COMPARED WITH NORMAL WEIGHT CONCRETE BY PROVIDING SHEARWALLS

[1]Bandla Venkatarao,[2]P.N.V.V.S.P. Kiran,[3]Bandela Srinu,[4]Tatapudi Lokesh, [5]J. Lakshmi Sudha
[1]UG Student, Department of Civil Engineering, Godavari Institute of Engineering & Technology(A), Rajahmundry, AP, India
[2]UG Student, Department of Civil Engineering, Godavari Institute of Engineering & Technology(A), Rajahmundry, AP, India
[3] UG Student, Department of Civil Engineering, Godavari Institute of Engineering & Technology(A), Rajahmundry, AP, India
[4] UG Student, Department of Civil Engineering, Godavari Institute of Engineering & Technology(A), Rajahmundry, AP, India
[5] Assistant Professor, Department of Civil Engineering, Godavari Institute of Engineering & Technology(A), Rajahmundry, AP, India

***Abstract*:**Concrete structures are prone to earthquake due to mass of the structures this should be minimized by replacing normal weight concrete by structural lightweight concrete. The primary use of structural lightweight concrete is to reduce dead load of structure which results in reduction of inertia forces in the structure. Lightweight concrete has the low density of range 1440 to 2400 kg/m^3 according to ACI-318R while the normal weight concrete has a density of 2400 kg/m^3. In this study, we use lightweight concrete of density 1800kg/m^3. The low density of lightweight concrete is achieved by the use of lightweight aggregates. In this study, A G+5 multi-storied RCC structure is considered. The structure is modeled using standard software i.e., STAAD Pro V8i SS6 (Structural analysis and aided design) with lightweight concrete and same structure is modeled with normal weight concrete by providing shear walls at four corners of the building. The structure is now subjected to response spectrum analysis and storey drifts, storey displacements, base shear, bending moment, shear force, and variation in steel quantity are found out for various load combinations with the aid of IS 1893-2002 (Part-1).

***Keywords*–Lightweight concrete, Normal weight concrete, Shear wall, Response spectrum method.**

1. INTRODUCTION

During an earthquake, ground motions occur in a random fashion in all directions radiating from hypo-center. These ground motions cause structures to vibrate and influence inertial forces on them. If structure has not been designed to resist these additional forces, it may fail causing loss of life and property. Thus, the building should be designed with the view in mind to resist minor, moderate and major levels of earthquake ground motion possibly with minimum structural damage and without structural collapse.As the structural concrete offers low density than the normal weight concrete. It is adoptable for construction of buildings in seismic zones. Due to its light weight, the member self-weight (Dead load) is reduced and the effect of lateral loads on the structure is considerably reduced.

In the seismic design of buildings, shear walls are one of the excellent means of providing earthquake resistance to multi-storey buildings. In high rise buildings, it is very important to ensure adequate lateral stiffness of resist lateral loads. The provision of shear walls is to achieve rigidity has been found effective and economical.

The aim of present work is to study the effect of use of light weight concrete structurers with provision of shear walls in seismic areas.

2. LITERATUREREVIEW

SwamyNadhVandanapu, Muthumani Krishnamurthy. "Seismic performance of lightweight concrete structure". In this two models are designed by using STAAD Pro. One represents by using Normal Weight Concrete and other represents Light Weight Concrete (LWC).The seismic analysis of the structure is functionally depending on dead load and the earthquake forces acting on that.He founded that LWC structure which is subjected to seismic analysis resulted in less bending moments and shear forces which results in reduce the cross section of members or to reduce the steel in moment and shear resisting sections.

Dr. P. S. Pajgade, P.P. Chandurkar"Seismic analysis of RCC building with and with-out shear wall". In this four different models with different positioning of shear walls in building were studied in all zones are done and found that shear wall on corners is more effective, when compared with other positions. Providing shear walls at adequate locations substantially reduces the displacements due to earthquakes.

Mr. Romy Mohan, Mr. ChomPraba "Dynamic analysis of RCC building with shear wall In this a seven storey and eleven storey models with different sections of shear walls are modelled and seismic analysis is carried out by equivalent static method, response spectrum analysis and time history analysis methods.It is found that square shaped shear wall is more effective and "L" shaped section shear wall is least effective. He founded that Equivalent static method can be used effectively for symmetric building up to a feet of 25m.For higher unsymmetrical building, response method is used. Time history analysis method is more accurate in predicting the structural seismic response, when compared with other two methods.

