Section A-Research paper
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COMPARISON ON STIFFNESS IRREGULARITIES IN CONVENTIONAL SLAB SYSTEMS AND BUBBLE DECK SLAB SYSTEM

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Abstract: In the past twenty years, the topic concerning sustainability has taken on significant importance in the building industry. A brand-new environmentally friendly building element that may be employed as a slab platform is called the Bubbles Deck concrete system. When compared to conventional slab alternatives, the benefits of adopting this method result in considerable cost savings for the building industry as well as benefits for the economy, society, and environment of up to (50%) and a self-weight decrease of (35%). As a result, less concrete must be manufactured and being shipped until its final the location, saving a significant amount on structural components like a basis and row frameworks. Additionally, because less concrete must be made and delivered via routes, power consumption and greenhouse gases gases are constrained. Using ETABS programme, a comparison with regard to stiff irregularity in standard slabs with different layouts and bubble deck slabs with various arrangements was done in this work. Eight models—normal conventional slab, flat slab with drop, flat slab without drop, normal bubble deck slab, and their stiffness irregularities—were studied. These models yielded some notable discoveries. Based on the comparison research, a flat slab system with a drop and a bubble deck slab system can perform better than a slab system without irregularities. Stiffness irregularities degrade all slab systems. These results show that stiffness inconsistencies and decreases in flat slabs or bubble deck systems are important for design and construction. Future study might examine stiffness irregularity mitigation measures and slab system durability under varied stress circumstances. This work adds to slab system knowledge and helps engineers, architects, and researchers choose and develop slab systems for varied structural purposes.
Keywords: conventional slab, bubble deck slab, irregularity, ETABS, RCC building

1. Introduction:

At the dawn during the 20^{th} along with 21^{st} century, the bubble platform surface was developed. Multiple feasibility research on the boom platform innovation were carried out in the previous ten years. Slabs are the primary structural components of any building alongside serve a purpose for mooring, conveying piling loads and receiving loads from other primary structures. The crushed stone in the section's midsection is not being completely used, pursuant to the quantitative assessments that were done. It is predicted that what is showed under the stress zone won't be used since it won't be needed to support any weight. As much as eighty per cent of the total quantity of concrete volume may come from the leftover concrete. Because it decreases your load ability to bear at the route limit and causes deflecting, this useless material has to be totally recovered. As a result, void predecessors that simply create voids may be 1056tilized to replace a partial proportion of this waste plaster. One of the biggest consumers of concrete is Slab. We are aware that as the width of the span

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grows, so does slab height. Reducing slab depth makes slabs heavier, leading to skeletons and beams bigger. Thus, it increases the usage of concrete and steel materials. This innovative technique has only been used on just a couple of home or high-rise buildings, as well as corporate floor slabs that support anything due to inadequate understanding. For the purpose of trying to better comprehend this approach and contrast it to the existing slab system as well, this inquiry will investigate the structural responses of Floating Deck underneath various loading circumstances(Ali & Kumar, 2017).

Using less concrete and innovative technology to maximise its use is not a novel concept. Jorgen, please find Breuning, an architect from Denmark, developed the concrete-reinforced Boom Deck platform structure during the 1990s. (https://www.researchgate.net/publication/323998413_Efficiency_of_applying_sustainable_technology_of_Bubbledeck_Technology_in_concrete_in_Russia). The Balloon Deck technology replaces the inefficient pavement in the central region of the piece with hollow globes composed of a high-density polyethylene and plastic from recycling. In this process, a two-directional matrix of voids is created inside a concrete slab, especially around its descriptive centering, using plastic vacancy formers. (Figs. 1 and 2).

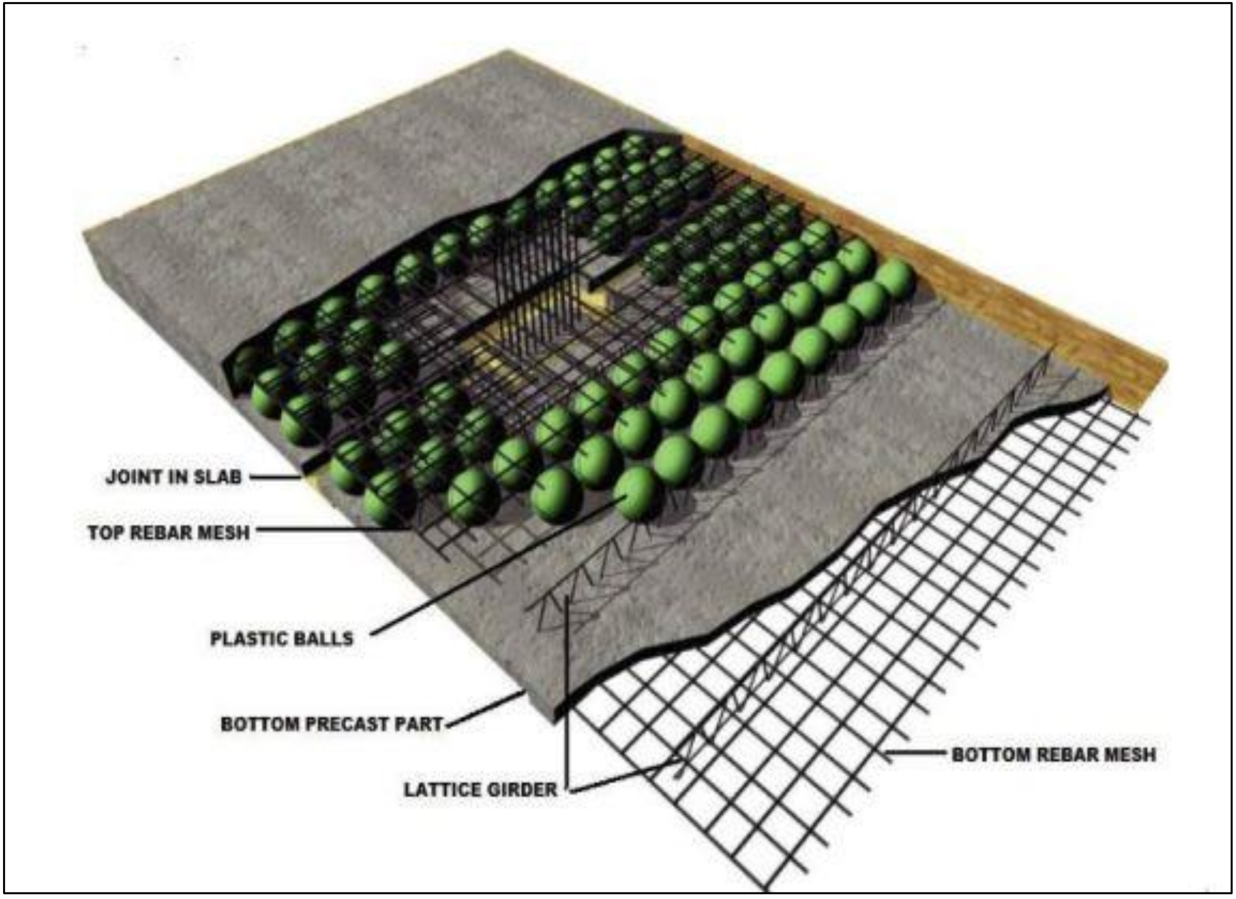

Fig 1: Structure of Bubble Deck Voided Slab System

Source: https://theconstructor.org/exclusive/voided-slab-systems/223645/ (Theconstructor, 2022)

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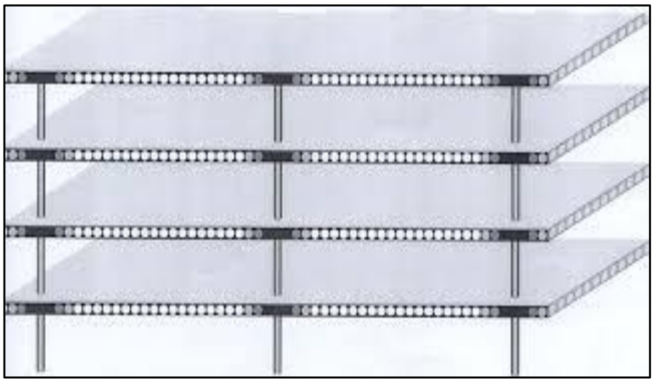

Fig 2: A typical building with BubbleDeck slab system

Source: http://ecosmartconcrete.com/docs/trrjcstage2appc.pdf (Fuchs, 2019)

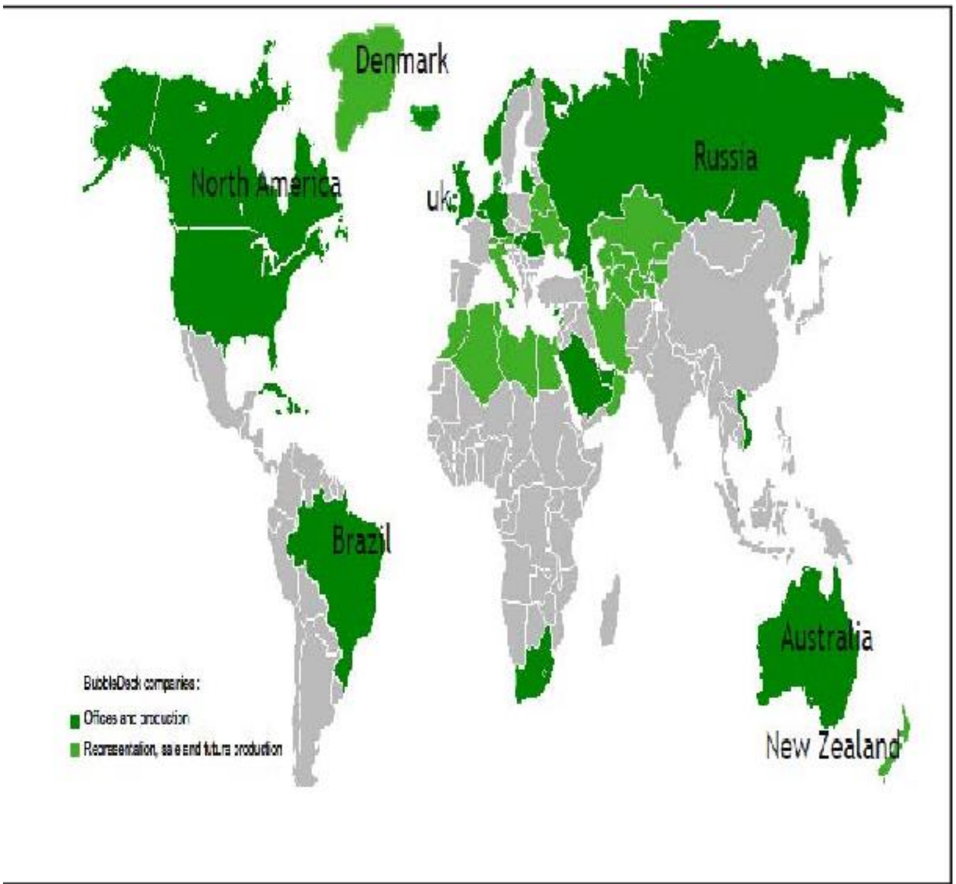

Fig 3: World map showing the usage of the system worldwide

Source: https://www.semanticscholar.org/paper/Sustainability-Analysis-and-Shear-Capacity-of-Slabs-Oukaili-Merie/a4068d20f8e5f4d1ef8b5bf4c875f2aadf1c216e (Oukaili & Merie, 2019)

Compared to traditional slab alternatives, Bubble Deck is a novel technology in the construction industry. This system substantially contributes to environmental preservation and pollution reduction. There are currently a large number of companies around the globe that use these surfaces. Shear impedance is one amongst the least important differences between Inflatable Decks with straight slabs of data, based upon the info that is presently accessible. Importantly, unlike solid cores networks, the holes created by the gases don't appear pyramidal. Rather, they are actually distinct areas stacked in a structure with two dimensions, which preserves the firmness and rigidity of the slab. From five to ten percent of all the CO2 generated by people's actions is attributable to the production of cement, much of which comes from materials. Therefore, a decrease in emissions of carbon dioxide (CO2) from buildings made of concrete will make a major difference in achieving the generally anticipated decreased greenhouse gas (GHG) pollution(Fidjestol, 2012). In the recent time, sustainability aspect becomes an essential issue from environmental as well as economic, political and social points of view(Szolnoki, 2013). Sustainable is one's capacity for maintaining a continuous state with the least amount of cumulative economic natural effect. A significant portion of the material usage, energy output, manufacturing of heat, pollutants, and litter are caused by the building sector. One of among the most crucial things to do to lessen the damage to the environment is to adopt the bubble that Deck device. By: (1) minimising the number of construction resources applied, facilitating a greater degree of autonomy in the design and development of sections, and decreasing the the funds of particles produced during destruction due a likelihood of recycling. This all-layer element, this framework heavily meets the goal from "sustainable building." (2) Less concrete plus its components, such as cement and coarse and fine gravel, may be carried by land and sea. As a result of the thermally induced Bubble Decking technique's thinness, it can be accomplished to shrink the size of some building components, such as the basis (making them lighter), containing walls, and columns and which may decrease both the volume of the building's components along with the amount of material used by up to 50%; (4) substantial savings in energy costs as well as important emission reductions of between 40% and 50% that results from the manufacture and delivery of the absorbed build materials The procedures readily accessible for this goal may be used to completely recycle the Bubble Decking equipment as it is nearing the conclusion of its useful life. Other uses include using recycled bubbles as new plastic gap precursors in new slab structures, steel reinforcement replicated form fresh metal bars, even elements of concrete recycled into superior fine aggregate. Due to its widespread use, the bubble-shaped Deck floor technique has an elevated probability of spreading. The machine's overall utilisation is shown in Figure 3. It is possible to exploit this floor method's outstanding effectiveness in terms of environmental effect as its primary appeal with Boom Decks. The price diminution, because is directly correlated to duration and saved materials during development, is one of the advantages of the patented Bubble Decking method. Due to the pervasiveness of harmful chemicals in the environment, engineers, designers, and landlords are turning more and more often to green construction practises. The ecological footprint of modern structures is greatly decreased by the Wave Bridge slab technique for strengthening concrete. One kilogramme of material of recovered plastic leftovers might replace 100 kilogrammes of standard-weight concrete, according to data supplied by Bubble Deck firms. It needs to be highlighted that 40% percent the carbon contained in flutes slabs may be reduced by using less concrete(Lai & Veneziano, 2010). Bubble the Deck slabs have the possibility of helping significantly help achieve BREEM's goals because of their ecological your login information. BREEM was established in 1990 with British Columbia and became the very first publicly traded environmental evaluations tool for buildings. The Inflatable Panel slab system also satisfies the standards for LEED in the US and Quebec. LEED is the American-developed and -adopted grading system for ecological saving environmental leading in green construction. It is feasible to build larger distances across columns without the necessity of prestressing due to the decrease in weight on its own of a Wave Floor slab, which might lead to a considerable diminution in the dimension of load-bearing structural components, such as blocks with pilasters(Oukaili & Merie, 2019).

