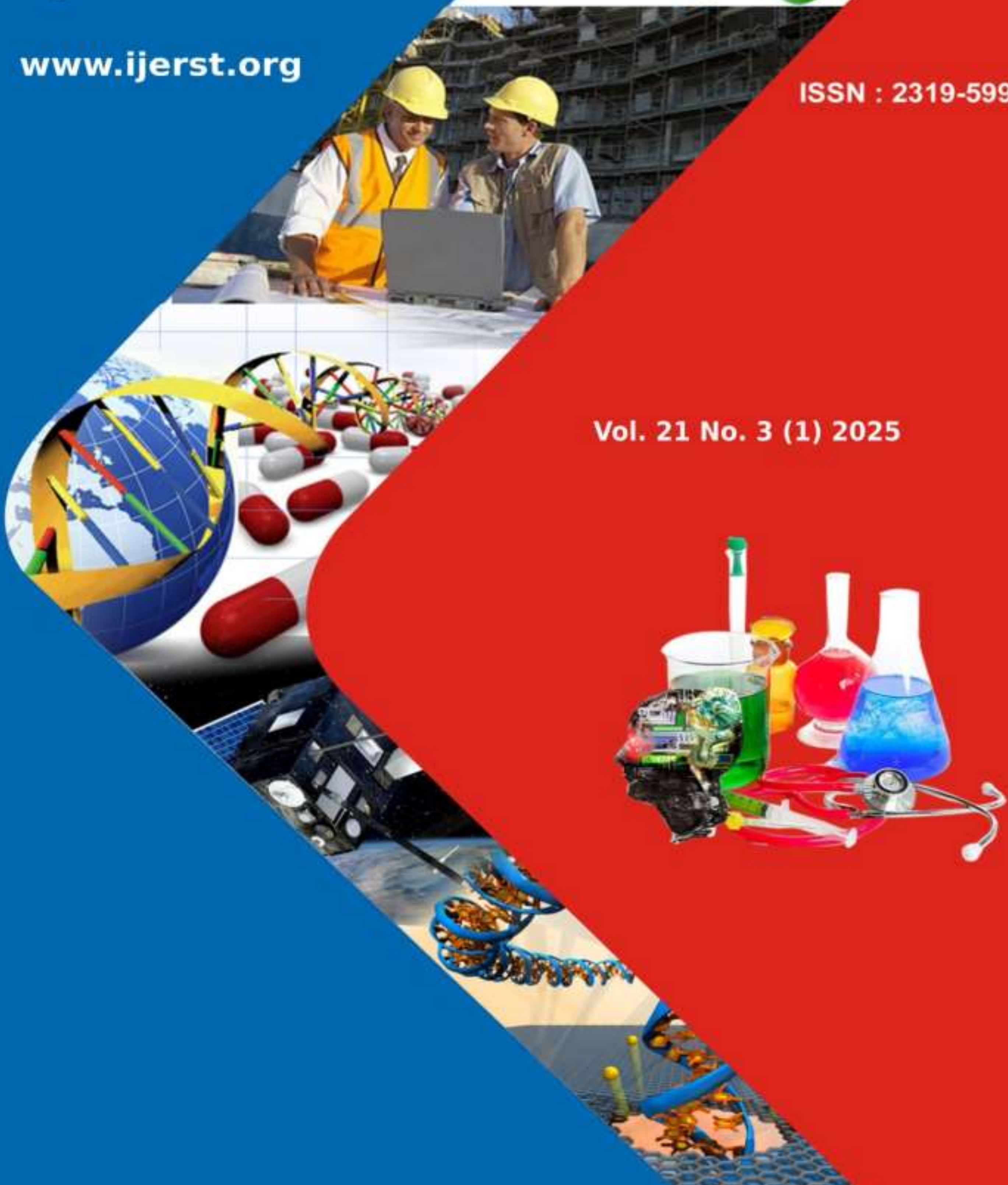
IJERST

International Journal of Engineering Research and Science & Technology

www.ijerst.org

ISSN : 2319-5991

Vol. 21 No. 3 (1) 2025



ijerst.editor@gmail.com

editor@ijerst.com

ISSN 2319-5991 www.ijerst.com
Vol. 21, No. 3(1), 2025
© 2025 IJERST. All Rights Reserved

Research Paper

STRUCTURAL ANALYSIS OF REGULAR AND IRREGULAR BUILDINGS WITH BUBBLE DECK SLAB AND CONVENTIONAL SLABS

CHILUMULA RAHUL[1], T.SUJATHA[2]

[1]M. Tech Student, Department of Civil Engineering, JNTUH University College of Engineering Sultanpur, Sultanpur, Choutkur, Telangana 502273

[2]Assistant professor, Department of Civil Engineering, JNTUH University College of Engineering Sultanpur, Sultanpur, Choutkur, Telangana 502273

