Dynamic Analysis of High Rise Building Structure with Lightweight concrete

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Abstract— Structural construction industry is growing as it has never been before; there is constantly something under new construction, even at places of odd habitats, thus; it requires to-pay direct attention in specific stresses generated by various loads in buildings via Dead load or Live load. Seismic forces are occasionally acting under internal earth mass disturbance but have high impact on the structural proficient unity of the building.

Structural lightweight concrete works offers design flexibility, ductility and substantial economy by providing less dead load, improved seismic structural response, lesser depth sections, and decreased story height, structural members and lesser percentage of reinforcing steel in substructure and superstructure saving cost as well as duration of construction.

Key Words— *Seismic Loads, Light weight concrete, Flexibility & Ductility*

1. INTRODUCTION

Most of the buildings, which do not full fill the current seismic requirements, may suffer extensive damage or even collapse if shaken by a severe seismic ground motion. The aim is for assessment is to assess the seismic capacity of earthquake vulnerable buildings or earthquake damaged buildings for the future analysis use. The evaluation may also prove helpful for degree of intervention required in seismically deficient structures. Over the last decade or more, other valuable and practical non-destructive evaluation methods have been developed for relatively rapid inspection of damage and deterioration of reinforced concrete structures. The long history of earthquakes and age-old tradition of construction should have lead to the reasoning, logic and assumption that sufficient precautionary measures are to be included in these constructions to withstand the earthquake forces. But, on the converse, this is not the case. Past know-how has shown that collapse of non-engineered construction is the single largest factor contributing to the huge losses and casualties during earthquakes till now.

Earthquake resistant design of reinforced concrete buildings is a continuing area of research since the earthquake engineering has started not only in India but in other developed countries also. The buildings still damage due to one or the combine effect of other reason during earthquakes. In spite of all the weaknesses in the structure, either code imperfections or error in analysis and designs, the structural configuration system has played a vital role in devastation. The IS: 1893 (Part 1): 2002 has recommended building configuration system in Section - 7 for the better performance of reinforced concrete buildings during earthquakes.

The term lightweight concrete itself describes a wide range of special aggregate bases which might be used in place of normal weight concrete. The specific gravities and in terms of density of compactness of these aggregates are significantly lower than that of normal weight concrete aggregates. Lightweight concrete can be used for as lighter weight thermal insulate and non-structural as well as structural concrete composed of extremely light natural or manmade aggregate.

In this research work it is tried to describe the use of lightweight concrete for construction in seismic regions. Major interest is the behaviour of structure dominated by dead and seismic loading causing flexure deformation. Software based analysis of the multi-stories structure with lightweight concrete say having density 1900kg/m^{3}is compared with normal weight concrete having density 2400kg/m^3. The main specialties or properties of lightweight concrete are its low density and thermal conductivity. Its advantages are that there is a reduction of dead load, faster building rates in construction and lower haulage and handling costs.

1.1. Objective of Study.

The foremost objective of the present work is to examine the usability of the light weight concrete as a filling mass instead of normal weight concrete. Utility of lightweight concrete has been investigated by analysis on staad.pro software using response spectrum method.

1) To study the effect of use of light weight concrete in seismic areas.
2) To compare the compressive, flexural and ductility strength with the given design specification of reinforced light weight concrete in seismic areas.

2. LITERATURE REVIEW

Ninad P. Pawar et. Al. [1] "Ductility Requirements of Earthquake Resistant Reinforced Concrete Buildings" concluded that In earthquakes, failure of buildings occurs due to non-ductile behaviour of its components, so following members should be designed with appropriate ductile detailing, for flexural members. The structural elements and their connections enhance the ductility of the structure which will enable the structure to absorb energy during earthquake and to sustain large inelastic deformation without sudden collapse of the structure.

Barbara Chang [2] "Ductile Reinforced-Concrete Beam-Column Joints with Alternative Detailing" at EERI Annual Meeting February University of California, San Diego 2009 by found that Fracture of longitudinal beam rebar requires consideration (but for demands greater than 7% drift).

Abdel hamid Charif et. Al. [3], "Ductility of reinforced lightweight concrete beams and columns" in Latin American Journal of Solids and Structures vol.11 no.7 Rio de Janeiro Dec. 2014 found that Lightweight concrete members developed more ductile behavior than their normal concrete counterparts, and this enhanced ductility was more pronounced in columns subjected to axial compression forces.