Various studies have been conducted on conventional slab, flat slab and bubble deck slab since a long time for understanding the loading on the buildings. Lai, T (Lai, 2010)analyzed the structural behaviour of Bubble Deck office slabs and suggested the application to lightweight bridge decks. Corey Midkiff J (COREY J MIDKIFF B.S., 2016) examined a two-way, reinforced concrete slab with plastic voids construction in comparison to traditional flat plate reinforced concrete slab construction. Neeraj Tiwari and Sana Zafar (Tiwari & Zafar, 2016)analyzed bubble deck slab system by the plastic hollow bubbles, which are made by the waste plastic material, which reduces the self- weight of the structure. Immanuel Joseph Chacko et al (Immanuel et al., 2016) studied the structural behavior of Bubble Deck Slab using Indian Standards by varying parameters like ball diameter.
Mahalakshmi S and Nanthini S (Mahalakshmi, 2017) Biaxial planks were created using the investigated balloon deck concrete technique. After conducting tests on foam deck slabs with oval and rectangular balls of grades M25 and M30, Jiji, also known Jolly (Jamal & Jolly, 2017)came to conclusion that those elliptical his balls suffer from a higher load carrying ability than the spherical spheres.

Reich, Lima, & Strelets (Strelets & Lima, 2017)) said that it is a never-ending quest to find innovative techniques, materials, and procedures that will raise building quality and cut down on redundant labour. The balloon decking concrete idea was developed because traditional slabs' central portion contains around 80% superfluous materials. 100 kilogrammes of concrete are substituted by 1 kg of rubber balls in a bubble board system. Additionally, for every 1m3 the masonry produced, roughly 40kg of possible CO2 emissions related with the production of cement are avoided(Bhade & Barelikar, 2016).
Maske & Kadao (Sankalp K. Sabale,Sandip R. Sule, 2019)It was emphasised that there are three different types of bubbly deck deployment: finished timbers, strengthening components, plus lattice elements. Through the plastic spheres and strong steel reinforcement detached and momentarily anchored while it is short on highest the bottom constructed layers the Filigree The element (types A) setting up method uses a predetermined concrete layer that is approximately 60 mm robust to serve as the two pieces of structure and a portion of the total the material deep before the set-up along with final building are completed on site(Lai, 2010). A ready to assemble sandwiched of metal mesh with silicone bubbling or balloon lattice, the Reinforcements Capsules (Type B) installment is an apparatus in which the inflated balls and the structural steel netting were previously created. These parts are delivered to the job site, placed on conventional framework, joined with any extra shearing or corner strengthening, followed by conventionally put down in two phases to the entire slab thickness(Terec & Terec, 2013).

2. Problem Statement:

Design Data:

The problem statement for the comparison of stiffness irregularities in conventional slab systems and bubble deck slab system is to investigate the differences in the structural behavior of these two slab systems. The study aims to analyze the stiffness irregularities by comparing the performance of the two systems in terms of storey displacement, storey drift, base shear, and base reactions. The research will involve modeling the conventional slab system and bubble deck slab system using ETABS software, and then analyzing the results of the simulation to determine the differences in stiffness irregularities between the two systems.

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The study will contribute to the understanding of the structural behavior of conventional and bubble deck slab systems, which could inform the selection of appropriate slab systems in future construction projects. In this project, comparison on stiffness irregularities in conventional slab systems and bubble deck slab system is done. The G+13-storey structure of a regular building with 3.5 m floor to floor height has been analysed Seismic Analysis of Multi-storey R.C.C Buildings using ETABS software.

Preliminary data required for Analysis:

Table1: Parameters to Be Consider for Rectangular Geometry Analysis

Parameter	Values
Number of stories	G+13
Base to plinth	4m
Grade of concrete	M40
Grade of steel	Fe 500
Floor to Floor height	3.5 m
Total height of Building	53m
Soil Type	Medium
Dead Load	Self-weight of structure
Live load on floors	5 kN/m2
Frame size	30m X 30m building size
Grid spacing	6 m grids in X-direction and Y-direction.
Size of column	700mm x 700 mm
Size of beam	350mm x 500 mm
Depth of slab	250 mm
Importance factor for office building	1
Damping percent	5 %

ETABS Models:
From the problem statement mentioned in above chapter the following models are proposed:

Table 2: Models in ETABS

MODEL 1	Normal conventional slab without any Irregularity
MODEL 2	Flat Slab with Drop, without any Irregularity
MODEL 3	Flat Slab without Drop, without any Irregularity
MODEL 4	Normal bubble deck slab without any Irregularity
MODEL 5	Normal conventional slab with Stiffness Irregularity
MODEL 6	Flat Slab with Drop, with Stiffness Irregularity
MODEL 7	Flat Slab without Drop, with Stiffness Irregularity
MODEL 8	Normal bubble deck slab with Stiffness Irregularity

The given text is a list of proposed models that will be used in a study to compare the stiffness irregularities in conventional slab systems and bubble deck slab system. Each model represents a different variation of the slab systems under investigation.

Model 1 represents a normal conventional slab without any irregularity, which serves as a baseline for comparison. Model 2 represents a flat slab with a drop, which is a type of conventional slab system with an irregularity. Model 3 represents a flat slab without a drop, which is another variation of the conventional slab system without any irregularity. Model 4 represents a normal bubble deck slab without any irregularity, which is a type of slab system that uses plastic spheres to reduce the amount of concrete used in the slab. Model 5 represents a normal conventional slab with stiffness irregularity, which is a modification of the baseline conventional slab system to introduce an irregularity. Models 6 and 7 represent variations of the flat slab with a drop and without a drop, respectively, but with a stiffness irregularity. Model 8 represents a normal bubble deck slab with a stiffness irregularity.

By using these models, the study aims to analyze the performance of each slab system in terms of storey displacement, storey drift, base shear, and base reactions to identify any significant differences in stiffness irregularities between the conventional slab and bubble deck slab systems.

3. Modeling:

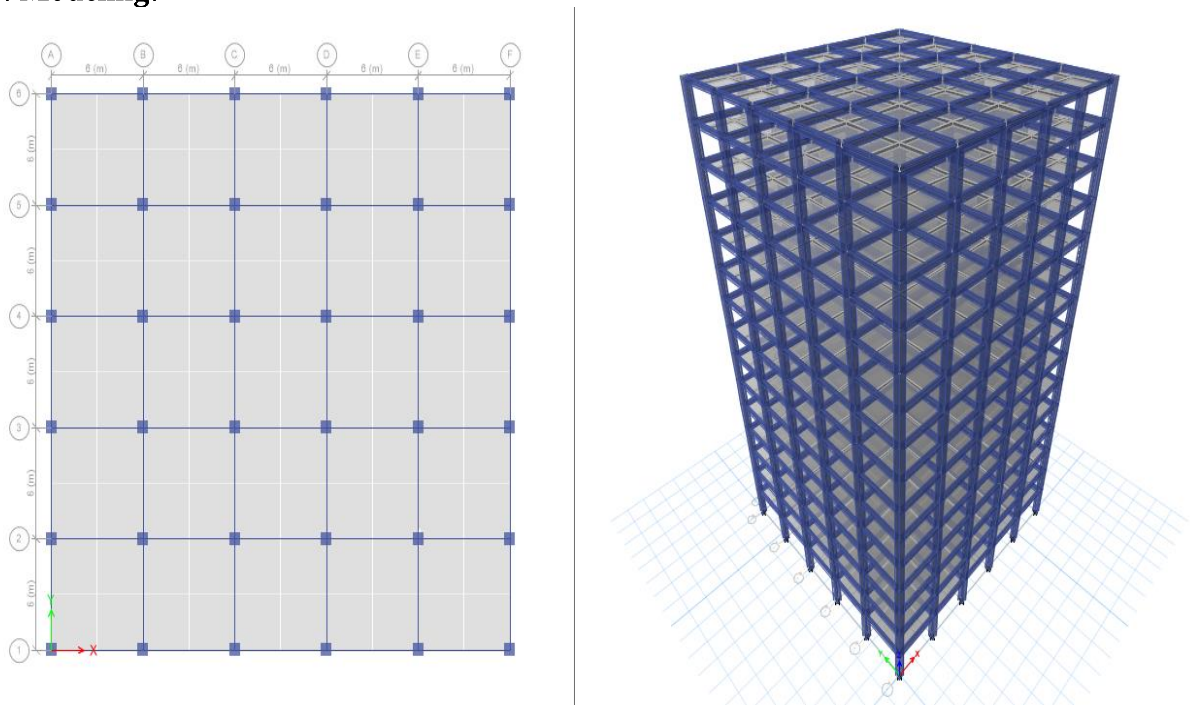

Fig 4: Model 1

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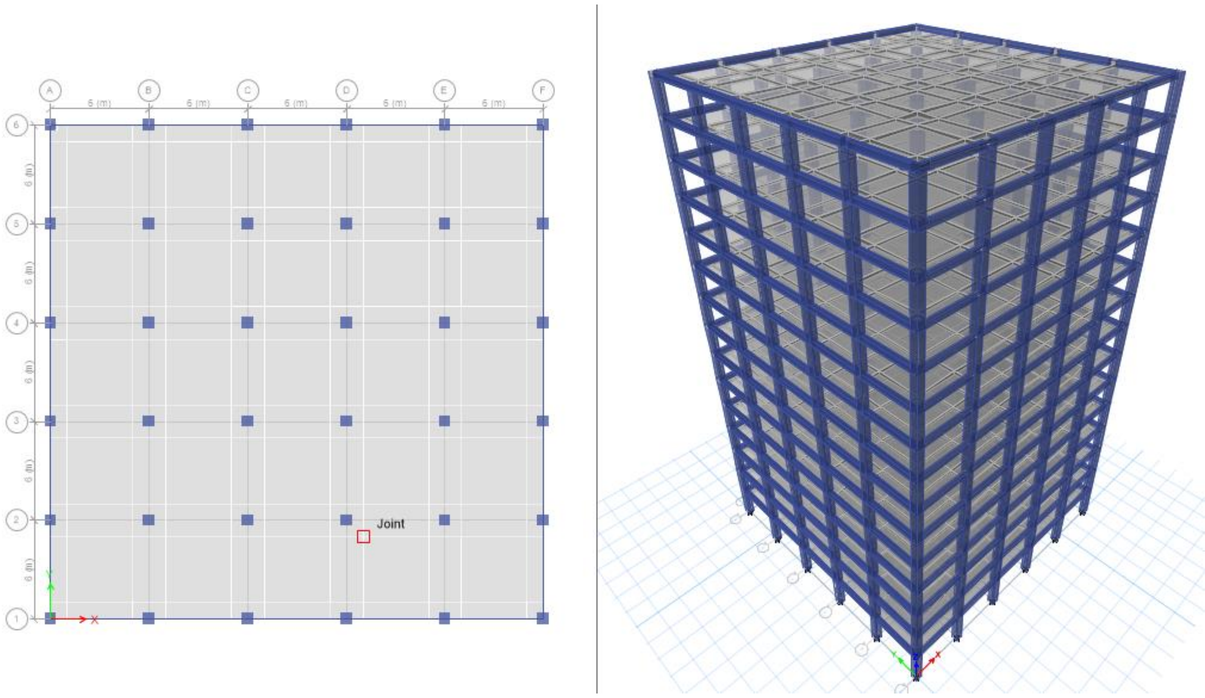