Abstract *Slab is a structural member which plays an important role in transferring the load safely to beam and column. While designing the reinforced concrete structure the main parameter considered is the span of the slabs between columns. For designing larger span slabs, support beams or/and thick slabs are provided which results in heavy or large amount use of concrete and which results is increase of self weight of slabs. Lighter structures are mainly preferable than the heavier structures because a larger dead load for a building increases the magnitude of inertia forces the structure must resist as large dead load contributes to higher seismic weight. Incorporating support beams can also contribute to larger floor-to-floor heights which consequently increases costs for finish materials and cladding. So, to avoid the increase in self-weight of slab, the centre inactive concrete in slab is replaced with HDPE Balls (High Density Polyethylene Balls). The bubble deck is also known as voided slab. Use of spherical balls to fill the voids in the middle of a slab eliminates 35% of a slab self-weight compared to solid slab having same thickness without affecting its deflection behavior & bending strength. This helps in reduce of self weight, less emission of CO2 as less concrete will be used in slab and large spans in slabs can also be adopted. In short, the HDPE balls helps to fill the voids in centre of slab. Flat slab is a bolstered concrete slab supported at once by concrete columns without the use of beams. Flat slab is described as one sided or -sided support gadget with sheer load of the slab being concentrated on the helping columns and a square slab known as 'drop panels'. Drop panels play a big function here as they increase the overall capacity and durability of the floors device beneath the vertical hundreds thereby boosting cost effectiveness of the construction.*

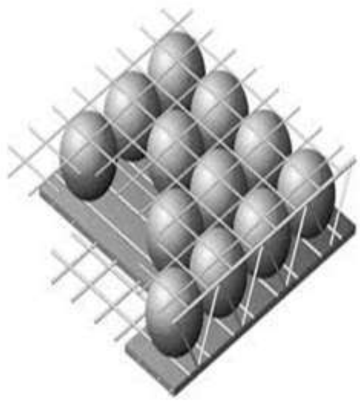
In the present study a comparative analysis of regular buildings and irregular buildings are carried out using flat slab, bubble deck slab for 10 storey building. The comparison of storey drift, storey shear, displacement, time period, frequency, bending values are compared with conventional slab using ETABS software.

Key words*: Flat slab, bubble deck slab, ETABS, HDPE, structural design, drift*

Received: 06-08-2025 Accepted: 08-09-2025 Published: 15-09-2025

1. Introduction

A slab is one of the most important structural building elements for distribution of load generated in the structure. The slab is generally of two types, one-way slab, the slab that primarily deflect in one direction are referred to as one-way slabs. And, when slabs are supported by columns arranged generally in rows so that the slabs can deflect in two directions they are usually referred to as two - way slabs. In the concept of bubble deck slab, the recycled spherical hollow blocks are placed in between the steel reinforcement. This creates voids in the slab and because of which, less concrete is been used during construction of the slab. The use of spherical balls to fill the voids in the middle of a flat slab eliminates 35% of a slab self-weight compared to solid slab having same thickness without affecting its deflection behavior & bending strength.



Bubble deck slab

Flat slab is a bolstered concrete slab supported at once by concrete columns without the use of beams. Flat slab is described as one sided or -sided support gadget with sheer load of the slab being concentrated on the helping columns and a square slab known as 'drop panels'. Drop panels play a big function here as they increase the overall capacity and durability of the floors device beneath the vertical hundreds thereby boosting cost effectiveness of the construction. Usually the peak of drop panels is ready two times the height of slab. Flat Slabs are considered appropriate for most of the development and for asymmetrical column layouts like flooring with curved shapes and ramps and so on. The advantages of making use of flat slabs are many like intensity solution, flat soffit and flexibility in layout layout.

Even though building flat slabs can be an luxurious affair however offers massive freedom to architects and engineers the luxurious of designing. Benefit of the use of flat slabs are manifold not simplest in phrases of potential layout and format efficacy but is likewise beneficial for total construction process in particular for alleviating off installation strategies and saving on production time. If feasible, try and remove drop panels as a good deal as viable and attempt to make the nice use of thickness of flat slabs. The purpose is to allow the advantages of flat soffits for the floor surface to be maintained, make sure drop panels are solid as part of the column.

Flat Slab

Objectives of the study

From this study the following objectives are made

1. To calculate the design lateral forces on bubble deck slab and Flat slab using response spectrum analysis and to compare the results of general slab.
2. To study three irregularities in structures namely mass, stiffness and vertical geometry irregularities.
3. To calculate the response of buildings subjected to various types of ground motions namely low, intermediate and high frequency ground motion using Response spectrum analysis and to compare the results.
4. To carry out ductility-based earthquake-resistant design as per IS 13920 corresponding to equivalent static analysis and time history analysis and to compare the difference in design

2. Literature reviews

Teodoro Esteban Amaya Astudillo.et al (2015)

In This project to first order structural analysis was Performed for the behavior of the application and BD slabs of esta system, Compared With waffle slabs systems. The models have been made inside the program

SAP2000, for the evaluation of the inner strain distribution, slab systems modeled have been With the inclusion of spheres of high density polyethylene; for the evaluation of BDS in application rates, different varieties of BDS modeled were With the dimensions precise for every case. As a end result values of stresses have been obtained and Their distribution interior a BDS thinking about the presence of polyethylene spheres, also it became obtained deflections produced in every sort of BDS and sooner or later to technical and monetary contrast of the effects of the usage of BDS and waffle slabs in buildings as much as 4 flooring.

