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Analysis Seismic Forces for Earthquake Resistant Constructions

Kakade Mahesh kumar Anant[1]*, DR. P. S. Charpe[2]

[1] Ph.D. Student, Kalinga University, Raipur

[2] Ph.D. Guide, Kalinga University, Raipur

Abstract - Earthquakes are the sign of change in our earth's inner crust. The past earthquake encounters have exhibitedgigantic death threats and infrastructure, influencing the social and monetary states of a country. However it is unimaginable to expect to prevent an earthquake, all today's technology is capable of making infrastructure earthquake safe. With the advancement in our comprehension of the earthquakes, most of the nations have commanded the in co-operation of seismic provisions in building plan and engineering. In case of an earthquake, the seismic waves starting from the center are sent in all the potential bearings. These shock waves propagate as body waves and surface waves through the interior of earth and are profoundly arbitrary in nature. These ground movements cause buildings to vibrate and instigate dormancy powers in the structures. Without a seismic plan, the structure may fall leading to catastrophic events. The seismic plan theory intends to principally ensure life safety and gets the usefulness of the structure. The paper means to make a statement about the earthquake-safe structures in different seismic zones. The impacts of plan and form configuration on irregularly shaped structures are discussed in this study. Seismic activity affects buildings with uneven geometry in diverse ways. The plan geometry is the parameter that determines how well it performs under various loading situations. Using the structural analysis programme STAAD Pro. V8i, the influence of irregularity (plan and form) on structure was investigated. There are numerous elements that influence how a building behaves, and storey drift and lateral displacement are two of the most significant in understanding how a structure behaves. Graphs and bar charts are used to display the results. According to the research, a basic layout and configuration must be selected at the planning stage to reduce earthquake effects .

Keywords - Earthquake, building, Irregular plan, Irregular shape¸ Seismic forces, Construction techniques.

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1. INTRODUCTION

Earthquakes and their devastating effects have been influential in determining recordedcivilization, and since the beginnings, acquiring knowledge to foresee or avoid earthquakehazards is still an important component of human search for information [1].Earthquake resistantconstruction has been on radar of technology evolution since the beginning of modern construction techniques. Shock proof and vibration proof design of buildings have been carried out since the old times. However, most of the innovation has been carried out to prevent loss of human beings than techno-economics aspects of these structures. Buildings that are constructed in a modern way are permitted during the event of an earthquake to go though plastic deformation wherein building supporting structures as well as steel in the joints helps the structure from getting collapsed. This is also the major reason for economic damage as the time it takes for the structures to renovate again and cost for their construction. Thus, for the structures to continue their activity immediately after the event it has become need of the day to design structures so that they can bear the loss caused by earthquake and can sustain their functionality even after that [2-3].

Without significant breakdown, all traditional technologies for earthquake-resistant construction helps the structures with the possibility of withstanding enormous sesmic forces. These advancements can be arranged into the groups given below:

1. Development strategies that use malleable development materials, like wood and bamboo houses.
2. Development advancements, like constructions with symmetric arrangement and elevation, use robust design styles.
3. Development innovations, like structures with groups and supports, that utilization robust primary setup.

4. Development advances decreasing seismic forces – for example, utilization of light-weight non-structural members [4].

Correlation of different techniques for their seismic reaction is profoundly requested for different various sorts of building developments to augment their safety. This will prevent human, monetary and structural loss during an earthquake. To better understand the tensile capacity both mathematical and simulation techniques must be utilized to identify the response of infrastructure [5]. For the effects of seismic forces utilization of distributed multiple tuned mass dampers can be isolated and can be added to the foundation or base of the structures. This innovation can be extended even in low rise structures to give insurance to those structures. Schools, clinics, power plants and gas/fire stations might get colossal advantages from this innovation [6].

There is a strong interest for new speculation in the development field for concealment of seismic forces which require arrangement of new designs, more robust assessment of reaction of new plans and materials utilized in structures. New strategies for underlying uprightness assessment are along these lines required for this reason [7-10].

2. REVIEW OF WORKS

This section presents the literature review of work carried out in the field of earthquake resistant construction so as to reduce seismic forces acting on them. This includes different construction material, structures and configurations and conventional and modern techniques.