Mohd Danish, MohdShariq, Zaid Mohammad , Amjad Masood " Seismic performance of RC buildings with shear wall ". In this, proper finite element analysis of RC frame models i.e., bare frame, 2 frame with shear wall considering infile, 2 frame with shear wall has been carried out.The number of storey vary as G+3, G+5, G+7, G+9 and response spectrum analysis is carried out.It is found out that increasing number of storeys result in increasing lateral movement causing more storey drift.In-file and shear wall enhance the rigidity and strength of the frame structure.

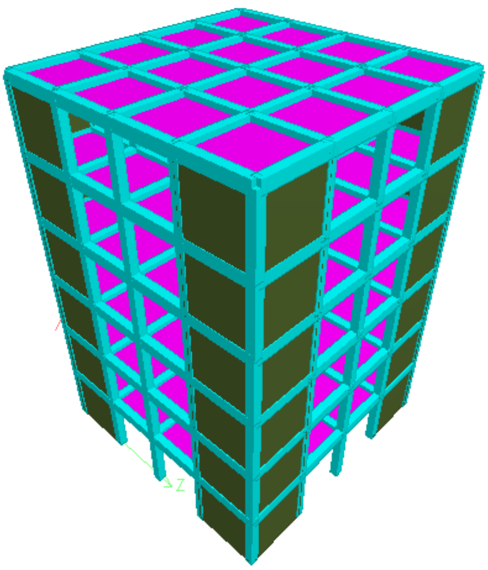
Chandan Nirmal, Dr. SK Jaiswal" Dynamic analysis of high rise building structure with lightweight concrete ".In this structure is modelled with structural lightweight concrete frame for (G+14) and seismic analysis is carried out by response spectrum method in seismic zone II. As per "IS 1893-2002 Part 1. He observed that Lightweight concrete structural members have lower value of shear force and bending moment applied as a result of seismic forces. Lightweight concrete due to lower density reduces effect of seismic vibrations and reduces threat of structural collapse. Amount of reinforcement used in lightweight concrete structure is less than the reinforcement used in NWC structure.

Dr. H. J. Shan, Dr. Sudhirr K Jain." Design example of a six storey building ".In this a six storey (G+5) building situated in vadodara city 'Zone III' was designed and analyzed with the aid of I S 456-2000 and seismic analysis is carried out with the help of IS 1893-2002 (Part 1).

3. REQUIRED DATA AND METHODOLOGY:

3.1 DESIGN DATA

Seismic zone	:	IV	
Live load	:	Typical floor load	= 4 kN/m^2
	:	Terrace load	=1.5 kN/m^2
Dead load	:	Floor finish load	= 1 kN/m^2
	:	Terrace finish load	=1 kN/m^2
Type of soil	:	Type 2 , Medium soil	
Support condition	:	Fixed	
Walls	:	230 mm brick walls at periphery	
Concrete grade	:	M 35	
Steel grade	:	Fe 500	
Size of column	:	600 mm x 600 mm	
Size of beams	:	600 mm x 800 mm	
Shear wall thickness	:	500 mm	
Slab thickness	:	120 mm	
Shear wall position	:	At 4 corners of the building	
Software	:	STAAD Pro V8i	
Storey height	:	5 m	
Number of stories	:	G + 5	



3-D View

LOAD COMBINATIONS:

1. 1.5(DL+LL)
2. 1.2(DL+LL)
3. 1.2(DL+LL+RL)
4. 1.2(DL+LL-RL)
5. 1.5(DL+RL)
6. 1.5(DL-RL)
7. 0.9DL+1.5RL
8. 0.9DL-1.5RL

Where DL = Dead Load
LL = Live Load
RL = Response spectrum Load

3.2 METHODOLOGY OF STRUCTURE:

A multi-storey residential building with (G+5) storey's located in seismic zone-IV is analyzed according to IS 456:2002. For the analysis, a light weight concrete structure frame is simulated in STAAD.Pro V8i. The building is provided with shear wall system at all four corners of thickness 300mm and length 5m.The dead loads and line loads are considered from IS 875:1987 Part-I and IS 875:1987 Part-II respectively.In order to determine the design earthquake force and distribute along the different floor levels of the building response spectrum analysis is done for various load combinations with the aid of IS 1893:2002 (Part-I) and maximum storey displacements, storey drifts, maximum shear force, maximum 8m is obtained. To reduce the complexity and to increase accuracy of analysis STAAD.Pro V8i is used.The member of storeys are increased to (G+7) and then to (G+9). The vulnerability in increasing the height is ascertained in terms of storey drift and optimum number of storeys with in the permissible limits is found out. The same procedure is followed with the normal weight reinforced RCC frame and the results are compared in terms of graphical representations.