Fig 5: Model 2

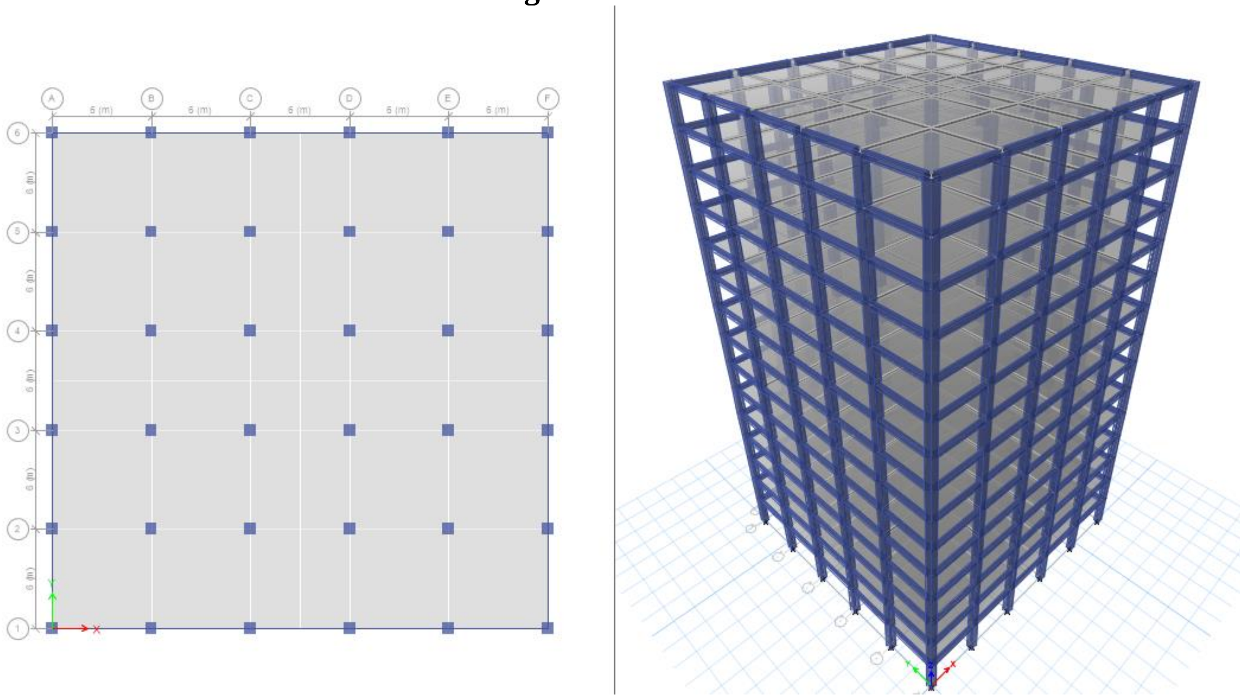

Fig 5: Model 3

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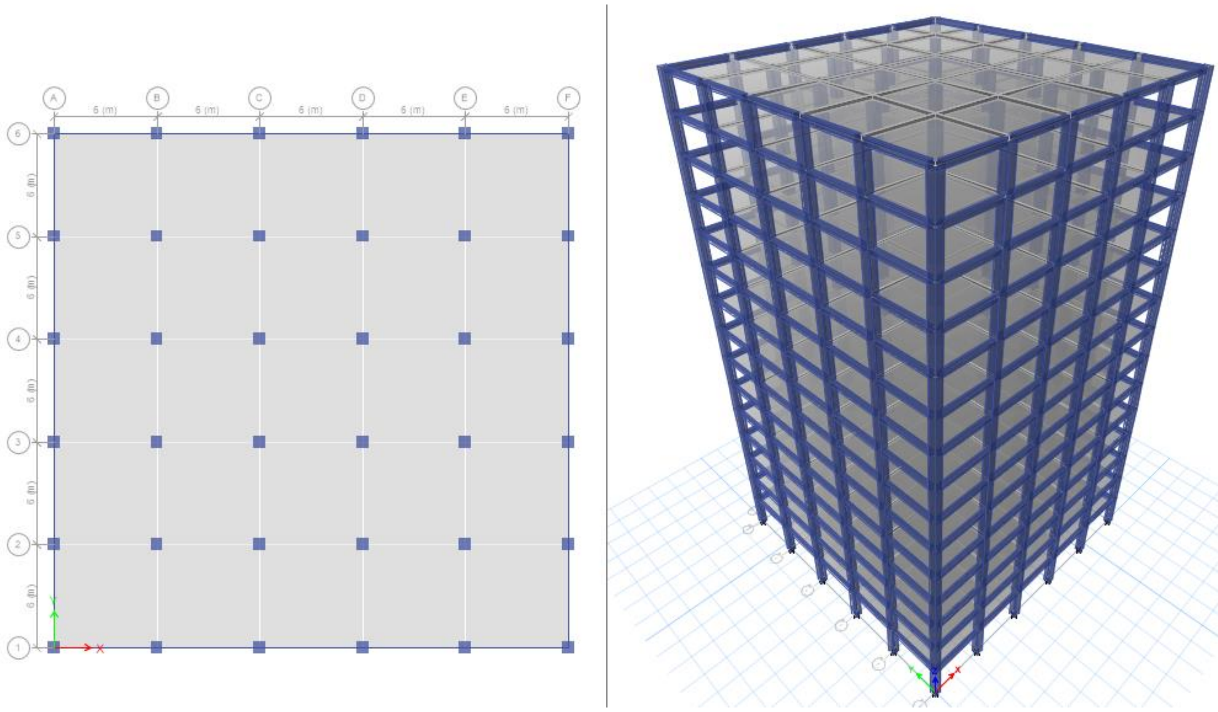