In [1] the authorexamines the requirement for new intuition for making building framework to oblige the prerequisites of life saving methodology as well as for monetary and business improvement also. The construction of the structures ought to be with the end goal that they ought to get effectively and immediately reestablished even after a significant seismic earthquake. The present plans permit plastic disfigurements with the goal that they disperse the energy from the earthquake while denying the structural breakdown and loss of human existence. In any case, it sets aside long effort for full recuperation of the structure which brings about tremendous monetary misfortune. Henceforth, there is a need to configuration structure which follow seismic separation component utilizing superstructure innovation.

In [2] the author audits the most regularly utilized strategies for seismic forces safe constructions created by individuals throughout past. They present a contextual analysis of Portugal culture of raising earthquake safe structures. Notwithstanding, this idea is losing its hold as development business is increasingly more centered around raising the constructions rapidly and at least expense which doesn't settle for the safety. Subsequently, it is important to readopt the prior demonstrated development innovation.

In [3] and [4] author examine the basics of earthquake safe constructions and their plan. They work on different parts of seismic demonstrating, reaction of various constructions for that displaying, strategies to address the interest that it induces and its assessment. They additionally talk about substitute ways to deal with earthquaketo lessen the effect of seismic waves on the constructions. The utilization of glass shade allotments is quickly filling in the places of advanced engineering. They have one day represented obliteration in the wake of experiencingearthquake developments. The conduct of such frameworks under seismic forces is examined in these compositions.

The author in [5] commits to aim towards upgradingthe usefulness of suppliers and designers. Structures might have phenomenal durability against leftover power applying underlying burden, but earthquake involving deficient limit involving earthquake forces against tensionand compression. Seismically reinforcing theirdevelopment is crucial as to get their underlying assurance and to broaden their useful life.

The review introduced in [6] adopts the strategy of supporting a notable arrangement of workmanship that has been built in the late nineteenth century however abandoned for quite a long while. Around 74% of private properties were built in Italy before 1980, while 25 percent of the district was marked as seismic. Right around 86% were introduced before 1991, while the essential prohibitive power yield law was passed. Numerous families need any seismic and power security development to build their level of supportability. For supported cement outlined houses, the recommended blended retrofit approach is primarily founded exclusively on the expulsion of the external layer of "double-leafinfill walls"[7].

Modular steel construction (MSC) includes volumetric components and on-site fabrication assembled off-site. When the ceiling height rises, the effect of the earthquakes is important. An analysis of mid-to-high MSC seismic output is described in [8]. The goal is to facilitate the further widespread application of MSC in earthquake zones .

Masonry work develops for the most partof the world happens by and by and is still in existence. These homes are in chargeofhigh outside loadings demanded with the guide of earthquake, heavywinds, blasts, and so forth.Some advanced seismicretrofitting and reinforcing structures are developed and applied in these recentyears to the construction [9].

Indeed, even in India, just about 80% of Delhi's homes, the capital of India, are not earthquake inclined. Parallel strain opposing gadgets, for example, chevron supports, knee supports are situated in total with aluminum shear hyperlinks to limit the effect of the earthquakes on the levied frameworks [10].

Multi-story houses are cause for wind or lateral masses. Structures might be built through a few methodologies to bring down these lateral masses. The conduct of primary diaphragm for the length of the seismic waves on their general yield is being noticed [11].

Because of more than one known attributes, wood frameworks generally delivered excellent seismic by and large execution. The consequences of the last worldwide earthquake have essentially shown that the seismic wooden design can be changed along these lines [12]. Today, wooden constructions target higher statures and face various serious seismic models. As an area of interest in wood designing science, seismic protectiontechnologies (SPTs) have emerged.

Precast cement works with a development technique utilizing strong and quickly erectable pre-assembled individuals to make economical and great designs. The associations between the precast individuals just as between the individuals and the establishment require extraordinary regard for guaranteed seismic execution [13].

The authors of [14] present extreme strategies for improving the seismic efficiency of houses and bridges. The investigation focuses on the impact of various insulators and dampers on building damage prevention. The multi-level pipe damper (MPD) is a static control device suggested by the authors in [15] to reduce seismic activity. The seismic performance of structural steel with MPDs is discussed. MPD may be utilised as a maintenance and repair method for structures in severe seismic zones .

During the structure interaction for the rope connect with slant development, it was discovered that there is no reconciliation between the dock and the foundation. When a quake strikes, the design will almost certainly overturn or the foundation turntable will break down. The differentiating pin at the centre of the ball-end turn has significant shearing strength under the 6-degree and 7-degree tremor adequacy. The seismic strides for gathering anchor bars at the turntable's edges are proposed in the investigation [16]. In the field of wood engineering, the creation of cross-laminated wood (CLT) is becoming commonplace. As a result, early adopters should avoid developing and constructing CLT systems in earthquake-prone areas. [17] shows the most recent seismic design of CLT structures.