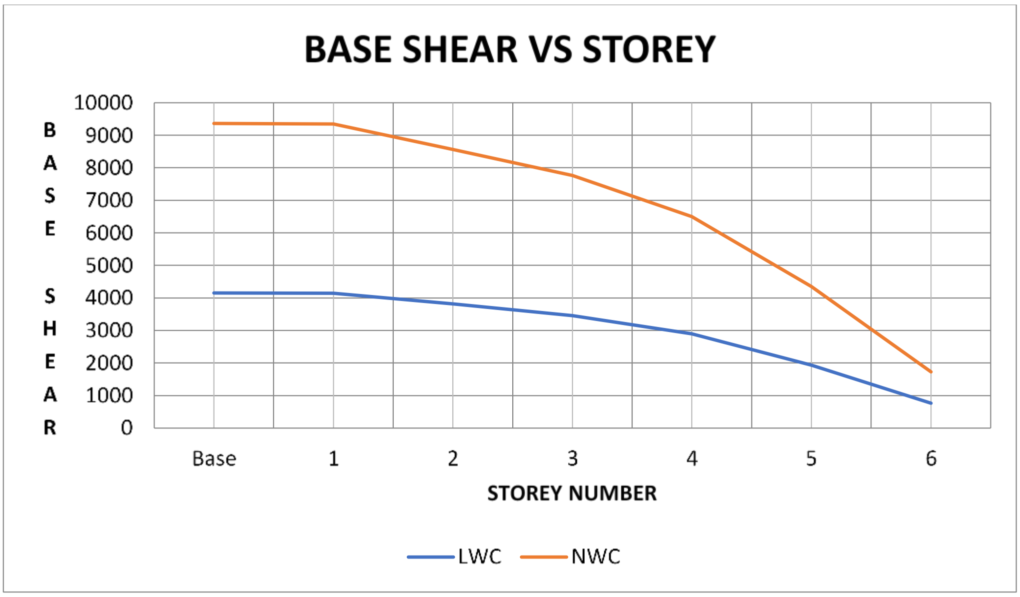
PROPERTIES OF LIGHTWEIGHT :

The material properties are considered from ACI 213R-03 Guide for structural lightweight-aggregate concrete.
Density = 18 kN/m^3
Coefficient of thermal expansion = 9 x10^-6 mm/°c
Poission's ratio = 0.21
Young's modulus (E) = $0.043 \times W^{1.5} \times \sqrt{f_c}$
= 19426.98 N/mm^2
Grade of concrete = M_{35}

4. RESULTS AND DISCUSSIONS:
BASE SHEAR

STOREY	LEVEL (m)	PEAK STOREY SHEAR (kN) for NWC	PEAK STOREY SHEAR (kN) for LWC
6	30	962.81	764.23
5	25	2408.34	1937.23
4	20	3603.23	2896.89
3	15	4301.26	3458.48
2	10	4752.17	3811.91
1	5	5200.80	4140.45
BASE	0	5211.81	4149.21