Fig 7: Model 4

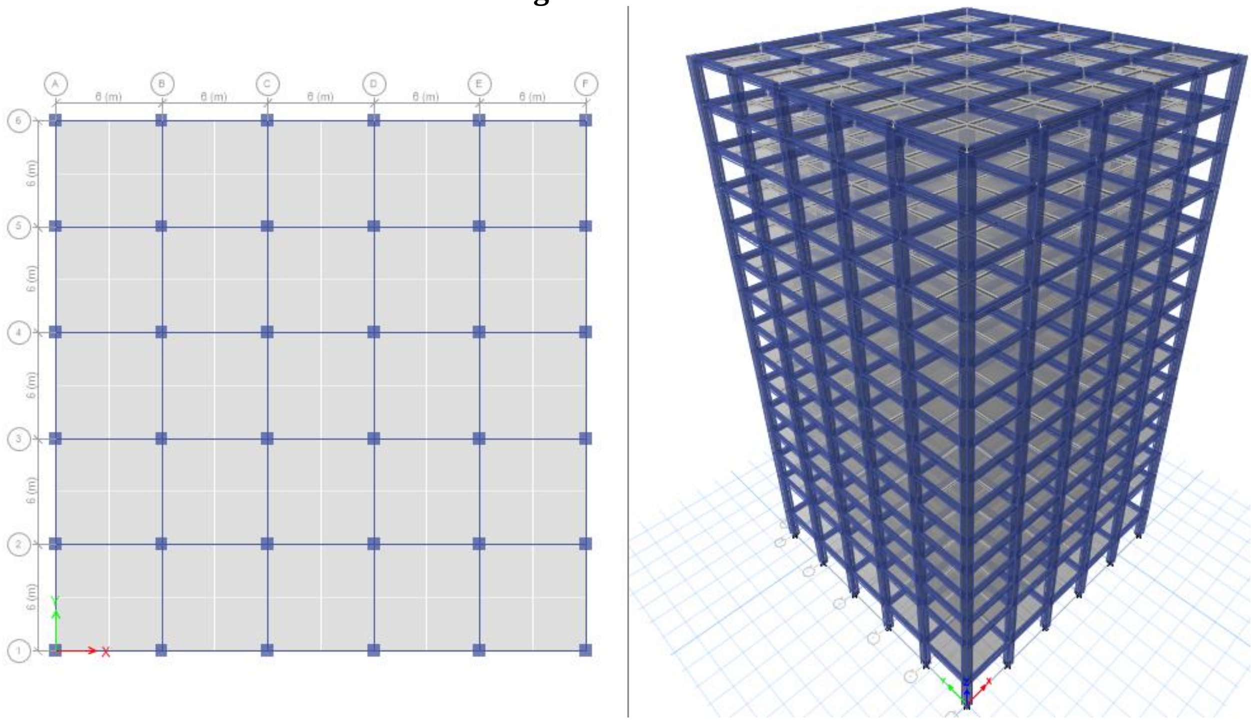


Fig 8: Model 5

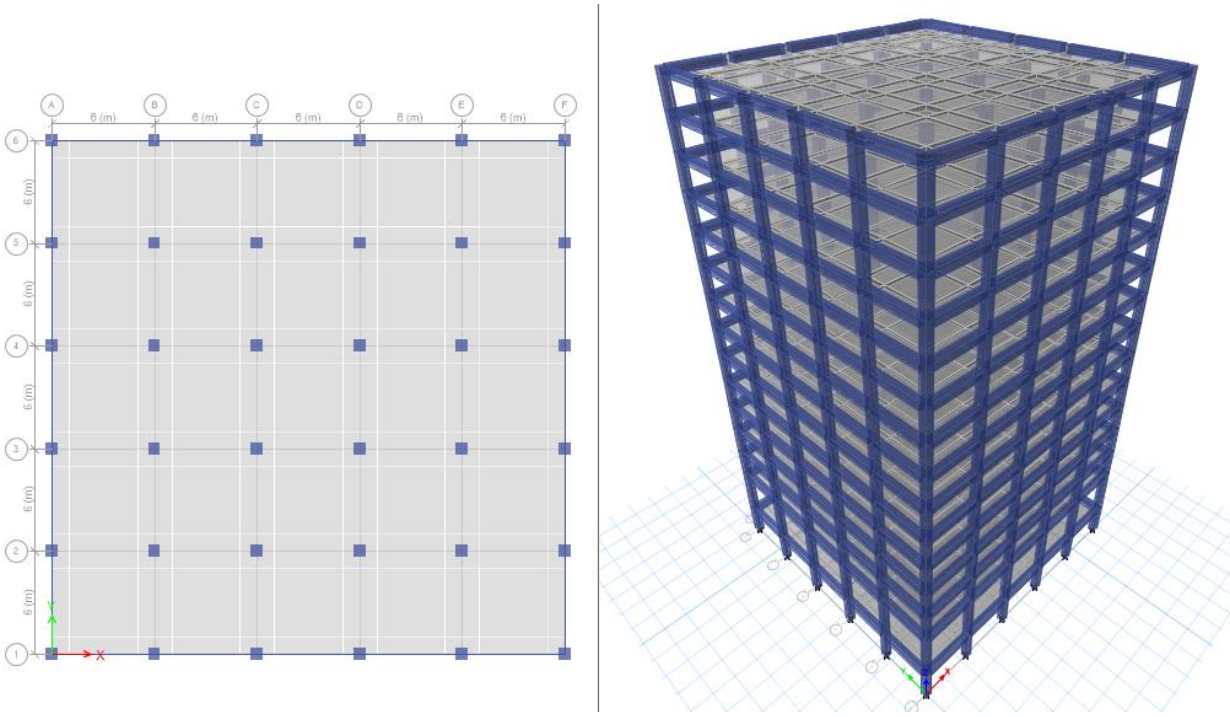


Fig 9: Model 6

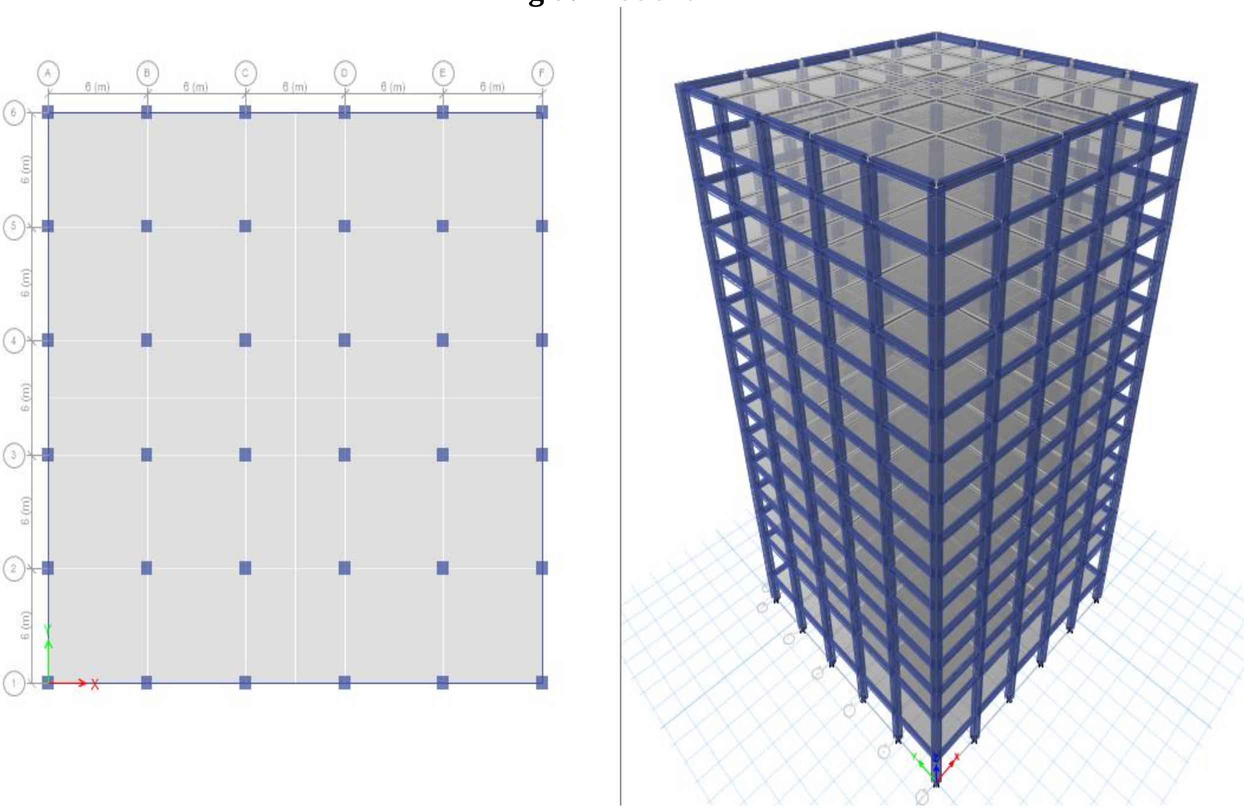


Fig 10: Model 7

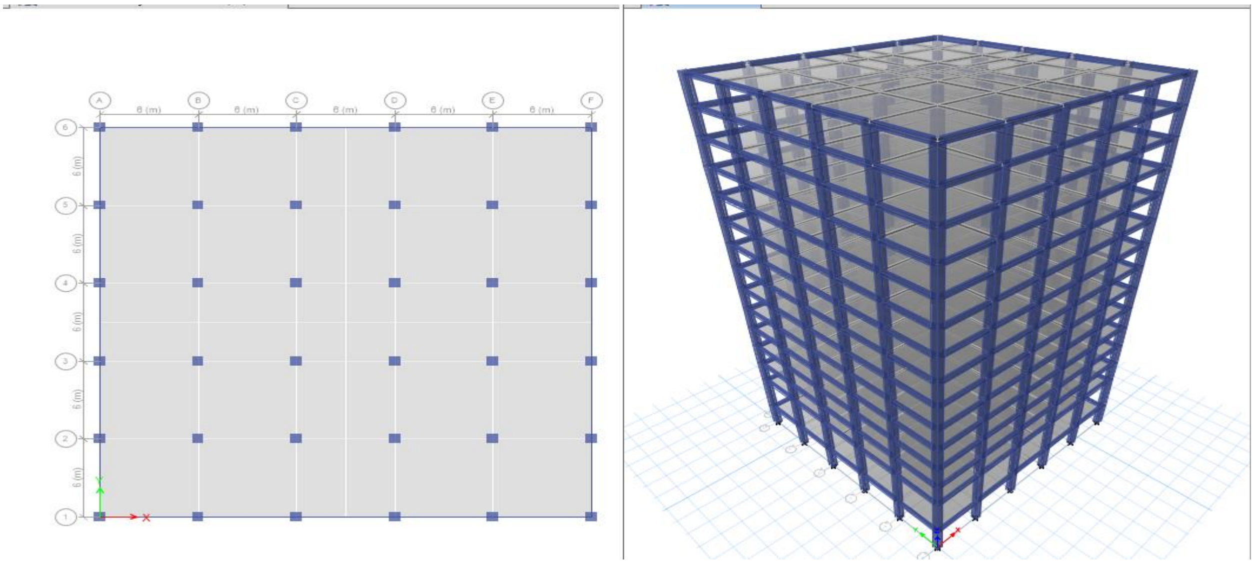


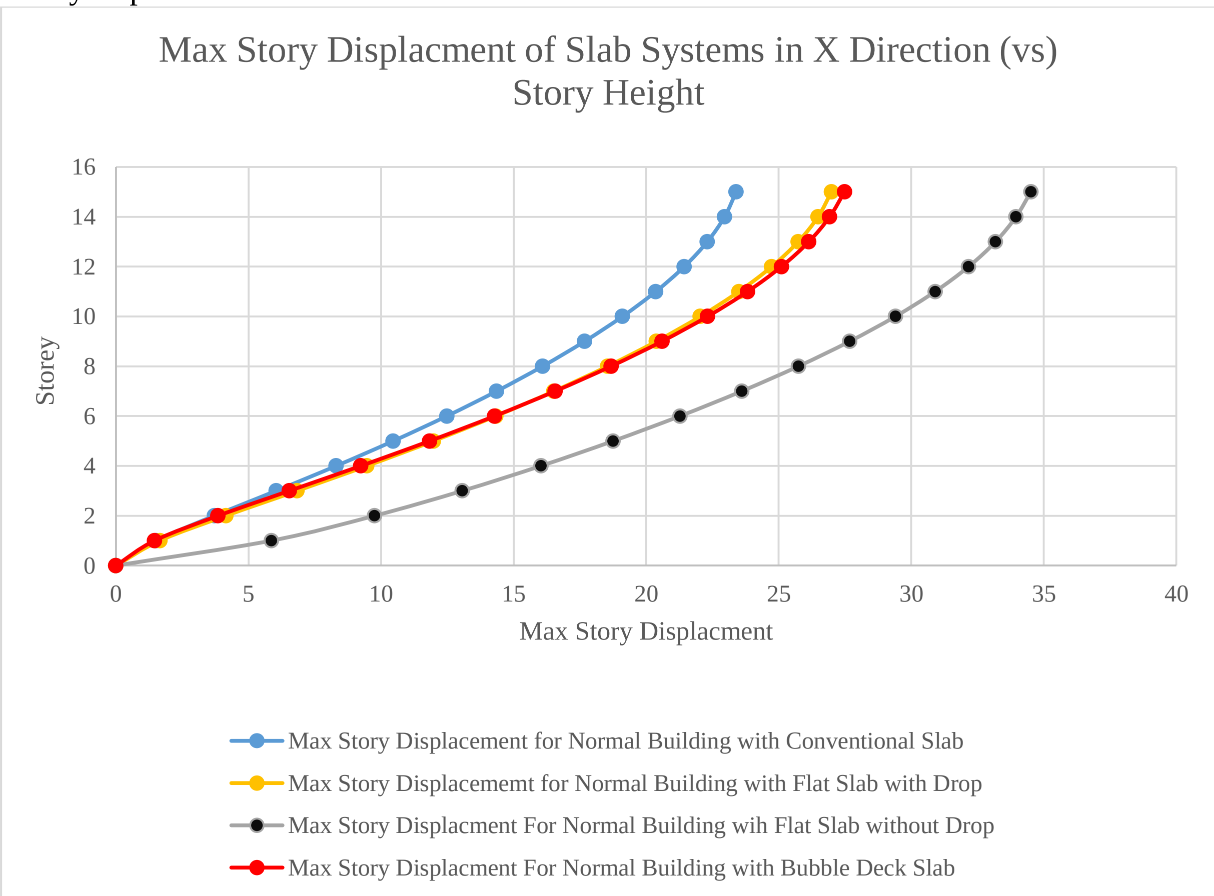
Fig 11: Model 8

4. Results and Discussion:

This part discusses conventional slab and bubble deck slab for comparing without irregularity and with stiffness irregularity.

- **Without Irregularity:**

Storey displacement



Graph 1: Max Story Displacement of Slab Systems in X Direction (vs) Story Height

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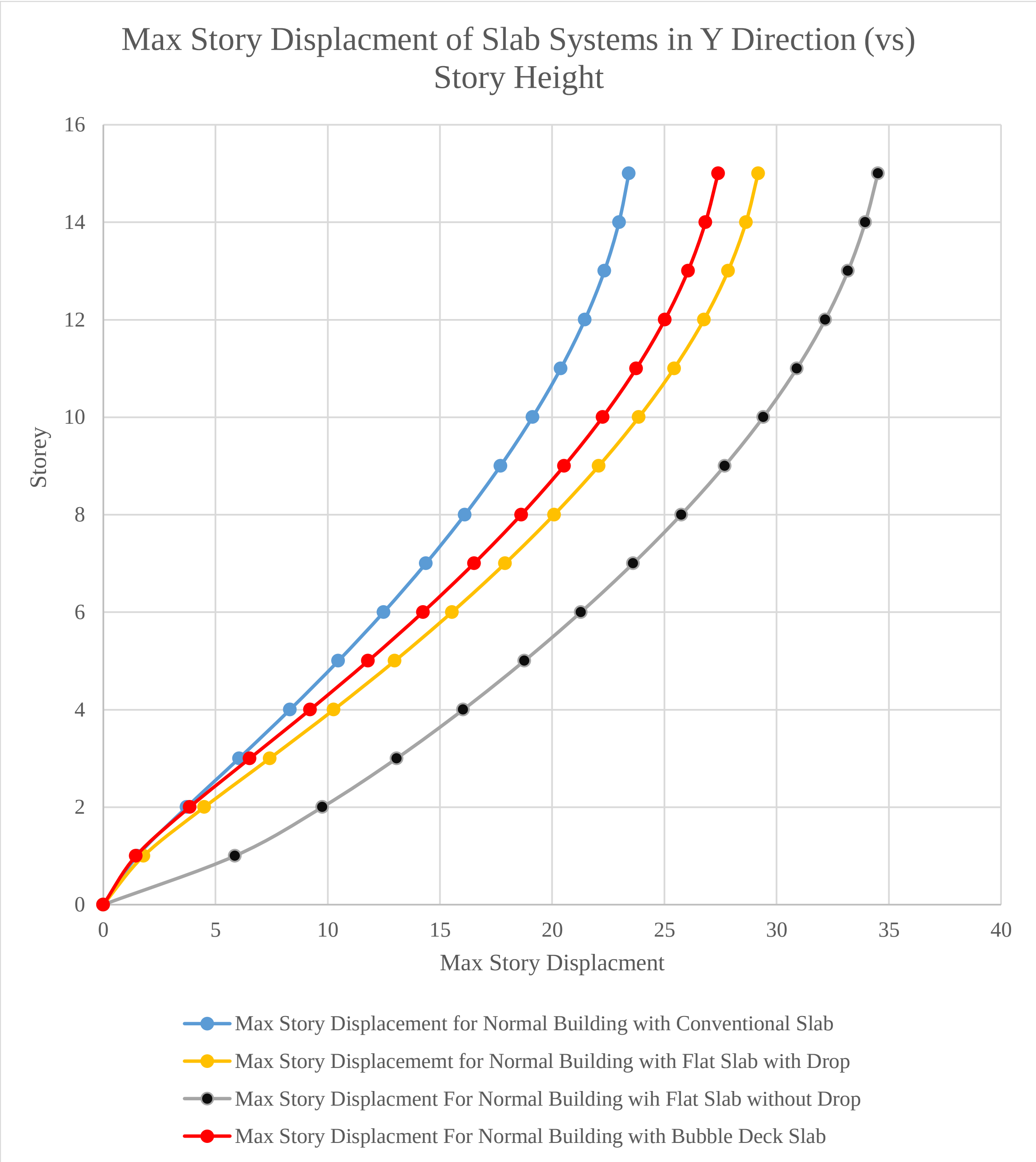
The above graph shows results for all without irregularity building. Graph shows maximum storey displacement of slab systems in X direction. X direction shows storey displacement and Y direction shows storey numbers. As we can see that as storey increases value of displacement is also increasing. Max story displacement for normal building with flat slab without drop has the highest displacement value than the max story displacement for normal building with conventional slab by 74%, max story displacement for normal building with flat slab with drop by 71% and max story displacement for normal building with bubble deck slab by 75%.