In [18] authorsome of the strategies utilized for investigation for earthquake safe plan which incorporate comparable horizontal power strategy and reaction range examination. They likewise give relative investigation of both these techniques. It is seen that assuming R factor is under 6, it is proposed to perform nonlinear reaction history investigation.

The authors of [19] and [20] suggest an earthquake-resistant masonry building design. These structures are extremely heavy, with no discernible tensile strength and poor wall construction. They recommend that building walls be reinforced vertically with steel to provide them enough flexibility to withstand seismic pressures. Accelerated Bridge Construction (ABC) has been tried in low seismic regions [21] and [22]. ABC has only been used in areas with high seismic activity. The linkages attempt to replicate the typical production of plastic hinges within the side of bridge columns by an earthquake. Seismic isolation devices are used to reduce the effects of earthquakes [23] and [24]. The bottom shear and displacement are reduced, while ground acceleration and inter-storey drift increase .

Blue mussels can be found sticking to rocks and ocean decks up and down the shore of New England. In between of their twin sea shells emerges a stingy outcrop of cabling which helps them to be anchored in their place. Normally, even the most incredibly elevated tides can't pry them free. To remain appended to their shaky roosts, mussels emit tacky filaments known as byssal strings. A portion of these strings are firm and inflexible, while others are adaptable and flexible. Specialists are attempting to join this specific component into structures to cause the structure to withstand earthquakes.

A team at Blume Earthquake Engineering Centre, USA, led by Deierlein are working on an innovative innovation known as the shaking outline, which comprises of three fundamental parts - steel outlines, steel links, and steel wires. During a seismic occasion, energy-dispersal is assigned to a wire while the post-tensioning (PT) links reestablish the edge to its underlying setup. At the point when a seismic tremor strikes, the steel outlines rock all over. The entirety of the energy gets coordinated descending to a fitting that houses a few tooth-like wires. The teeth of the wires grind together and may even fizzle, however the actual edge stays unblemished. When the shaking has halted, the steel links in the casing pull the structure once again into an upstanding position. Laborers then, at that point investigate the circuits and supplant any that are harmed. The benefit is that the structure can be reoccupied rapidly after a seismic tremor.

Seismic Invisibility is a term used to describe the invisibility of earthquake Cloak - A sequence of boreholes is drilled around the perimeter of the structure to be protected. These boreholes appear to act as a seismic cloak, shielding a building or maybe a whole city from the devastating waves of an earthquake. Isolators, dampers, and other vibration response control devices are no longer necessary.

Cardboard can be used as a strong and long-lasting construction material. Several constructions constructed by Japanese architects use polyurethane-coated cardboard tubes as the major frame elements. The Transitional Cathedral in Christchurch, New Zealand, was built from 98 massive cardboard tubes and wooden beams. The cardboard-and-wood construction is exceptionally light and flexible, outperforming concrete during seismic events by a wide margin. It's also less likely to crush those who are within if it does collapse.

Levitating Houses – A Japanese company has developed an idea where a house in stable condition rests on a deflated airbag. When the sensors detect a vibration, they switch on the compressor which turns pumps the air into this bag. This airbag lifts the house by 3cm from its foundation. The structure will hover for the duration of the quake and then the airbag deflates and the structure settles to its original condition. This technique can be fitted to new homes of appropriate weight and also, can be used to retrofit the existing house.

Another research team from ARX PAX (California) has filed a patent for the levitating house. The mechanism is quite different from the Japanese and this may find wide applications is tall buildings. A three-part foundation system is used to support a structure in this method. A containment vessel, a buffer medium, and a construction platform are what they are. The buffer medium can be a fluid, a gas, or a liquefiable solid, and the building can be built on the construction platform. The containment vessel is subjected to lateral forces which transfer the load to the buffer medium. This medium acts as a damper and significantly reduces the forces being transmitted to the building. The system can levitate the building for around 90seconds which are considered as the average time of the earthquake.