Reshma Mathew et al - (2016)

In this have a look at GFRP(Glass Fiber reinforced Polymer) strips with diverse orientation is used as a strengthening gadget for bubble deck slab .Finite element analysis was done using ANSYS software program. She concluded that Punching shear capacity of bubble deck slab is a prime hassle due to its decreased weight. GFRP strengthening system is used on this report. Strengthened slabs have greater punching potential compared with normal BDS. Increase in load carrying capacity up to 20 percent because of strong of BDS with GFRP. Reinforced bubble deck has low deflection compared to un reinforced bubble deck slab.

Sameer Ali.et al - (2017)

The objective of this take a look at is to perform the behavioral evaluation of conventional slab and bubble deck slab using Ansys workbench 14.0. This study includes the take a look at of normal slab and BDS with HDPE ball. The analysis result confirmed the maximum stresses and internal forces within the BD about to 40% lower than the normal slab due to the reduced useless load from using HDPE balls in place of concrete. The deflection of the BDS was slightly higher but the stiffness reduced due to the presence of the HDPE ball, but this situation will be overcome by the reduced overall stress in the slab. Upon the brief study of the bridge deck slab shows that it don"t follows the office slab of the models which was created with the same general parameters

3. Methodology used

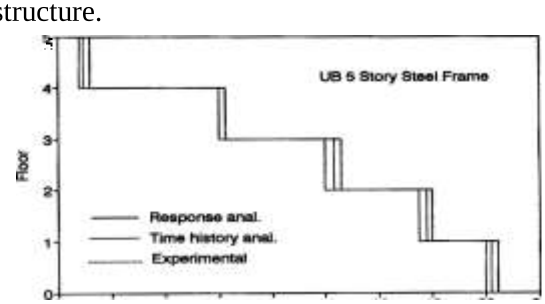
Response Spectrum Analysis

This method is also known as modal method or mode superposition method. It is based on the idea that the response of a building is the superposition of the responses of individual modes of vibration, each mode responding with its own particular deformed shape, its own frequency, and with its own modal damping.

According to IS-1893(Part-l):2002, high rise and irregular buildings must be analysed by response spectrum method using design spectra shown in Figure 4.1. There are significant computational advantages using response spectra method of seismic analysis for prediction of displacements and member forces in structural systems. The method involves only the calculation of the maximum values of the displacements and member forces in each mode using smooth spectra that are the average of several earthquake motions. Sufficient modes to capture such that at least 90% of the participating mass of the building (in each of two orthogonal principlehorizontal directions) have to be considered for the analysis. The analysis is performed to determine the base shear for each mode using given building characteristics and ground motion spectra. And then the storey forces, accelerations, and displacements are calculated for each mode, and are combined statistically using the SRSS combination.

However, in this method, the design base shear (VB) shall be compared with a base shear (Vb) calculated using a fundamental period T. If V_B is less than Vb response quantities are (for example member forces, displacements, storey forces, storey shears and base reactions) multiplied by VB/Vb Response spectrum method of analysis shall be performed using design spectrum. In case design spectrum is specifically prepared for a structure at a particular project site, the same may be used for design at the discretion of the project authorities. Figure 3.1 shows the proposed 5% spectra for rocky and soils sites.

For structures with VE dampers, the seismic response envelopes of the structure can be also carried by response spectrum analysis using the response spectra of the input ground motions with damping ratios calculated from Equation (3). Figures 8a and 8b show typical results of the floor lateral displacement and story shear envelopes of a 5. story steel frame with added VE dampers (4 = 15 0/0) under 0.62 El Centro earthquake using the CQC method (Kiureghian 1981). The structure remained elastic during the earthquake. Also included in these figures are the envelopes of experimental and analytical time history analysis results. It can be seen that the response spectrum analysis gives reliable predictions on the lateral displacement and story shear envelopes of the viscoelastically damped structure.