Graph 2: Max Story Displacement of Slab Systems in Y Direction (vs) Story Height

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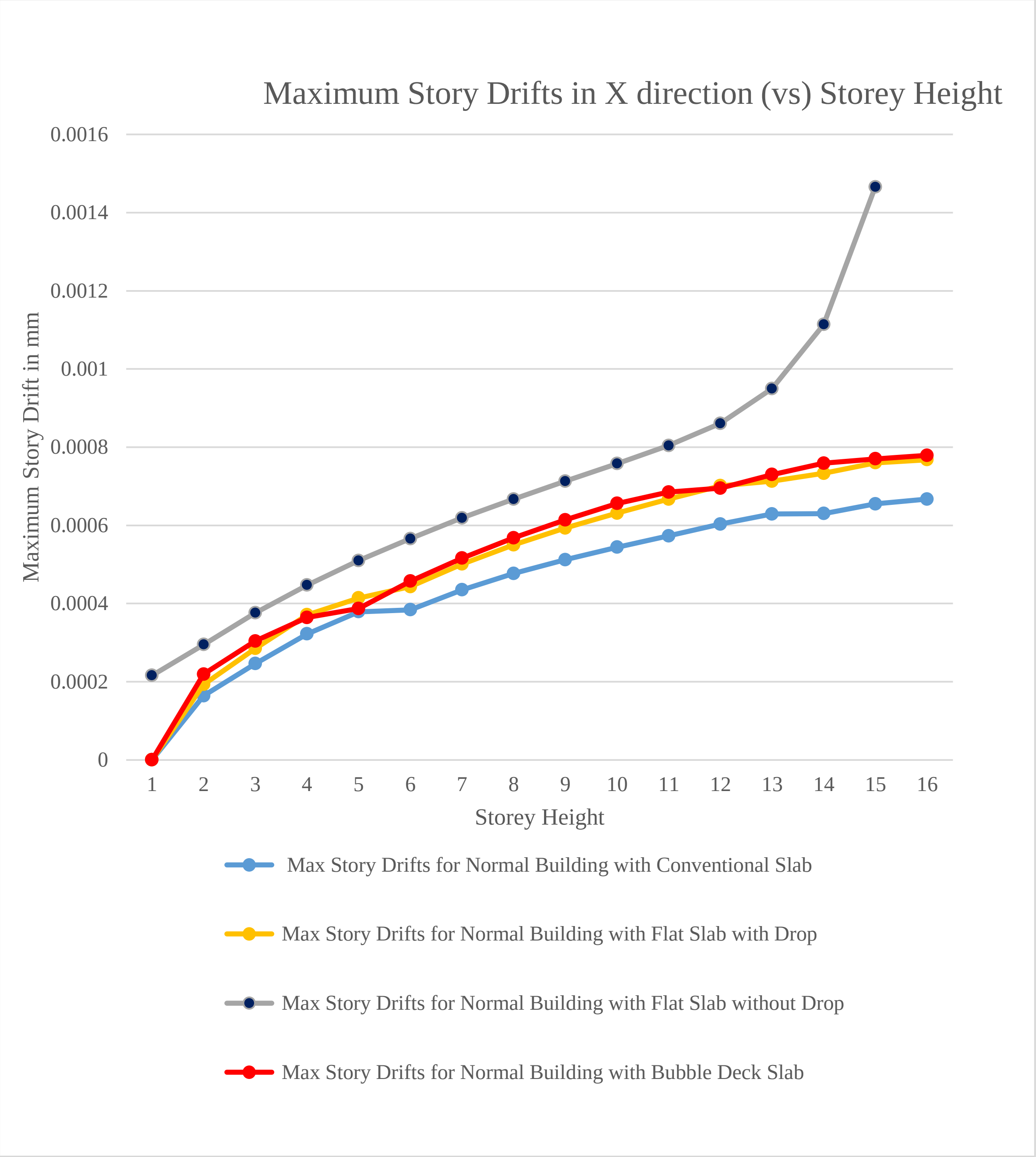
The above graph shows results for all without irregularity building. As well as Graph shows maximum storey displacement of slab systems in Y direction. X direction shows storey displacement and Y direction shows storey numbers. As we can see that as storey increases value of displacement is also increasing. Max story displacement for normal building with flat slab without drop has the highest displacement value than the max story displacement for normal building with conventional slab by 74%, max story displacement for normal building with flat slab with drop by 69% and max story displacement for normal building with bubble deck slab by 75%.

Storey drift:



Graph 3: Maximum Story Drifts in X direction (vs) Storey Height

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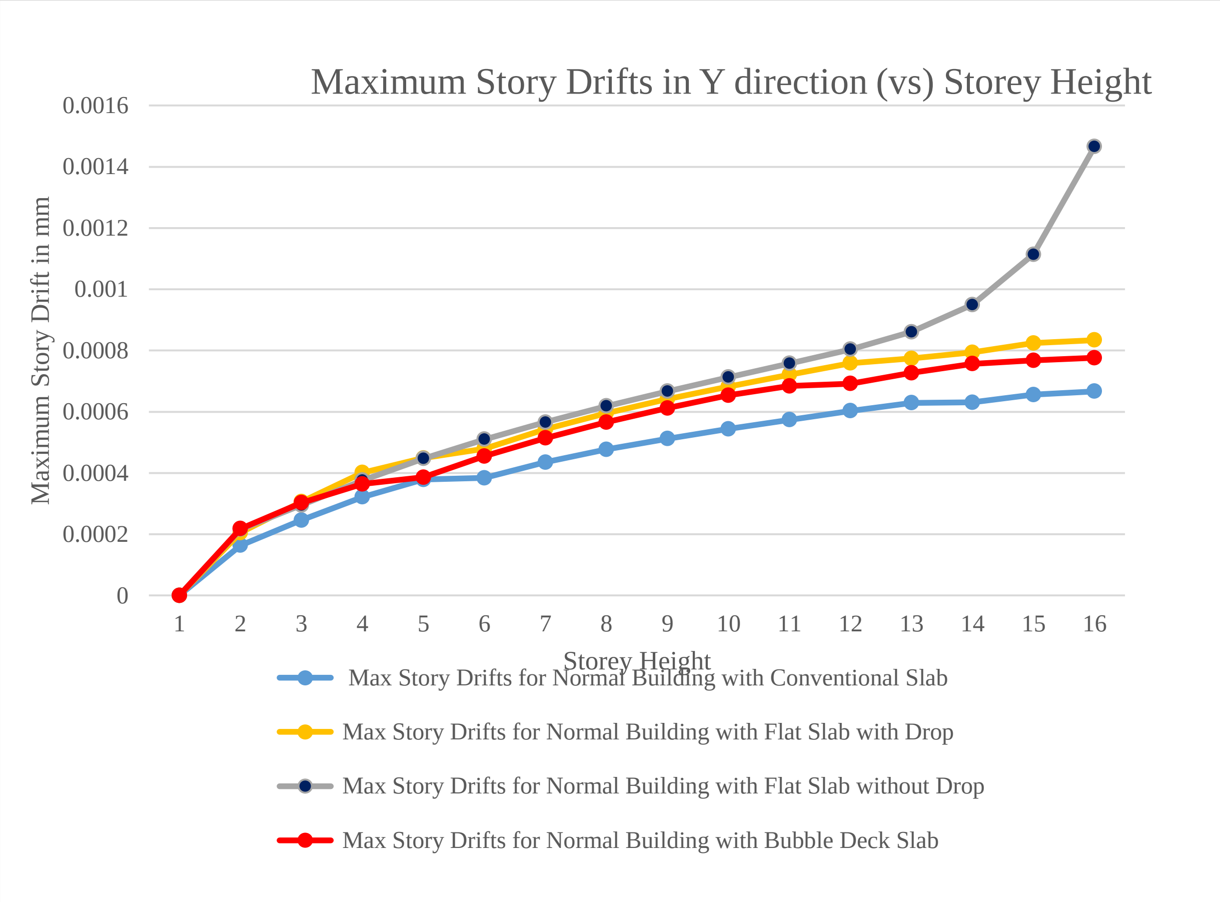
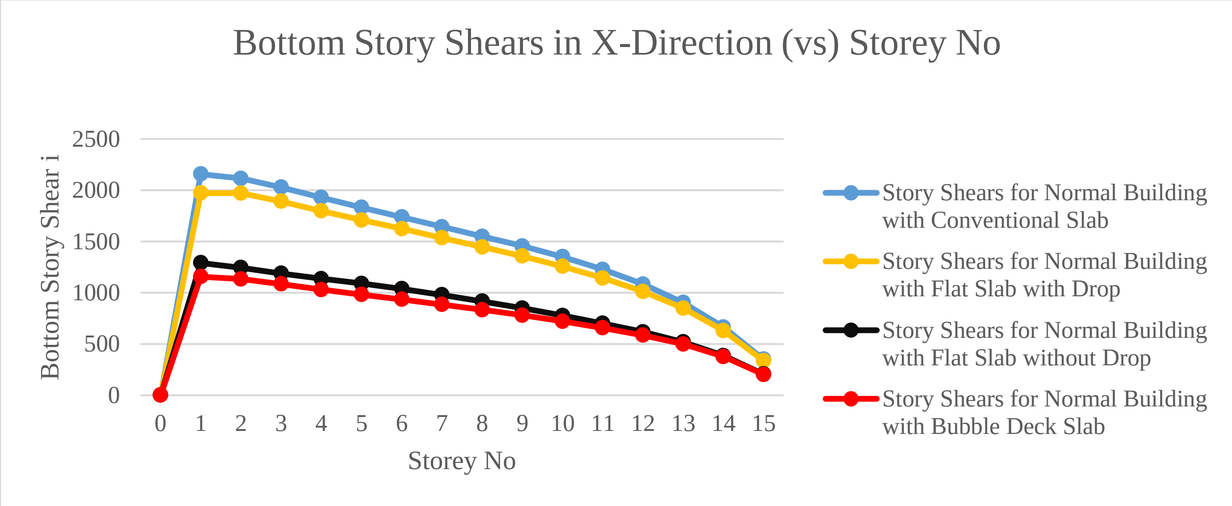
The above graph shows results for all without irregularity building. Graph shows maximum storey drift of slab systems in X direction. X direction shows storey height numbers and Y direction shows storey drift. As we can see that as storey increases value of drift is also increasing. Max Story Drifts for Normal Building with Bubble deck Slab has the highest drift value than the max Story Drifts for Normal Building with Conventional Slab by 26%, max Story drifts for Normal Building with Flat Slab with drop by 13% and Max Story Drifts for Normal Building with flat Slab without drop by 1.36%.



Graph 4: Maximum Story Drifts in Y direction (vs) Storey Height

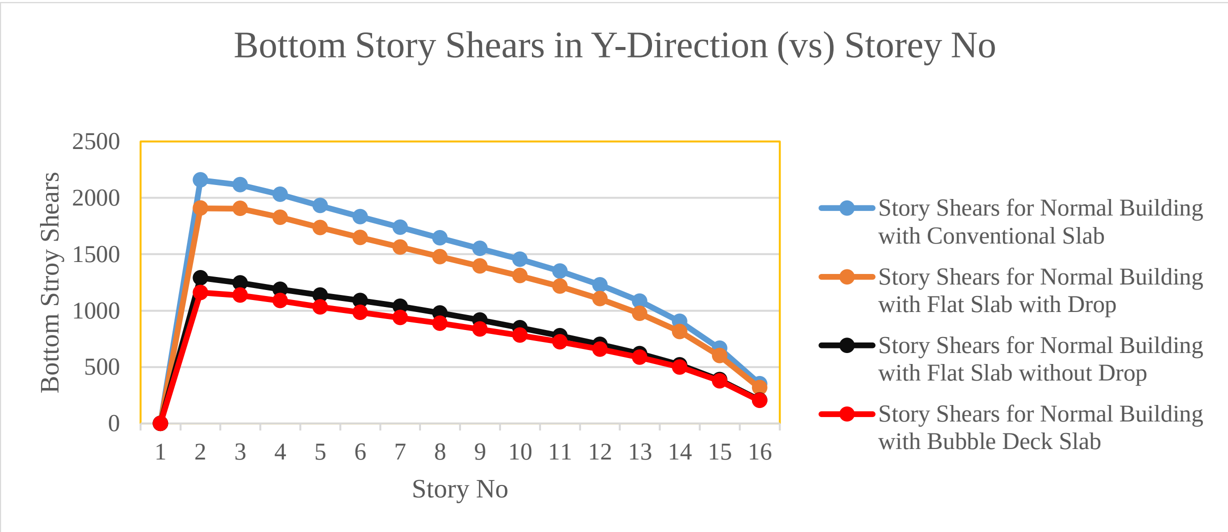
The above graph shows results for all without irregularity building. Graph shows maximum storey drift of slab systems in Y direction. X direction shows storey height numbers and Y direction shows storey drift. As we can see that as storey increases value of drift is also increasing. Max Story drifts for Normal Building with Bubble deck Slab has the highest drift value than the max Story drifts for Normal Building with Conventional Slab by 12%, max Story drifts for Normal Building with Flat Slab with drop by 5.16% and Max Story Drifts for Normal Building with flat Slab without drop by 0.92%.

Base shear:



Graph 5: Bottom Story Shears in X-Direction (vs) Storey No

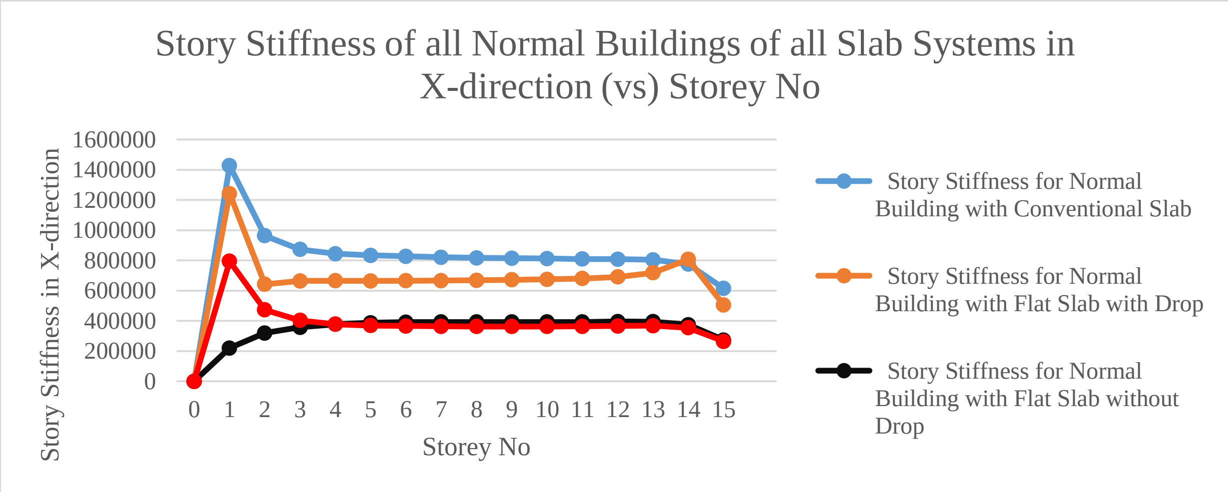
The above graph shows results for all without irregularity building. Graph shows bottom story shears in X direction. X direction shows storey number and Y direction shows bottom storey shear. As we can see that as storey increases value of story shear is also increasing. Bottom Story Shears for Normal Building with Conventional Slab has the highest story shear value than the bottom Story Shears for normal building with flat slab with drop by 0.08%, bottom story shear for normal building with flat slab without drop by 40.16 % and story shear for normal building with bubble deck slab by 46.35%.