Eco-friendly ductile cementations composite (EDCC) spray – A research team from the University of British Columbia (Vancouver, Canada) has developed a new radical approach to make the buildings resist earthquakes. EDCC combines cement with polymer-based fibers, flash, and other additives in making it eco- friendly and has been engineered at a molecular level to be strong and malleable at the same time. This material when applied as a thin coating (10mm), was found to have improved seismic resistance of the structure by withstanding an earthquake of intensity 9 to 9.1 on Richter scale (Tohoku earthquake, Japan, 2011). At present, this technique has been suggested for retrofitting of the existing structures such as an elementary school building in Vancouver.

2.1. Research gaps identified in proposed research

The focus of this research is to propose technologies to be used in earthquake resistantconstruction of buildings and structures so as to reduce the effect of seismic forces actingon themduring the actual occurrence of the quake. Form the literature review, following research gaps were identified.

a) Use of dampers for seismic isolation such as multi-tuned mass dampers and multi-level yielding pipe damper is still not fully explored for modern constructions.

b) There is a need to develop technologies so as to protect timber structures from seismic forces to further improve their design.

c) Modular steel structure is used in construction as the whole structure may not be feasible to manufacture on-site. As such there is demand in conducting seismic performance in mid-to-high rise buildings where modular steel structure is used.

d) There is a huge gap in research concerning retrofitting of old buildings without seismic resistance with modern techniques for their protection from earthquakes.The research gaps show that the seismic performance of the timber structures can further be improved by using modern techniques. The use of modular steel structure which has proven its performance in low rise buildings are now getting popular withmid-to-high rise buildings and thus there is a need to conduct its analysis. Mass dampers need to be studied in more depth for isolating the building from seismic forces.

2.2. Significance and scope of the study

The significance and scope of this work is to evaluate existing methods for earthquake resistant construction and propose a design which help suppress seismic forces acting on them. Earthquake fundamentals like its occurrence, causes, related terminologies,assessment of the site of occurrence and ground designs consisting of its motions are studied in detail. Based on this study, various methods to suppress seismic forces acting on the structures were evaluated using numerical and simulation techniques. It was concluded that use of single damper for seismic isolation of buildings proved inefficient in case of major earthquakes. Moreover, non-engineered and masonry buildings which are cheap alternatives to more reformative and complex structures suffer heavy loss during an occurrence of earthquake.

To overcome these disadvantages, use of multiple mass dampers, earthquake resistant materials and structures and modular steel structure in low to high rise buildings is suggested. Comparison of various structures and materials were done using numerical and simulation platform and new design of structures and its material was proposed for reduction of seismic forces acting on them. Moreover, use of mass dampers was studied in depth for its role in seismic isolation of buildings, its response was improved by placing multiple dampers on site and its performance was evaluated using simulations.

2.3. Objectives of proposed study

The aim of this research work is to propose and evaluate Construction Technologies which help in reducing Seismic Forces for Earthquake Resistant Construction. Apart from this below arebasic objectives of this project:

- To study literature and analyze techniques used for Earthquake Resistant Construction.
- To propose the state-of-the-art techniques for reducing seismic forces on building structures.
- To propose materials and structures to be used for non-engineered building constructions for resisting damage due to earthquake.
- To calculate seismic response of proposed techniques and to verify whether the design is complacent according to guidelines specified in IS:4326.

3. SYSTEM MODEL

Seismic loading and analysis have grown increasingly important in recent years all around the world. This is primarily owing to the high frequency of big-magnitude earthquakes that have been seen, especially in large urban areas, and which have generally resulted in terrible loss of life. As a result, more effort has been put into understanding and quantifying the loads that could be encountered during an earthquake. However, depending on the seismicity, soil characteristics, natural frequency of the building, and anticipated usage of the structure, this approach has been improved to allow progressively appropriate designs [4]. Buildings have longer durations of vibration and periods of vibration that are mostly orthogonal and tightly spaced. As a result, the Equivalent Static Analysis approach was used to design structures and counteract the effects of earthquakes. In this work, I used IS 1893-2002 to do static analysis. I created 9 models in STAAD Pro V8i programme to investigate the effects of irregular plan and form configuration. To achieve the expected behaviour, several forms of input data were used to build all nine models. The many forms of data used to create the models are listed below .