Story Shear (kN)

Fig 3.1 Response spectrum analysis, 0.6g El Centro, damping, story shear

4. Problem statement

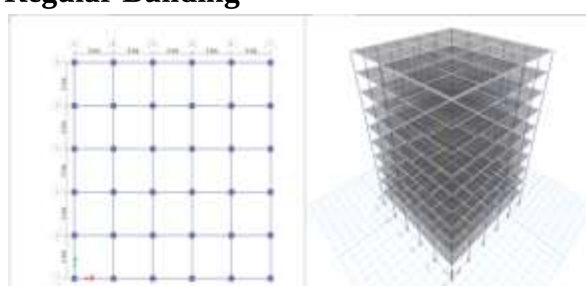
In the present study, analysis of G+ 10 stories building in Zone V is carried out in ETABS.

Basic parameters considered for the analysis are

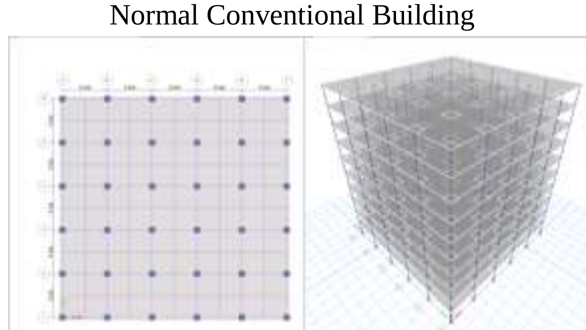
1. Grade of concrete : M40
2. Grade of Reinforcing steel: HYSD Fe500
3. Dimensions of beam : 230mmX460mm
4. Dimensions of column : 690mmX690mm
5. Thickness of slab : 150mm
6. Bubble deck slab thickness :230mm
7. Height of bottom story : 3m
8. Height of Remaining story : 3m
9. Live load : 5 KN/m^2
10. Dead load : 2 KN/m^2
11. Density of concrete : 25 KN/m^3
12. Seismic Zone : Zone V
13. Site type : II
14. Importance factor : 1.5
15. Response reduction factor : 5
16. Damping Ratio : 5%
17. Structure class : B
18. Basic wind speed : 44m/s
19. Risk coefficient (K1) : 1.08
20. Terrain size coefficient (K2): 1.14
21. Topography factor (K3) : 1.36
22. Wind design code : IS 875: 1987 (Part 3)
23. RCC design code : IS 456:2000
24. Steel design code : IS 800: 2007
25. Earth quake code : IS 1893 : 2002 (Part 1)