Jan A. Overli et. Al. [4] "Increasing ductility in heavily reinforced LWAC structures" in Engineering Structures Volumes 62–63, Jensen founded that the ductility index proved to be the same for beams with fibre or stirrups, and was almost doubled for beams with both fibre and stirrups and The effect of adding steel fibre reinforcement in the compressive gradient zone of full-scale, over-reinforced LWAC beams was much more pronounced regarding ductility than the effect achieved from tests of stress–strain relationships on cylinders with the same fibre reinforced LWAC.

C. V. R. Murty et. Al. [5] "Some Concepts in Earthquake Behaviour of Buildings" a book published by Gujarat State Disaster Management Authority in (2002) shows the structural behaviour of various building members under various condition of seismic loading.

X.-K. Zou et. Al. [6] "Optimal seismic performance-based design of reinforced concrete buildings using nonlinear pushover analysis" published in Engineering Structures (2005) by concluded that, It has been demonstrated that steel reinforcement plays a significant role in controlling the lateral drift beyond first yielding and in providing ductility to an RC building framework. a restrictive move limit imposed on the steel reinforcement design variables is necessary to ensure a smooth and steady on vengeance of the inelastic drift design process.

3. METHODOLOGICAL BACKGROUND

The background for this dissertation project lies within; catastrophic loss of humman life and wealth after earthquake vibrations, leaving behind bulk of dismentalled and scraped mass of structure.Which is quite heavy and requieres large machineries and equipments for removing of debried scrap.

Heavier the mass higher will be the time period as well as the cost of removal and transpotation at damping site, too will be on higher side. Large and big machinery requires large amount of fuel consumption and higher operational cost. Most importantly lighter the building structure mass lesser will be the chances of casualty and faster will be the rescue operation if required at an reasonable cost.

The experimental setup was done to analyse the effects of structural lightweight concrete seismic behaviour in High - rise building by framing out simulation model in STAAD.Pro software tool. The building is having fifteen stories and overall 44.8 m assembled as G + 14. The building to be analysed here is completely made up of lightweight concrete; structural members includes both hoizontal and vertical members. The building is located at seismic zone II, which is highly prone to earthsake effects and regular seismic actions due to various internal disturbances.

Structural details of LWC (G + 15) building:

i.	Number of storey	=15 (G + 14)
ii.	Height of storey	= 2.8 m with G.F column and storey column 3.0 m
iii.	Cross-section of beams	= 350 x 300
iv.	Cross-section of columns	= as follows 350 x 400 in Outer section, 400 x 400 in intermediate section, 500 x 600 in core column and base.
v.	Span of beam =	4m(x-dir) & 4 m(y-dir).
vi.	Grade of concrete =	M35
vii.	Grade of steel =	Fe 415
viii.	Dead Load =	-1 factor load and -2.5 kN/m2 as floor load.
ix.	Live Load =	-1.5KN/m2 on Floor and -2 on beams.
x.	Seismic Load =	As per IS: 1893– 2002, with Z = 0.1,

xi. RF = 5, I = 1, SS = 1, DM = 0.045

Analysis of Building: Analysis is done by using STAAD. Pro under design consideration IS: 456 - 2000 and IS: 13920 - 1993.

Appling the response spectrum command loading for dynamic analysis. This capability allows for analyzing the structure for seismic loading. for any supplied response spectrum (either acceleration vs. period or displacement vs. period), joint displacements, member forces, and support reactions may be calculated. Modal responses are combined using the complete quadratic combination (CQC), methods to obtain the resultant responses. Results of the response spectrum analysis may be combined with the results of the static analysis to perform subsequent design. to account for reversibility of seismic activity, load combinations can be created to include either the positive or negative contribution of seismic results.