Graph 6: Bottom Story Shears in Y-Direction (vs) Storey No

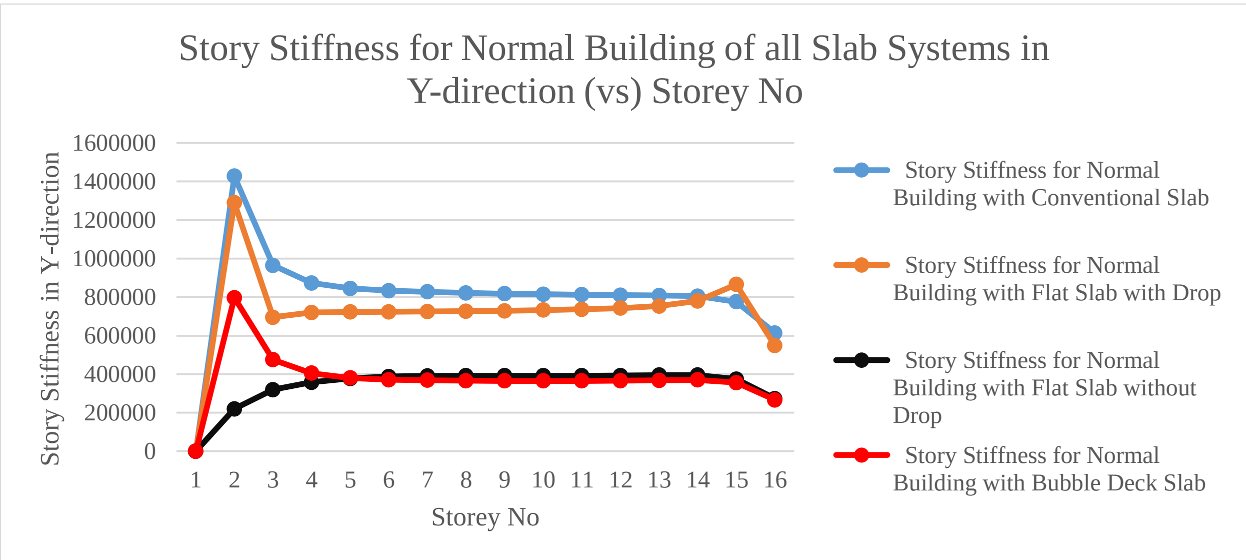
The above graph shows results for all without irregularity building. Graph shows bottom story shears in Y direction. X direction shows storey number and Y direction shows bottom storey shear. As we can see that as storey increases value of story shear is also increasing. Bottom Story Shears for Normal Building with Conventional Slab has the highest story shear value than the bottom Story Shears for normal building with flat slab with drop by 11.59%, bottom story shear for normal building with flat slab without drop by 40.2% and story shear for normal building with bubble deck slab by 46.22%.

Storey stiffness



Graph 7: Story Stiffness of all Normal Buildings of all Slab Systems in X-direction (vs) Storey No

The above graph shows results for all without irregularity building. Graph shows Storey stiffness of slab systems in X direction. X direction shows storey numbers and Y direction shows Storey stiffness. As we can see that as storey decreases value of stiffness is increasing. Story Stiffness for Normal Building with Conventional Slab has the highest drift value than the Story Stiffness for Normal Building with Flat Slab with Drop by 13%, max Story stifness for Normal Building with Flat Slab without Drop by 84.5% and Max Story Stiffness for Normal Building with Bubble Deck Slab by 44.4%.



Graph 8: Story Stiffness for Normal Building of all Slab Systems in Y-direction (vs) Storey No

The above graph shows results for all without irregularity building. Graph shows Storey stiffness of slab systems in Y direction. X direction shows storey numbers and Y direction shows Storey stiffness. As we can see that as storey decreases value of stiffness is increasing. Story Stiffness for Normal Building with Conventional Slab has the highest drift value than the Story Stiffness for Normal Building with Flat Slab with Drop by 13%, max Story stifness

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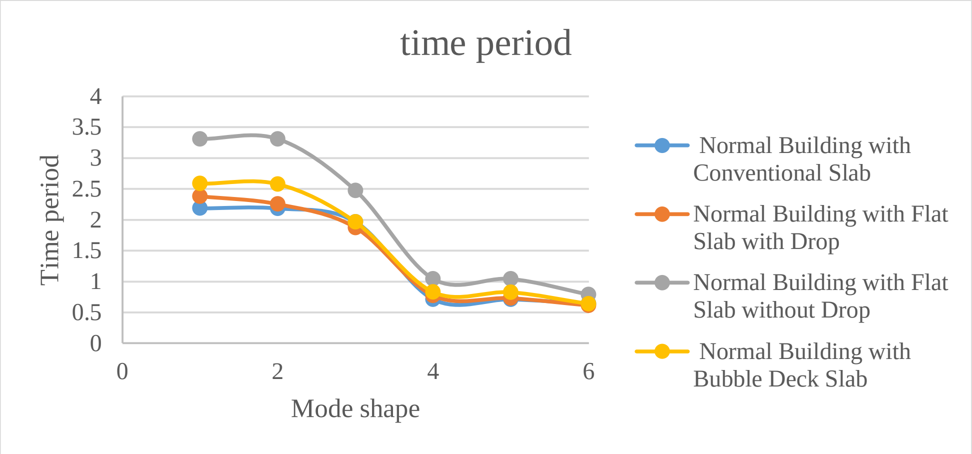
for Normal Building with Flat Slab without Drop by 0.84% and Max Story Stiffness for Normal Building with Bubble Deck Slab by 44.1%.

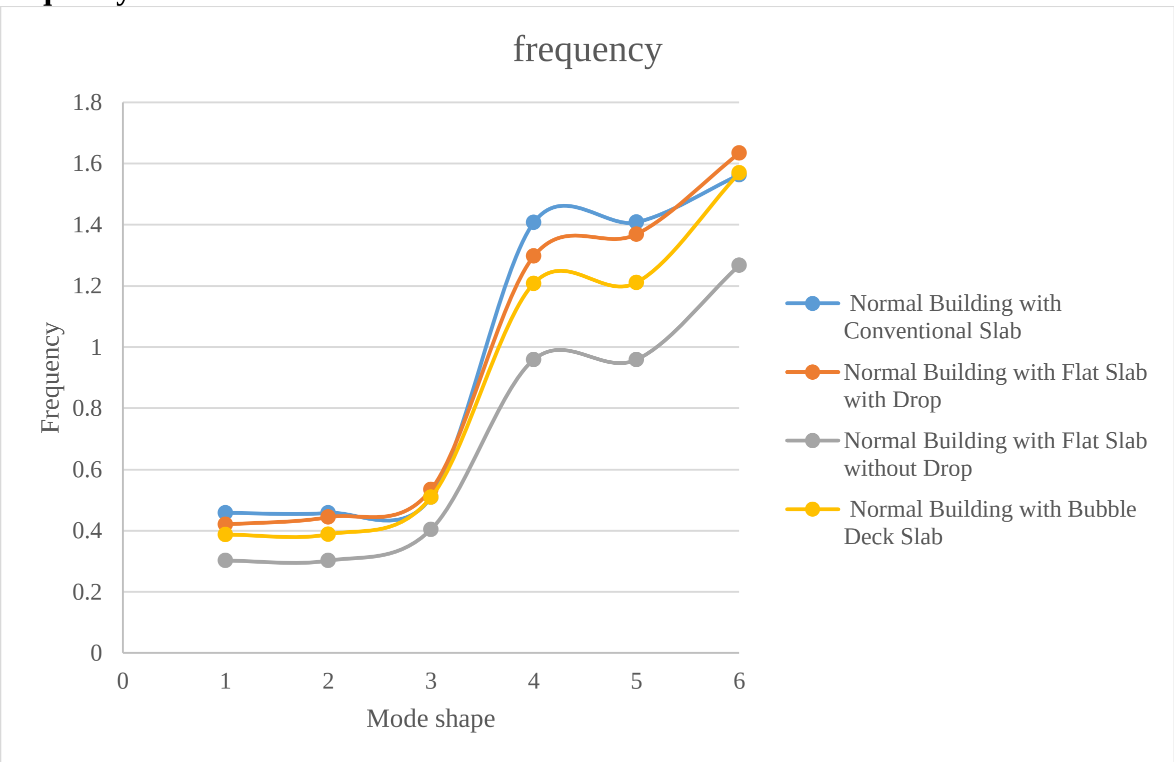
Time period:



Graph 9: time period

The above graph shows results for all without irregularity building. Graph shows time period normal building with slab in X direction. X direction shows mode shape and Y direction shows time period. As we can see that as mode shape decreases value of time period is increasing. Normal Building with Flat Slab without Drop has the highest time period value than the Normal Building with Conventional Slab by 33.99%, time period for Normal Building with Flat Slab with Drop by 28% and Max Story Stiffness for Normal Building with Bubble Deck Slab by 21.89%.

Frequency:



Graph 10: frequency

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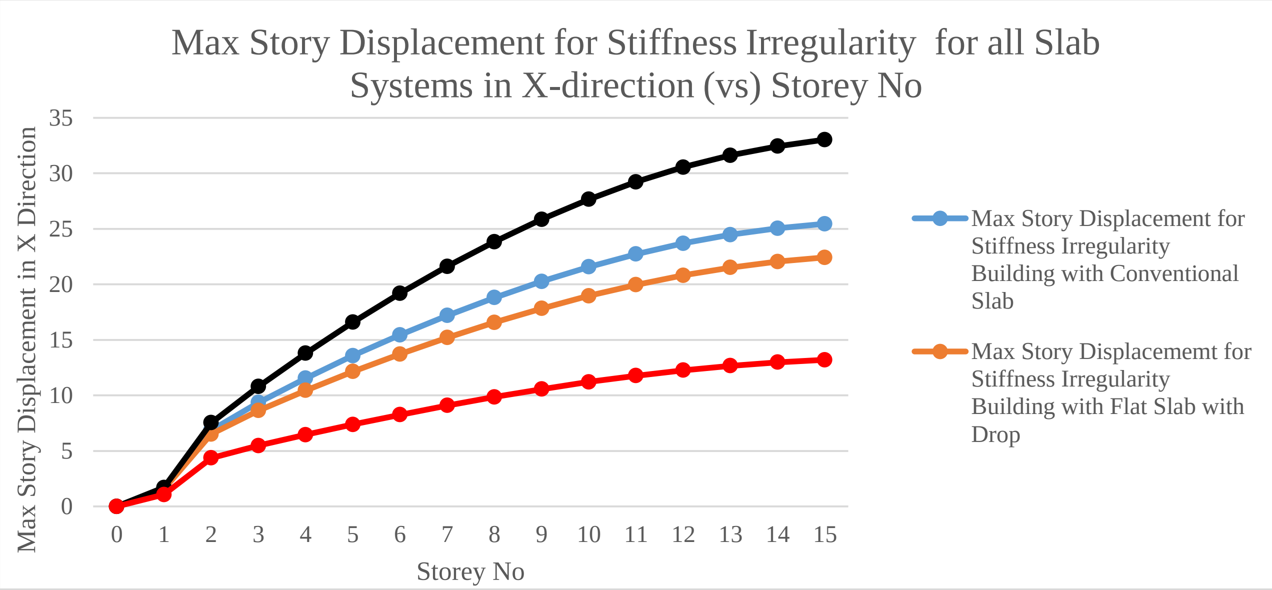
The above graph shows results for all without irregularity building. Graph shows Frequency normal building with slab in X direction. X direction shows mode shape and Y direction shows Frequency. As we can see that as mode shape increases value of Frequency is increasing. Normal Building with Conventional Slab has the highest time period value than the Normal Building with Flat Slab with Drop by 8.30%, Normal Building with Flat Slab without Drop by -39.07% and Max Story Stiffness for Normal Building with Bubble Deck Slab by -8.54%.