5. Models in ETABS

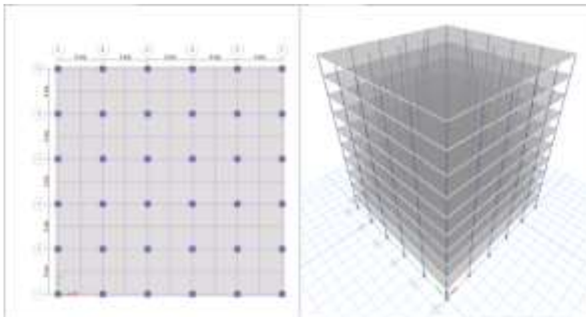
Regular Building



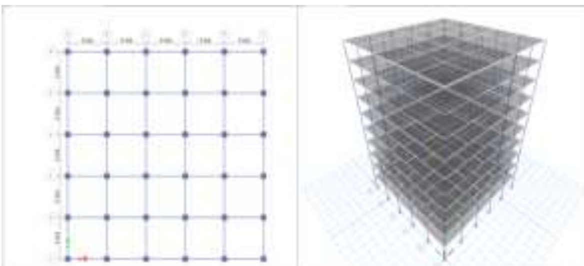
Normal Conventional Building



Flat Slab with drop

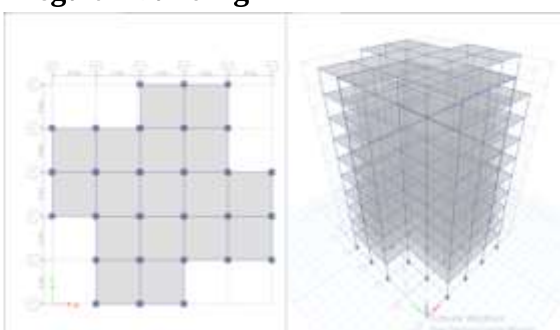


Flat slab without drop

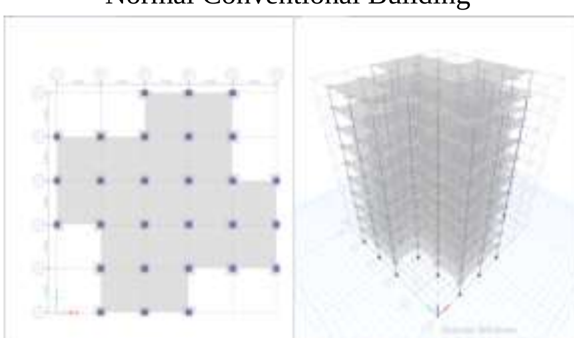


Bubble deck slab

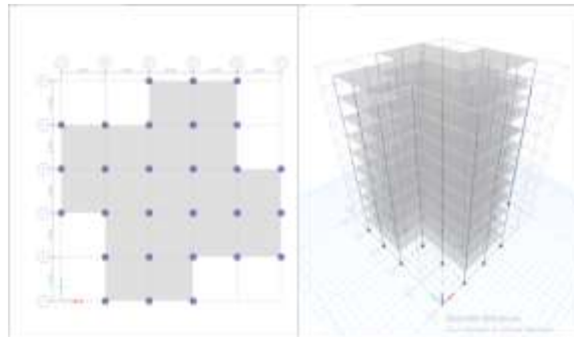
Irregular Building



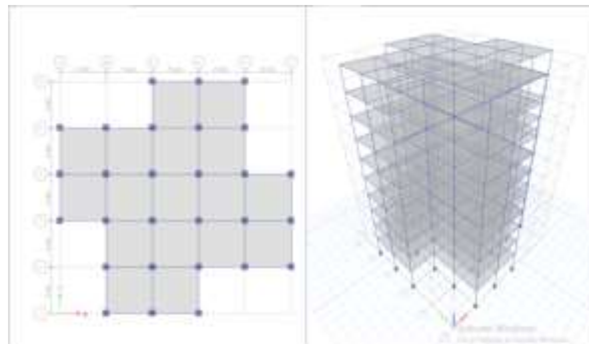
Normal Conventional Building



Flat Slab with drop



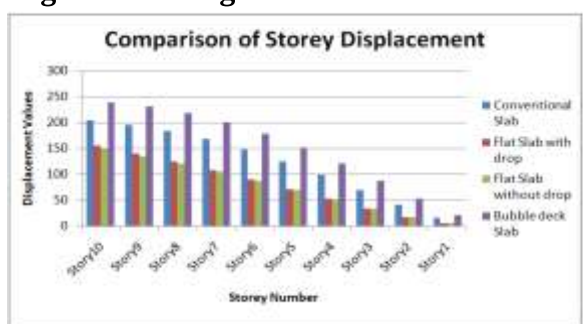
Flat slab without drop



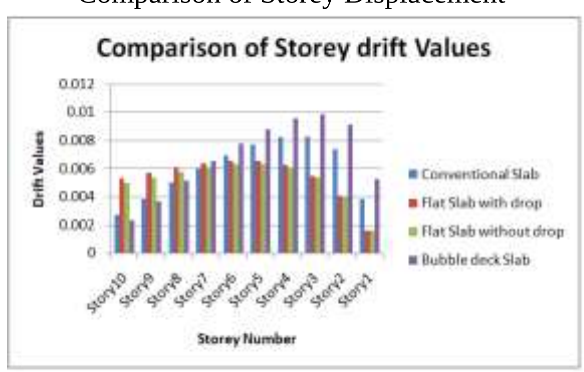
Bubble deck slab

6. Results and analysis

Regular building results

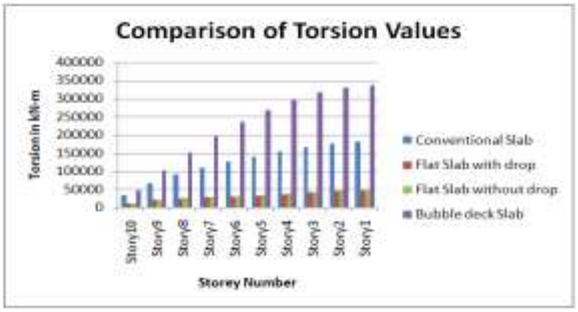


Comparison of Storey Displacement

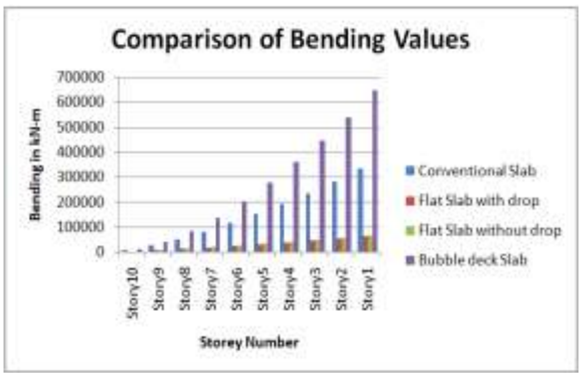


Comparison of Storey drift Values

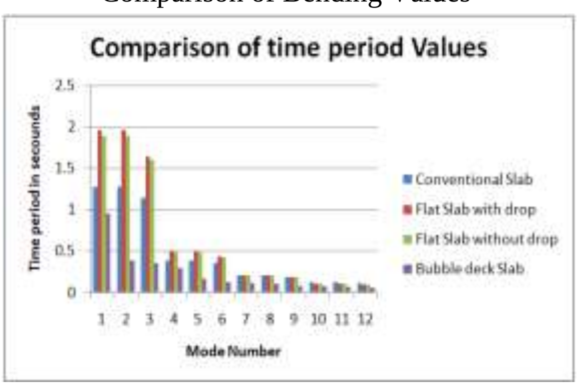
Comparison of Shear Force Values



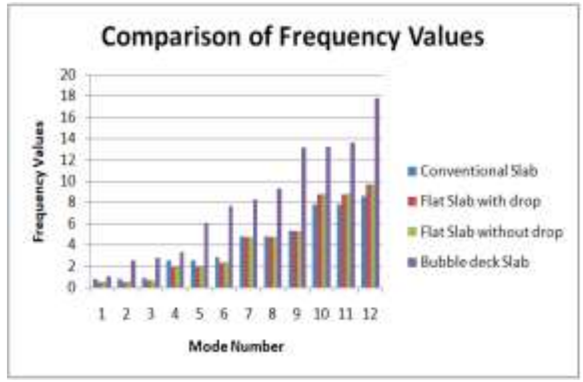
Comparison of Torsion Values



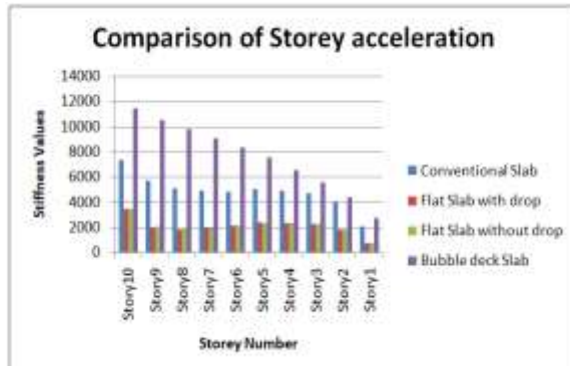
Comparison of Bending Values



Comparison of time period Values

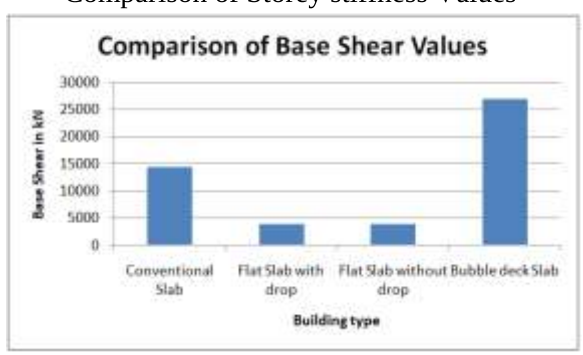


Comparison of Frequency Values



Comparison of Storey acceleration

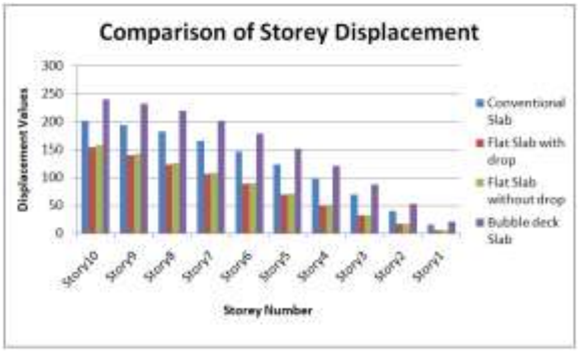
Comparison of Storey stiffness Values



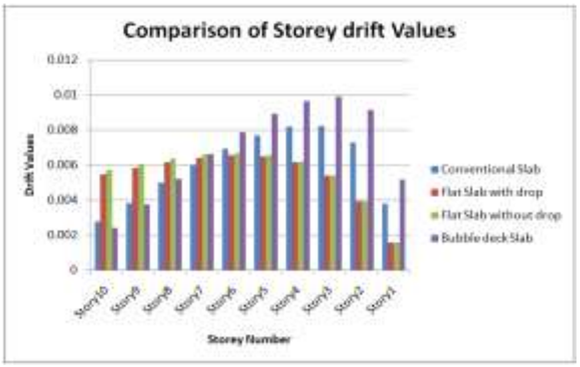
Comparison of Base Shear Values

International Journal of Engineering Research and Science & Technology

Irregular building results

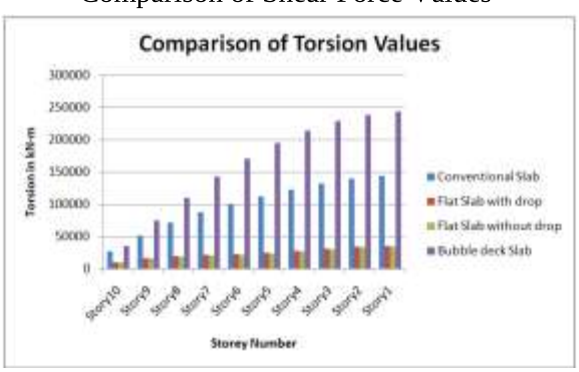


Comparison of Storey Displacement

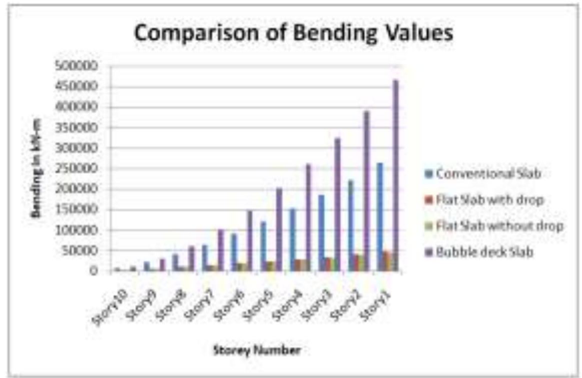


Comparison of Storey drift Values

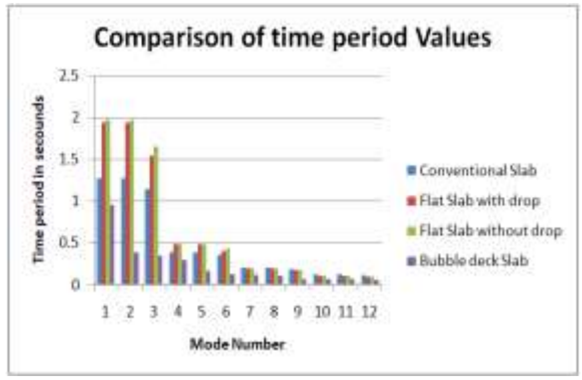
Comparison of Shear Force Values



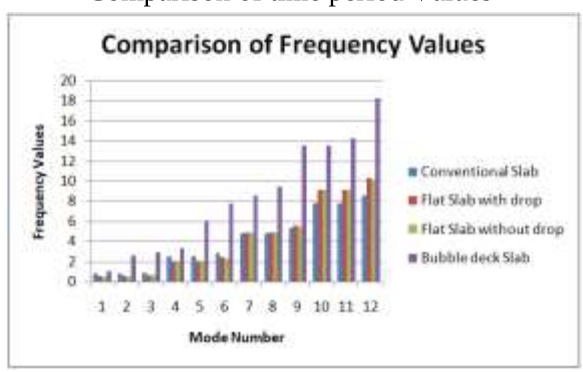