Peak story shear

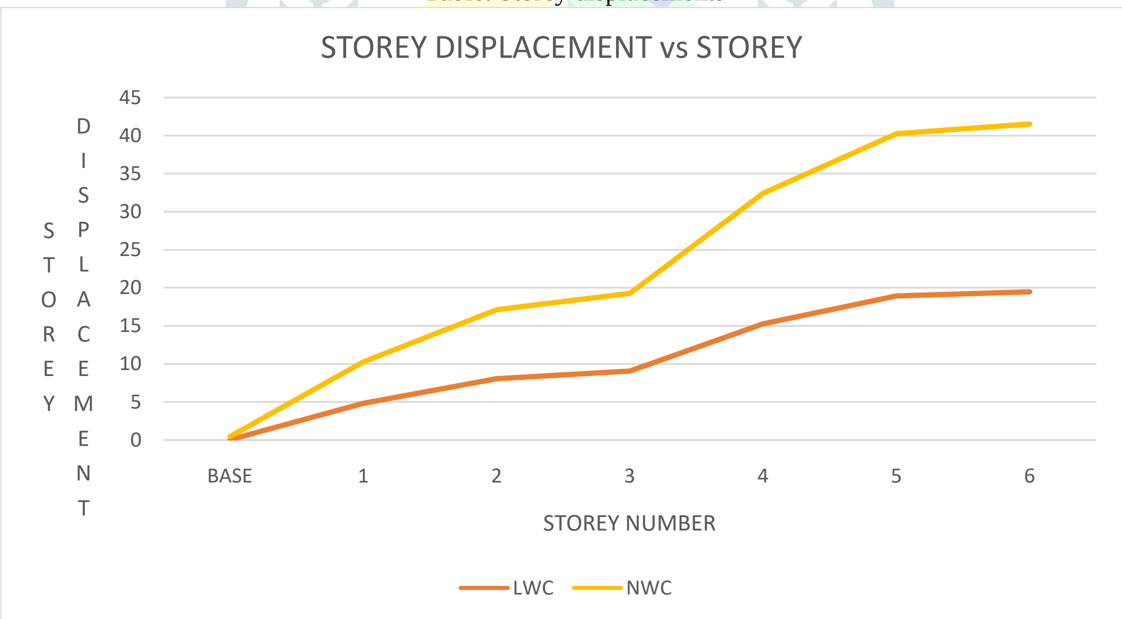


Base shear v/s storey number

STOREY DISPLACEMENTS

STOREY	HEIGHT (m)	DISPLACEMENT(cm) for NWC	DISPLACEMENT(cm) for LWC
BASE	0	0.426	0.0408
1	5	5.4219	4.8279
2	10	9.0720	8.0505
3	15	10.2465	9.0421
4	20	17.2112	15.2497
5	25	21.3621	18.9214
6	30	22.0869	19.4599