- **WITH STIFFNESS IRREGULARITY**

Storey displacement



Graph 11: Max Story Displacement for Stiffness Irregularity for all Slab Systems in X-direction (vs) Storey No

The above graph shows results for all with stiffness irregularity. Graph shows maximum storey displacement of slab systems in X direction. X direction shows storey numbers and Y direction shows storey displacement. As we can see that as storey increases value of displacement is also increasing. Max Story Displacement for Stiffness Irregularity Building with Flat Slab without Drop has the highest displacement value than the max story displacement for Stiffness Irregularity Building with conventional slab by 4.71%, Max Story Displacement for Stiffness Irregularity Building with Flat Slab with Drop by 7.9% and max story displacement for Stiffness Irregularity Building with bubble deck slab by 37.6%.

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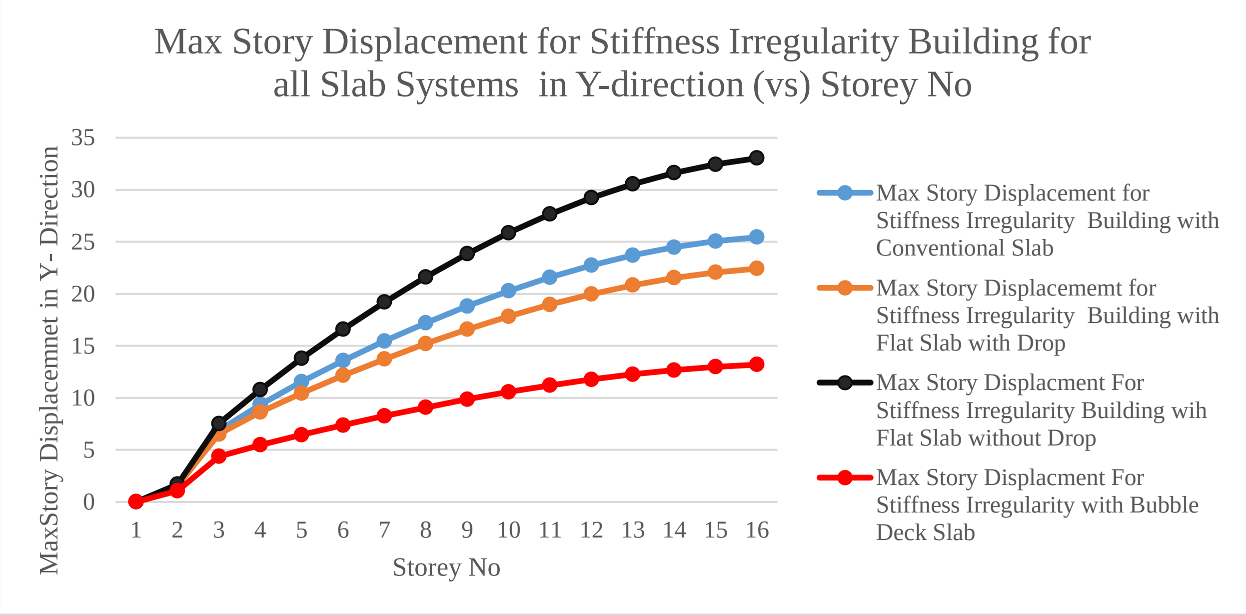
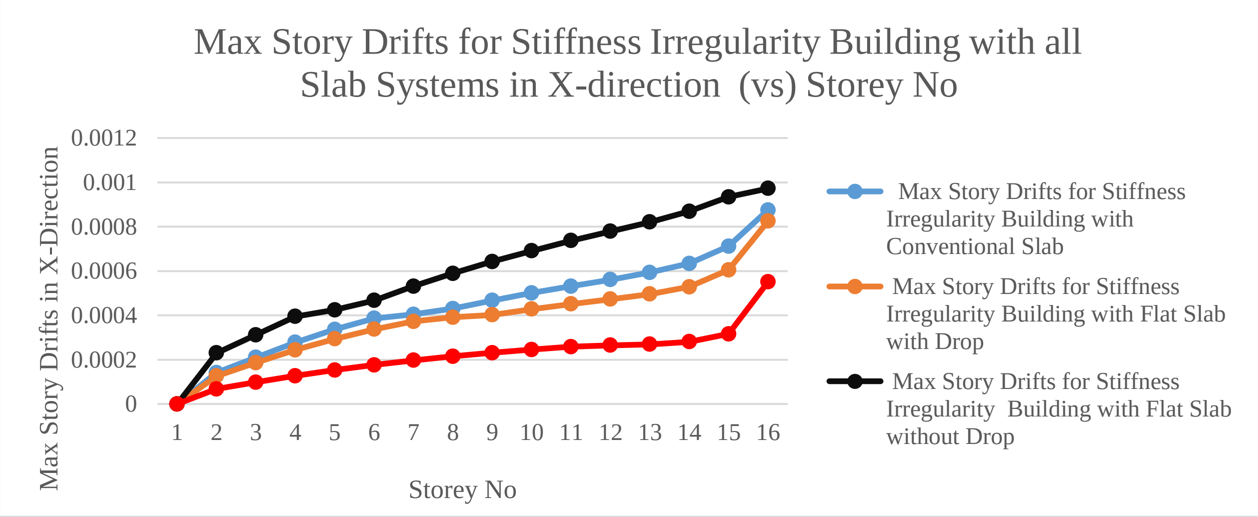


Graph 12: Max Story Displacement for Stiffness Irregularity Building for all Slab Systems in Y-direction (vs) Storey No

The above graph shows results for all with story drift irregularity building. Graph shows maximum storey displacement of slab systems in Y direction. X direction shows storey numbers and Y direction shows storey displacement. As we can see that as storey increases value of displacement is also increasing. Max Story Displacement for Stiffness Irregularity Building with Flat Slab without Drop has the highest displacement value than the max story displacement for Stiffness Irregularity Building with conventional slab by 4.71%, Max Story Displacement for Stiffness Irregularity Building with Flat Slab with Drop by 7.8% and max story displacement for Stiffness Irregularity Building with bubble deck slab by 37.6%.

Storey drift:



Graph 13: Max Story Drifts for Stiffness Irregularity Building with all Slab Systems in X-direction (vs) Storey No

The above graph shows results for all with stiffness irregularity building. Graph shows maximum storey drift of slab systems in X direction. X direction shows storey numbers and Y direction shows storey drift. As we can see that as storey increases value of drift is also increasing. Max Story Drifts for Stiffness Irregularity Building with Flat Slab without Drop

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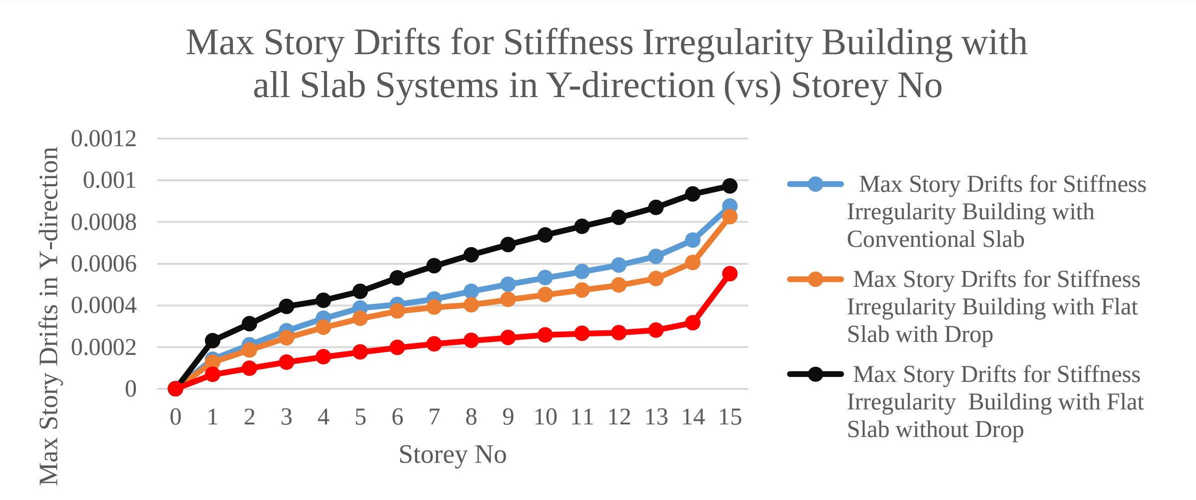
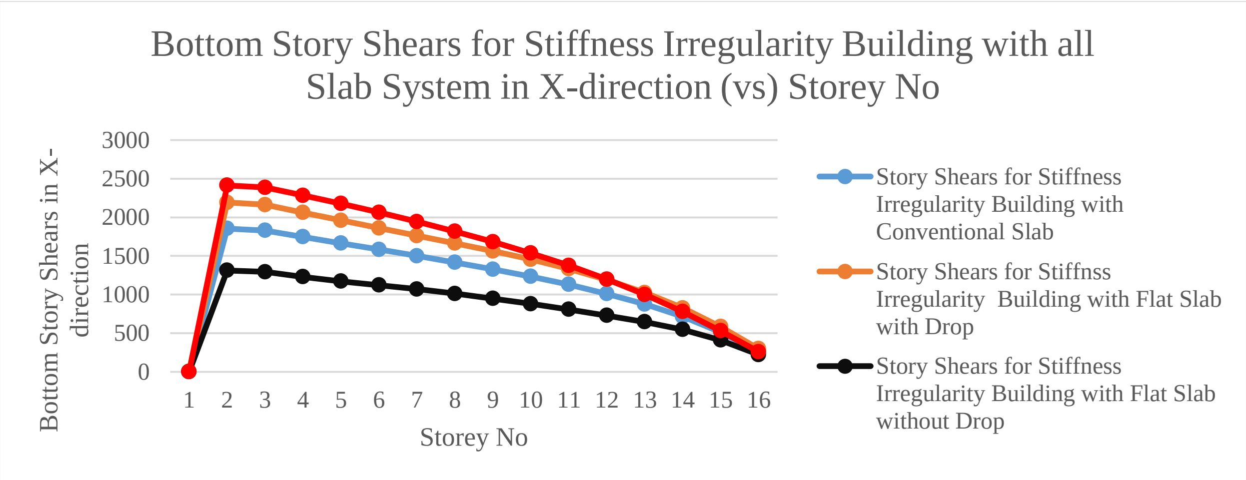
has the highest drift value than the max Story Drifts for Normal Building with Conventional Slab by 38.69%, Max Story Drifts for Stiffness Irregularity Building with Flat Slab with Drop by 45.21% and Max Story Drifts for Stiffness Irregularity Building with Bubble Deck Slab by 70.43%.



Graph 14: Max Story Drifts for Stiffness Irregularity Building with all Slab Systems in Y-direction (vs) Storey No

The above graph shows results for all with stiffness irregularity building. Graph shows maximum storey drift of slab systems in Y direction. X direction shows storey numbers and Y direction shows storey drift. As we can see that as storey increases value of drift is also increasing. Max Story Drifts for Stiffness Irregularity Building with Flat Slab without Drop has the highest drift value than the max Story Drifts for Normal Building with Conventional Slab by 38.69%, Max Story Drifts for Stiffness Irregularity Building with Flat Slab with Drop by 44.78% and Max Story Drifts for Stiffness Irregularity Building with Bubble Deck Slab by 70.43%.

Base shear:



Graph 15: Bottom Story Shears for Stiffness Irregularity Building with all Slab System in X-direction (vs) Storey No

The above graph shows results for all with stiffness irregularity building. Graph shows bottom story shears in X direction. X direction shows storey number and Y direction shows bottom storey shear. As we can see that as storey decreases value of story shear is