Comparison of Torsion Values



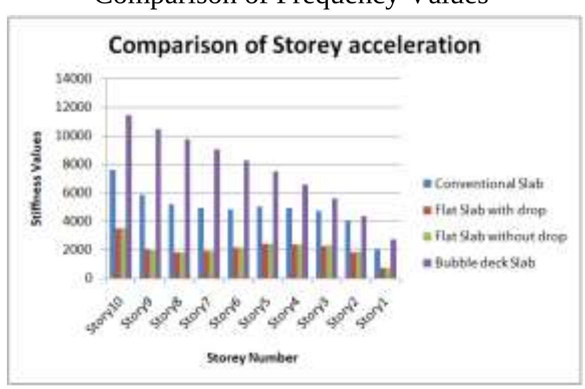
Comparison of Bending Values



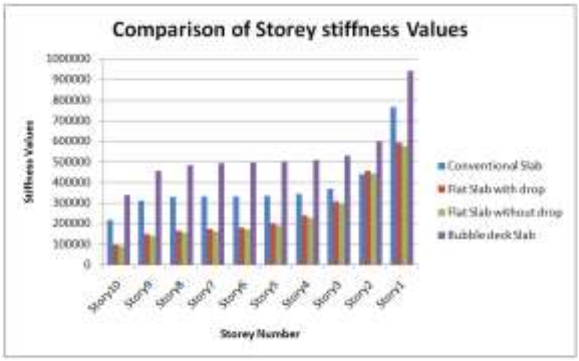
Comparison of time period Values



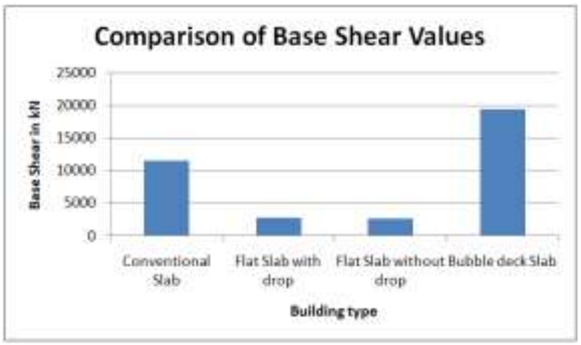
Comparison of Frequency Values



Comparison of Storey acceleration



Comparison of Storey stiffness Values



Comparison of Base Shear Values

7. Conclusions

1. The values of the storey drift has less values for the building model made with bubble deck slab system when we compared with other building cases.
2. As per the shear force, bending moment and torsion values the building made with flat slab, less values when we compared with other building models.
3. The total quantity of concrete of Flat slab is maximum because the thickness of Flat slab is greater than bubble deck slab, the steel quantity is also greater than other combinations.
4. The time period for bubble deck slab is low and its safe the low values are occurred due more stiffness and less mass (mass/ stiffness)^0.5
5. The frequency values depends on time period , frequency is reciprocal of Time period so low time period give more safe and less displacement values.
6. We observe more story acceleration due to less mass in bubble slab as compared with conventional slab.
7. Although mass reduces, over all stiffness may remain relative high , especially due to Effective reinforcement ,Concrete rib continuity.
8. The story stiffness values are high for bubble deck slab when comparing with other slabs , the higher the stiffness the lower the lateral movements in the building.
9. The base shear values are high for bubble deck slab this can be counter acted by providing shear walls and braced frames or dampers.