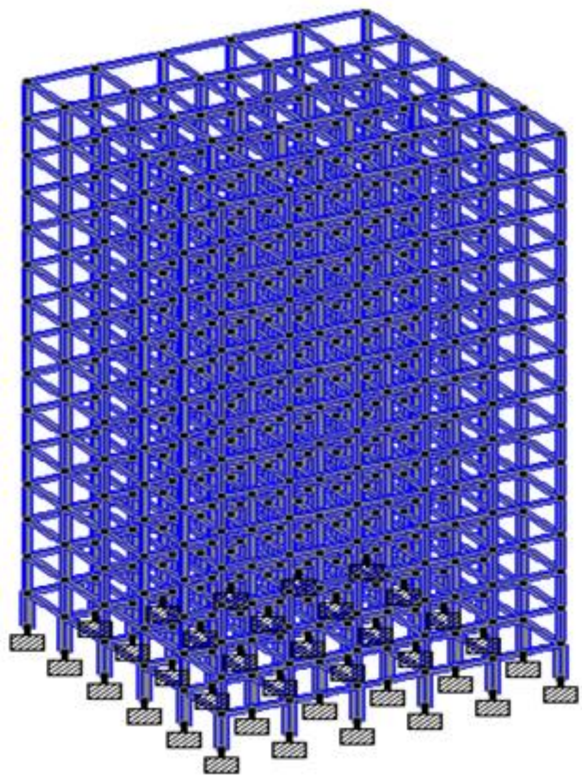

FIG. 3.1: LWC RCC structure framed in Staad.Pro

4. RESULT ANALYSIS

A light weight concrete structure is analyzed on the basis of codal provisions and in STAAD.pro software with different specifications of design details as specified previously in methodology. The result analysis is obtained by the software as per the feaded data. Here result is shown on the basis of tables and graphs obtained from analysis.

TABULAR RESULTS –

Table No. – 4.1 - Max Displacement under applied loads for M35 grade concrete with fe415.

	Beam	L/C	Node	Fx kN	Fy kN	Fz kN	Mx kNm	My kNm	Mz kNm
Max Fx	70	9 GENERATED INDIAN CODE GENRAL STRUCTURES 6	46	1886.193	-0.384	55.116	1.361	288.589	0.303
Min Fx	1435	1 LOAD CASE 1	3	-501.485	0.023	68.364	0.944	21.041	0.027
Max Fy	334	10 GENERATED INDIAN CODE GENRAL STRUCTURES 7	139	0.420	116.807	0.026	-0.013	-0.053	208.240
Min Fy	334	9 GENERATED INDIAN CODE GENRAL STRUCTURES 6	145	0.420	-116.807	-0.026	0.013	-0.053	208.240
Max Fz	91	10 GENERATED INDIAN CODE GENRAL STRUCTURES 7	15	1774.542	-0.346	141.177	0.575	-337.643	-0.812
Min Fz	97	9 GENERATED INDIAN CODE GENRAL STRUCTURES 6	21	1774.542	-0.346	-141.177	-0.575	337.643	-0.812
Max Mx	188	4 GENERATED INDIAN CODE GENRAL STRUCTURES 1	68	1597.267	63.416	3.217	12.194	7.749	100.078
Min Mx	187	4 GENERATED INDIAN CODE GENRAL STRUCTURES 1	103	1512.396	-63.416	-4.821	-12.194	-6.716	-93.789
Max My	74	9 GENERATED INDIAN CODE GENRAL STRUCTURES 6	50	1513.000	-0.012	127.697	1.197	344.559	-0.010
Min My	62	10 GENERATED INDIAN CODE GENRAL STRUCTURES 7	38	1513.000	-0.012	-127.697	-1.197	-344.559	-0.010
Max Mz	334	9 GENERATED INDIAN CODE GENRALSTRUCTURES 6	145	0.420	-116.807	-0.026	0.013	-0.053	208.240
Min Mz	334	11 GENERATED INDIAN CODE GENRAL STRUCTURES 8	139	0.252	-83.231	-0.026	0.013	0.053	-181.686

Table No. – 4.2 - Max beam forces and moments under applied loads for M35 grade concrete with fe415

	Beam	L/C	Node	Fx kN	Fy kN	Fz kN	Mx kNm	My kNm	Mz kNm
Max Fx	70	9 GENERATED INDIAN CODE GENRAL STRUCTURES 6	46	1886.193	-0.384	55.116	1.361	288.589	0.303
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Min Mz	334	11 GENERATED INDIAN CODE GENRAL STRUCTURES 8	139	0.252	-83.231	-0.026	0.013	0.053	-181.686

Table No. – 4.3 - Max beam stresses under applied loads for M35 grade concrete with fe415.