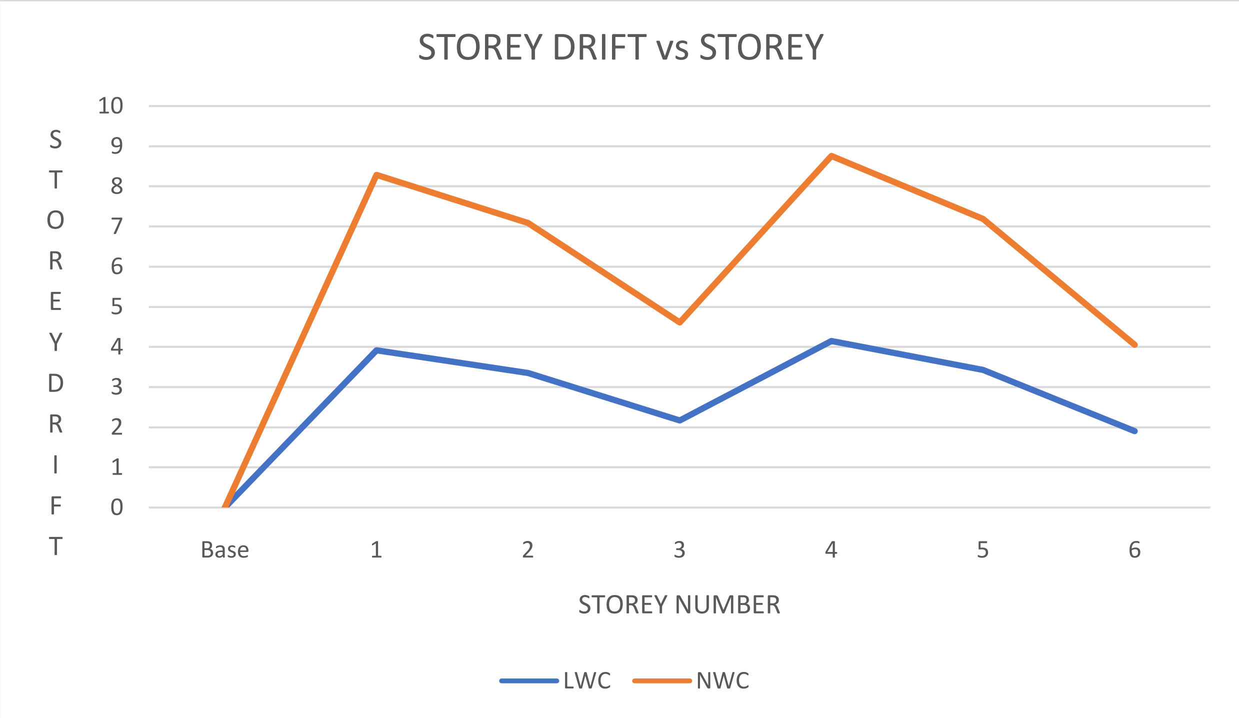
Table: Storey displacements



Graph: Storey displacement v/s storey number

STOREY DRIFTS

STOREY	HEIGHT (m)	STOREY DRIFT(cm) for NWC	STOREY DRIFT(cm) for LWC
BASE	0	0	0
1	5	4.3787	3.9111
2	10	3.7366	3.3496
3	15	2.4466	2.1627
4	20	4.6140	4.1428
5	25	3.7686	3.4232
6	30	2.1544	1.9000

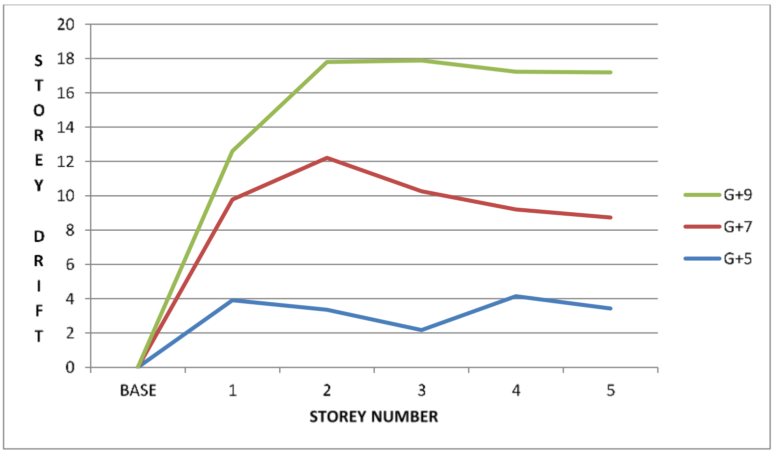


Graph: Storey drift v/s storey number

STOREY DRIFTS FOR LIGHTWEIGHT COCRETE STRUCTURE FOR INCREASED STOREY NUMBER

STOREY	HEIGHT (m)	For (G+5) in (cm)	For (G+7) in (cm)	For (G+9) in (cm)
BASE	0	0	0	0
1	5	3.9111	5.8683	2.8223
2	10	3.3496	8.8518	5.5930
3	15	2.1627	8.0871	7.1285
4	20	4.1428	5.0508	8.0374
5	25	3.4232	5.3116	8.4588
6	30	1.9000	8.0451	8.5329
7	35		7.6379	8.3649
8	40		4.3790	8.0537
9	45			7.6784
10	50			7.2678

Table : Storey drifts for increased storey number



Graph: Storey drift v/s storey number

MAXIMUM BENDING MOMENT AND MAXIMUM SHEAR FORCEFOR SELECTIVE BEAMS :

The bending moments and shear forces of lightweight concrete structural elements are also reduced due to reduction in dead load of the structure.

BEAM NO	LOAD CASE	MAX BM (kN-m) FOR NWC	MAX BM (Kn-m) FOR LWC	MAX SF (kN) for NWC	MAX SF (kN) for LWC
6	9	398.156	168.259	206.054	63.331
7	9	424.617	177.525	161.782	68.963
10	9	629.895	258.747	287.950	141.454
11	9	644.994	168.281	203.617	114.383
14	9	622.914	152.280	291.535	49.645
15	9	676.006	172.447	219.089	64.403
63	6	625.913	221.449	300.395	128.798