10. By Means of adjusting the parameters And other components such as dampers we can effectively use bubble deck slab in India for slab construction to overcome the mass concreting and by less concrete use we can give better results in bubble deck slab.with bubble deck slab when we compared with other models namely normal building model and flat slab models as per the analysis.

References

[1]. P. Prabhu Teja , “Structural Behaviour of Bubble Deck Slab” (IEEE-International Conference On Advances In Engineering, Science And Management (ICAESM -2012 March 30, 31, 2012)W.-K. Chen, Linear Networks and Systems. Belmont, Calif.: Wadsworth, pp. 123-135, 1993. (Book style)

[2]. Amer M. Ibrahim , Nazar K. Ali Oukaili and Wissam D. Salman , “Flexural Behavior and Sustainable Analysis of Polymer Bubbuled Reinforced Concrete Slabs” (Fourth Asia-Pacific Conference on FRP in Structures (APFIS 2013)11-13 December 2013, Melbourne, Australia© 2013

[3]. Er. Immanuel Joseph Chacko, Er.Sneha M. Varghese, “Structural Behaviour of Bubble Deck Slab using Indian Standards (International Journal of Innovative Research In Technology, IJIRT 143950,

September 2016 | IJIRT | Volume 3 Issue 4 | ISSN: 2349-6002)R. Nicole, "The Last Word on Decision Theory," J. Computer Vision, submitted for publication. (Pending publication)

[4]. Neeraj Tiwari1, Sana Zafar, “Structural Behaviour of Bubble Deck Slabs and Its Application” (IJSRD - International Journal for Scientific Research & Development| Vol. 4, Issue 02, 2016 | ISSN (online): 2321-0613).D.S. Coming and O.G. Staadt, "VelocityAligned Discrete Oriented Polytopes for Dynamic Collision Detection," IEEE Trans. Visualization and Computer Graphics, vol. 14, no. 1, pp. 1-12, Jan/Feb 2008, doi:10.1109/TVCG.2007.70405. (IEEE Transactions)