Mode	Frequency Hz	Period seconds	Participation X %	Participation Y %	Participation Z %
1	0.757	1.320	78.193	0.000	0.000
2	0.777	1.288	0.000	0.000	77.645
3	0.854	1.170	0.000	0.000	0.000
4	2.306	0.434	9.737	0.000	0.000
5	2.371	0.422	0.000	0.000	9.762
6	2.581	0.387	0.000	0.000	0.000

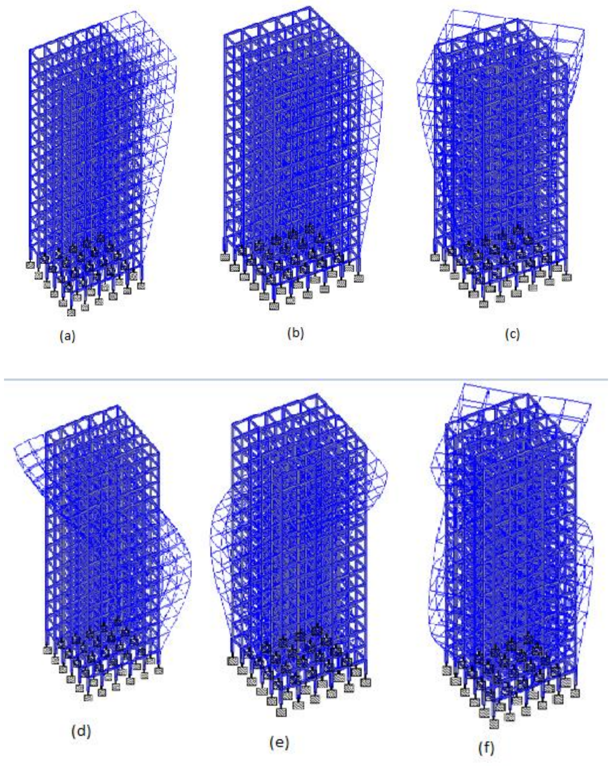
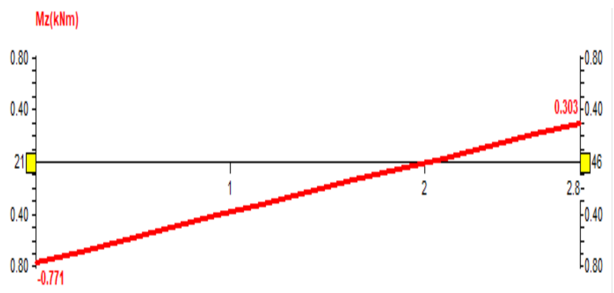
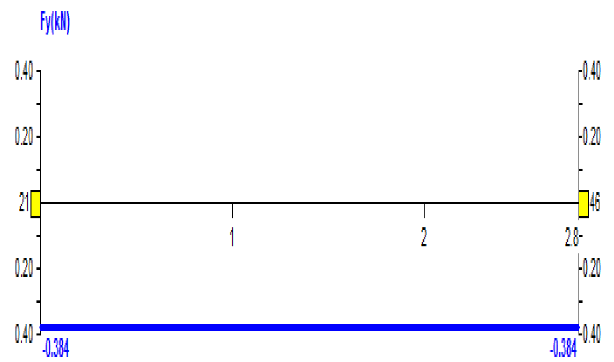


FIG. 4.1: Mode shapes (a, b, c, d, e & f) for LWC RCC structure framed in Staad.Pro