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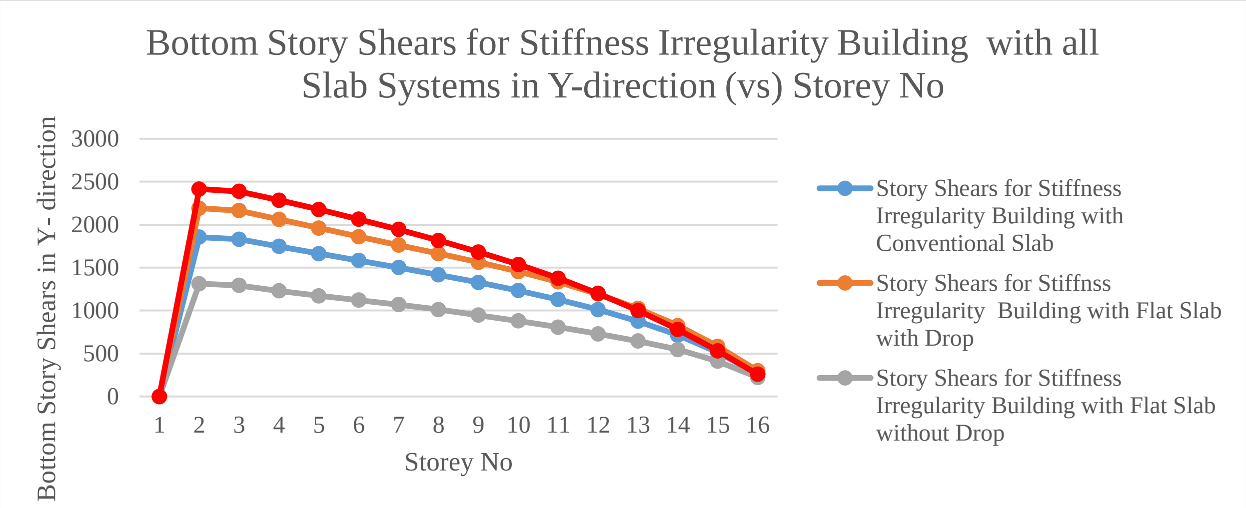
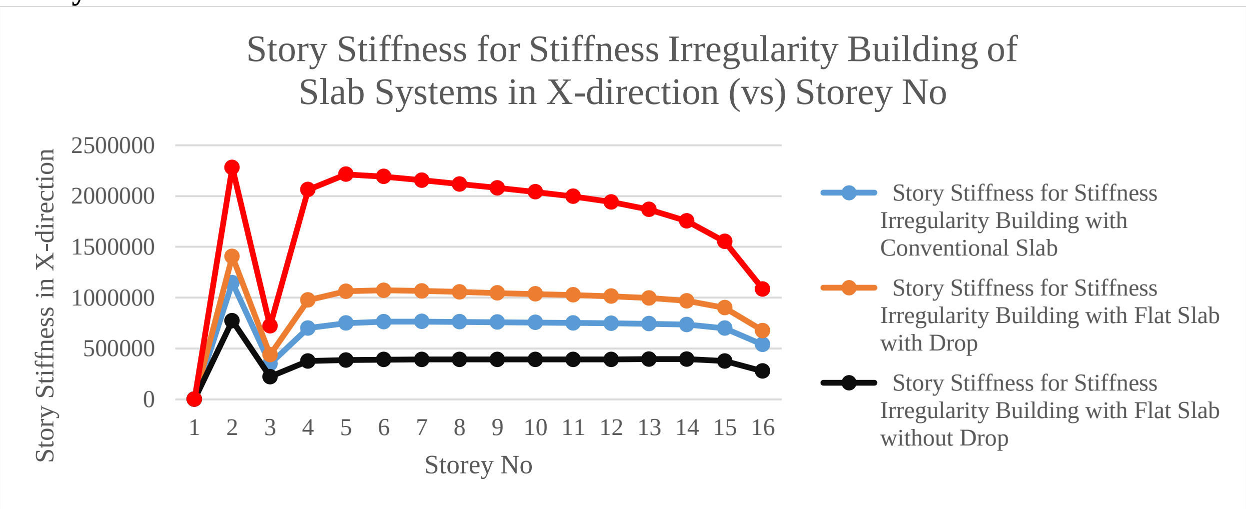
increasing. Bottom Story Shears for Stiffness Building with Bubble Deck Slab has the highest stiffness value than the bottom Story Shears for Stiffness Irregularity Building with Conventional Slab by 23.16%, bottom story Shears for Stiffness Irregularity Building with Flat Slab with Drop by 9.16% and max story Shears for Stiffness Irregularity Building with Flat Slab without Drop by 45.61%.



Graph 16: Bottom Story Shears for Stiffness Irregularity Building with all Slab Systems in Y-direction (vs) Storey No

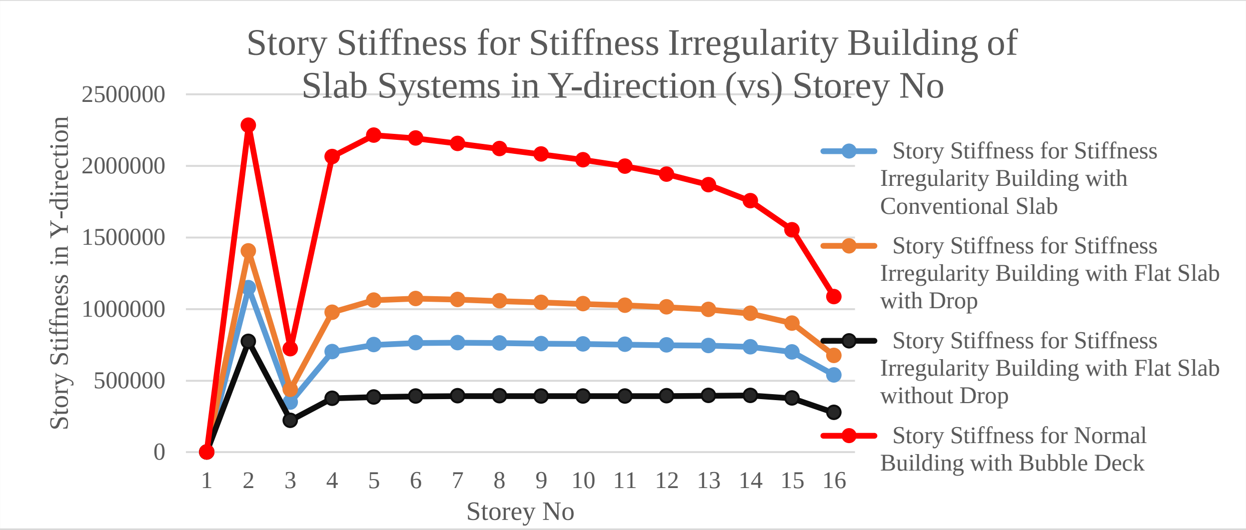
The above graph shows results for all with stiffness irregularity building. Graph shows bottom story shears in Y direction. X direction shows storey number and Y direction shows bottom storey shear. As we can see that as storey decreases value of story shear is increasing. Bottom Story Shears for Stiffness Building with Bubble Deck Slab has the highest stiffness value than the bottom Story Shears for Stiffness Irregularity Building with Conventional Slab by 23.16%, bottom story Shears for Stiffness Irregularity Building with Flat Slab with Drop by 9.17% and max story Shears for Stiffness Irregularity Building with Flat Slab without Drop by 45.61%.

Storey stiffness:



Graph 17: Story Stiffness for Stiffness Irregularity Building of Slab Systems in X-direction (vs) Storey No

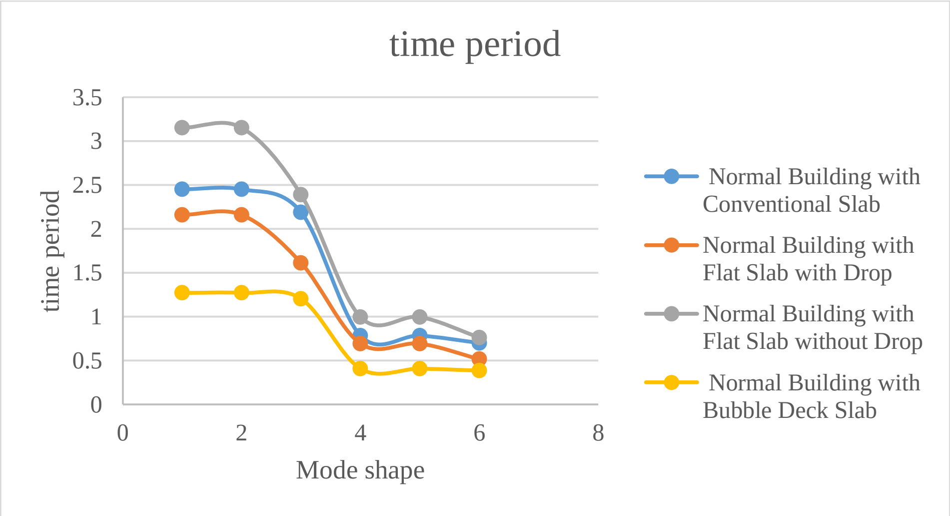
The above graph shows results for all with stiffness irregularity building. Graph shows Storey stiffness of slab systems in X direction. X direction shows storey numbers and Y direction shows Storey stiffness. As we can see that as storey decreases value of stiffness is increasing. Story Stiffness for Normal Building with Bubble Deck has the highest stiff value than the Story Stiffness for Stiffness Irregularity Building with Conventional Slab by 49.65%, Story Stiffness for Stiffness Irregularity Building with Flat Slab with Drop by 38.37% and Story Stiffness for Stiffness Irregularity Building with Flat Slab without Drop by 66.09%.



Graph 18: Story Stiffness for Stiffness Irregularity Building of Slab Systems in Y-direction (vs) Storey No

The above graph shows results for all with stiffness irregularity building. Graph shows Storey stiffness of slab systems in Y direction. X direction shows storey numbers and Y direction shows Storey stiffness. As we can see that as storey decreases value of stiffness is increasing. Story Stiffness for Normal Building with Bubble Deck has the highest stiff value than the Story Stiffness for Stiffness Irregularity Building with Conventional Slab by 0.49%, Story Stiffness for Stiffness Irregularity Building with Flat Slab with Drop by 0.38% and Story Stiffness for Stiffness Irregularity Building with Flat Slab without Drop by 66.09%.

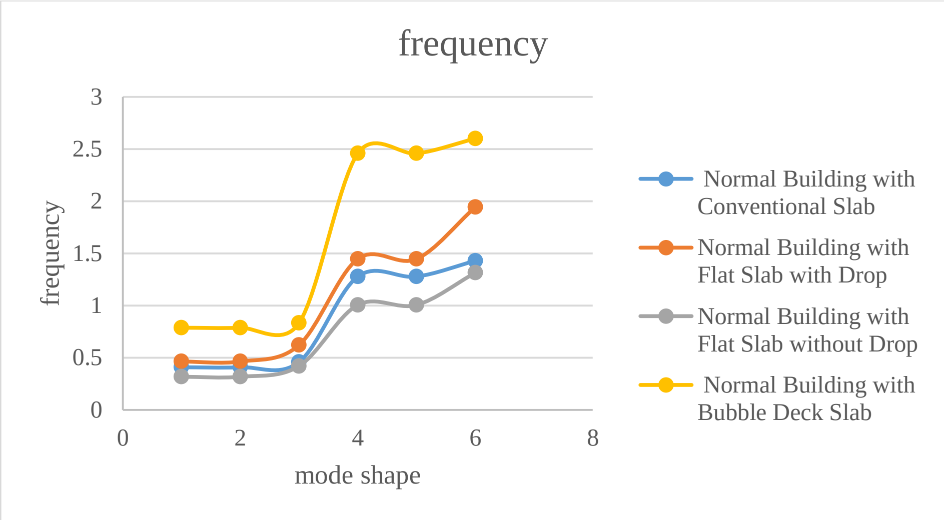
Time period:



Graph 19: time period

The above graph shows results for all with stiffness irregularity building. Graph shows time period normal building with slab in X direction. X direction shows mode shape and Y direction shows time period. As we can see that as mode shape decreases value of time period is increasing. Normal Building with Flat Slab without Drop has the highest time period value than the Normal Building with Conventional Slab by 22.24%, time period for Normal Building with Flat Slab with Drop by 31.48% and Max Story Stiffness for Normal Building with Bubble Deck Slab by 0.59%.

Frequency:



Graph 20: frequency

The above graph shows results for all with stiffness irregularity building. Graph shows Frequency normal building with slab in X direction. X direction shows mode shape and Y direction shows Frequency. As we can see that as mode shape increases value of Frequency is increasing Normal Building with Bubble Deck Slab has the highest time period value than the Normal Building with Conventional Slab by 48.15%, Normal Building with Flat Slab with Drop by 41.16% and Normal Building with Flat Slab without Drop by 59.72%.

5. Conclusion:

A more practical alternative to traditional solid planks is the inflated office slab, which has been used in over fifteen nations internationally. The use of the bubbling platform slab method will shorten completion dates, lower expenses for building, and boost workmanship effectiveness while reducing the amount of greenhouse gases released in our environment. The bubble-shaped decking slab design does have certain shortcomings, however, namely a higher risk of piercing shear injury with deviation.

The study focused on eight models, including normal conventional slab, flat slab with drop, flat slab without drops, normal bubble deck slab, and their respective variations with stiffness irregularities. Through the analysis of these models, several significant findings have emerged. Firstly, it was observed that the inclusion of a drop in the flat slab system resulted in improved performance compared to the flat slab without a drop. The presence of the drop enhanced the structural stiffness, leading to reduced storey displacement and drift. Furthermore, the study revealed that the bubble deck slab system demonstrated comparable performance to the conventional slab system. This finding is noteworthy as the bubble deck slab system utilizes voids within the slab, reducing the amount of concrete required and potentially providing economic and environmental benefits.

However, when considering the presence of stiffness irregularities, it was observed that both the conventional slab and the bubble deck slab system experienced adverse effects. The introduction of stiffness irregularities resulted in increased storey displacement, drift, base shear, and base reactions for both systems. This indicates that stiffness irregularities have a significant impact on the overall structural behavior, irrespective of the slab system employed. Based on the comparative analysis, it can be concluded that the inclusion of a drop in the flat slab system and the utilization of the bubble deck slab system can offer advantageous performance characteristics compared to a conventional slab system without any irregularity. However, when stiffness irregularities are present, all slab systems experience a decline in performance.
These findings have practical implications for the design and construction industry, highlighting the importance of considering stiffness irregularities and the benefits of incorporating drops in flat slabs or utilizing bubble deck systems. Future research could explore mitigation strategies for stiffness irregularities and investigate the long-term performance and durability of the different slab systems under various loading conditions.
Overall, this study contributes to the body of knowledge regarding slab systems and provides valuable insights for engineers, architects, and researchers in making informed decisions regarding the selection and design of appropriate slab systems for different structural applications.

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