Table: Max BM and Max SF

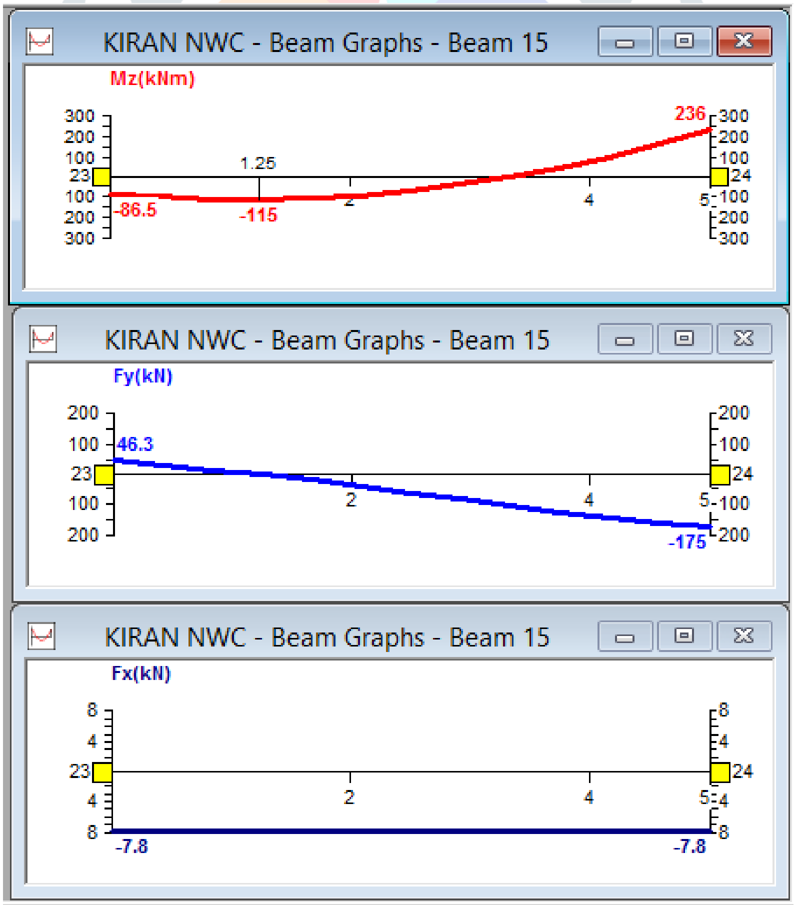


Fig: Beam graphs for NWC

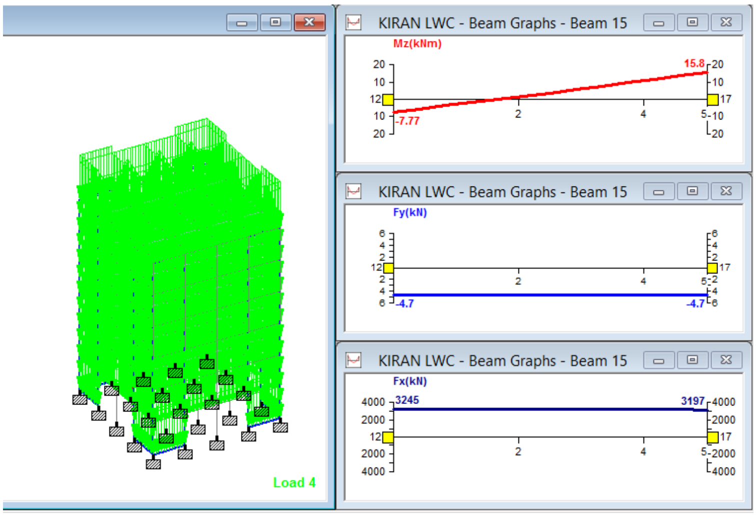


Fig: Beam graphs for LWC

- **STEEL QUANTITY:** The steel quantity in structural lightweight concrete structure is reduced when compared to normal weight concrete structure due to flexibility and ductility.

For normal weight concrete:
Steel quantity = 1083483N
For lightweight concrete:
Steel quantity = 1026464N
Reduction in steel quantity = 1083483-102646
= 57019N
Reduction in percentage = $\frac{1083483-1026464}{1083483} \times 100$
= 5.26%
.

5.CONCLUSIONS:

- The structural lightweight concrete has the advantage over the normal weight concrete in the following aspects when it is used in seismic zone IV

1. The base shear is reduced by 20.38%
2. Storey displacements are reduced by 12.55%
3. Storey drifts are reduced by 10.63%

- This is due to low density and reduced modulus of elasticity of structural lightweight concrete.
- The bending moments and shear forces of lightweight concrete structural elements are also reduced due to reduction in dead load of the structure.
- The steel quantity in structural lightweight concrete structure is reduced by 5.26% when compared to normal weight concrete structure due to flexibility and ductility.
- The storey drifts of lightweight concrete structure are increased gradually with the increase in number of stories from G+5 to G+7 then to G+9. So, the storey drifts are proportional to the height of the structure and structure becomes more vulnerable to seismic forces with the increase in height.

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