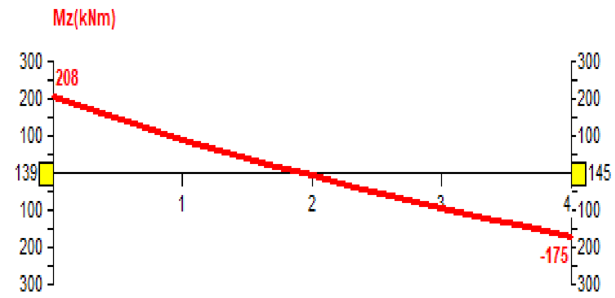
GRAPHICAL RESULTS –



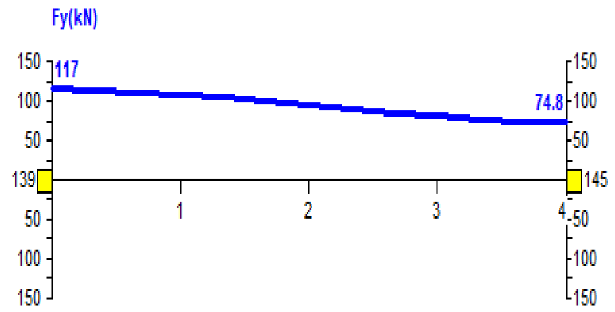
Graph No. 4.1. – Moments (z – Direction) critical Beam No. 70 under combination load - 9.



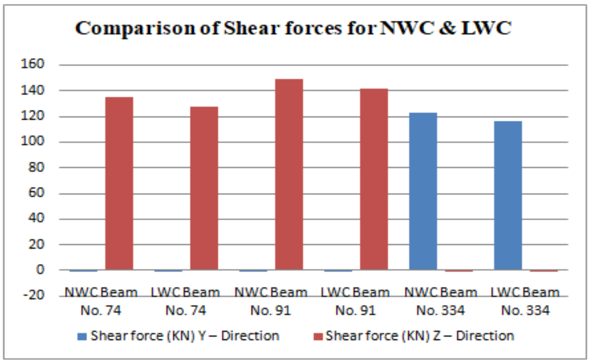
Graph No. 4.2. – Shear Force (y – Direction) critical Beam No. 70 under combination load - 9.



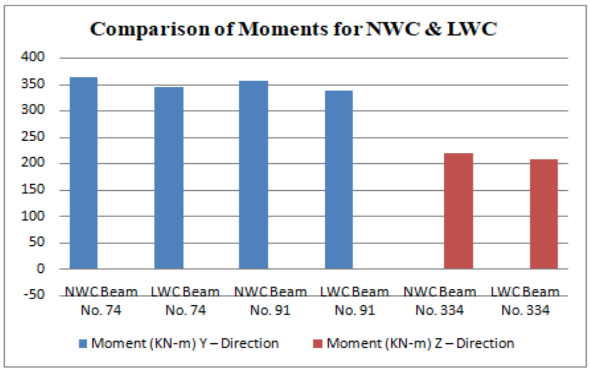
Graph No. 4.3. – Moments (z – Direction) critical Beam No. 334 under combination load - 10.



Graph No. 4.4. – Shear Force (y – Direction) critical Beam No. 334 under combination load - 9.



Graph No. 4.5. – Comparison of Shear forces for NWC & LWC under applied loads.



Graph No. 4.6. – Comparison of Moments for NWC & LWC under applied loads.

5. RESULT DISCUSSION.

Results as obtained from tabulated data and graphical representations shows that there is considerable fall down in shearing forces and moments along all coordinate axes under applied structural defined loads like; dead, live and seismic loadings. The loads causes significance vibrations, which make structure to deform or get displaced from connecting joints, or say; the node to node displacements. Data shows that the structural entity assembled is at most on critical side as if not properly investigated for seismic time period and its after affects (bursting of column and beams in lateral direction) which might be disastrous.

The confined detailed go-through in this research work study reveals that the Light weight concrete reduces effect of seismic vibrations and reduces threat of structural collapse under base shear, storey drift and soft storey effect. Lower density material reduces seismic vibration effect by allowing forces to pass through structural members. Amount of reinforcement required in Light weight concrete structure is lesser than Normal weight concrete as the value of moments get reduced. Danger of story drift under seismic response is reduced by increasing stiffness of members. Ductility of structure is also increased by using light weight concrete due to reduction in dense medium, which retards and dumps the seismic vibrations within it.

6. CONCLUSION

i. Light weight concrete structural members have lower value of joint displacement under axial and lateral loads applied as a result of seismic forces.
ii. Light weight concrete structural members have lower value of shear forces and bending moment applied as a result of seismic forces.
iii. Light weight concrete due to lower density reduces effect of seismic vibrations and reduces threat of structural collapse under base shear effect.
iv. Amount of reinforcement required in Light weight concrete structure made up of different grades like M35 lower the grade lesser will be the reinforcement area.
v. Amount of reinforcement required in Light weight concrete structure is lesser than Normal weight concrete.

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