[5]. Tae-Young Jang, Sang-Mo Kim2, Sang-Dae Kim, “New Eco-friendly Two-way Void Slab” (International Conference on Sustain Building Asia)

[6]. Tim Gudmand Høyer, “Note on the Moment capacity in a Bubble deck joint” (Danmarks Tekniske Universitet,byg•dtu R-074,ISSN 1601-2917,2003,ISBN 87- 7877-137-4)

[7]. Corneille Charles Marais, “Design Adjustment factors and the Economical Application of Concrete Flat-Slabs with Internal Spherical voids in South Africa” (University of Pretoria,August 2009)

[8]. Mihai Bindea, Raul Zagon, Zoltan Kiss, “Flat slabs with spherical voids. Part II: Experimental tests concerning shear strength” (ActaTechnicaNapocensis: Civil Engineering & Architecture Vol. 56, No. 1 (2013),Received 26 February 2013; Accepted 15 August 2013)

[9]. Kivanc Taskin , Kerem Peker, “ Design Factors and the Economical application of Spherical Type Voids in RC Slabs” (International Scientific Conference People, Buildings and Environment 2014 (PBE2014) 15-17 October, 2014, Kromeriz, Czech Republic)

[10]. Ma. Leilani T. Manalaysay, Neil Bryan P. Robles, Ayah Rose M. Rosete and Melchor F. Pilones, “Design of Two-Storey Cultural Center Localizing Bubble Deck System” (School of Civil, Environmental and Geological Engineering, Philippine,September 2014, CEGE Journal).

[11]. IS:875-1987.‘IndianStandardCodeof PracticeforDesign Loads (otherthan Earthquakes) for BuildingsandStructures, (2nd revision).’ BureauofIndian Standard,New Delhi

[12]. IS: 456-2000.‘IndianStandardCode of PracticeforDesign of reinforcedconcrete”, Bureau ofIndianStandard, New Delhi