Table 1: Load Data

Live Load	3kN/m^2
Roof Live Load	1kN/m^2
Floor Finish	1kN/m^2

Table 2: Seismic Definition

Earthquake Zone	III
Damping Ratio	5%
Importance factor	1
Type of Soil	Medium Soil
Type of structure	All General RC frame
Response reduction Factor	5 [SMRF]
Time Period	Program Calculated
Foundation Depth	2 m
Poison's Ratio	0.15

Table 3: Geometric and Material Data

Density of RCC considered:	25 kN/m3
Thickness of slab	160 mm
Depth of beam	380 mm
Width of beam	300 mm
Dimension of column	300 mm x 450 mm
Density of infill	20 kN/m3
Thickness of out wall	230 mm
Height of each floor	3.4 m
Poison's Ratio	0.15
Conc. Cube Comp. Strength, fck	20000 N/mm2
Bending Reinforcement yield strength , fy	415000 N/mm2
Shear Reinforcement yield strength , fys	415000 N/mm2
Beam Rebar Cover	30 mm
Column Bar Size	12 φ

These 9 models are created by taking into account plan irregularities, which means that the plan area of each construction is the same, but the geometry differs. The total number of storeys for all sorts of structures is 12. All nine models have the same elevation. The height distribution of each floor is shown below .

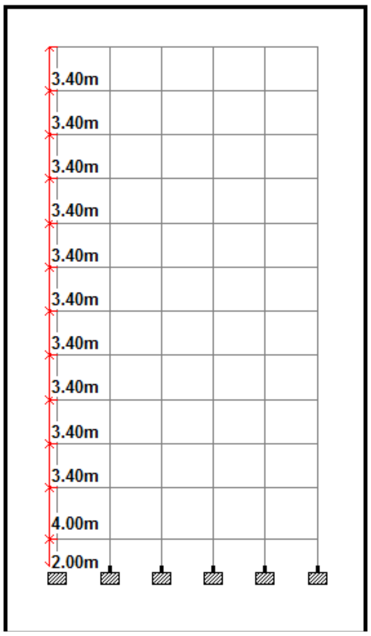

Figure 1: Elevation of model

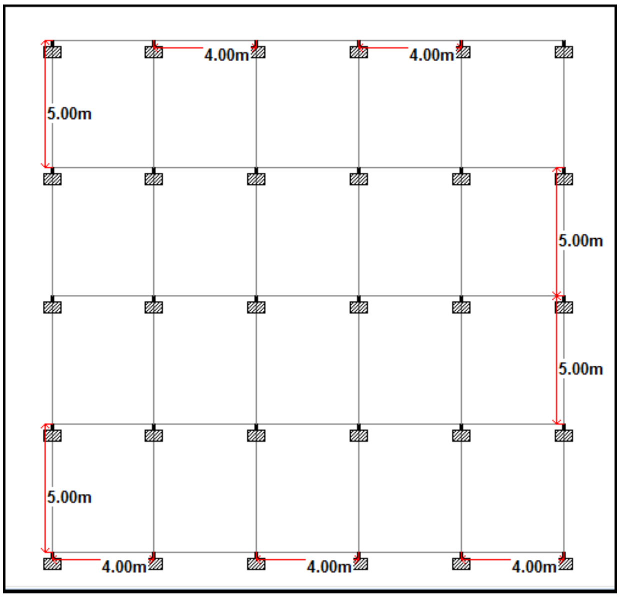

Figure 2: Regular Square (S-1)

The specified shapes (PLAN) of models are as follows ,

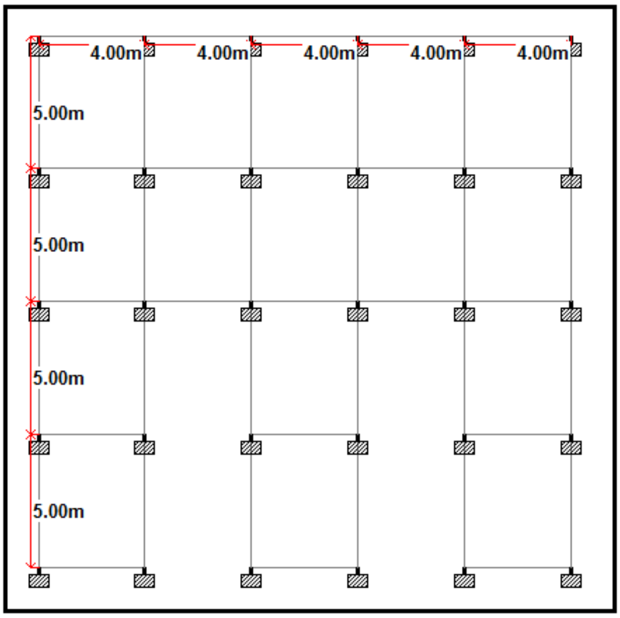

Figure 3: E shaped (S-2)

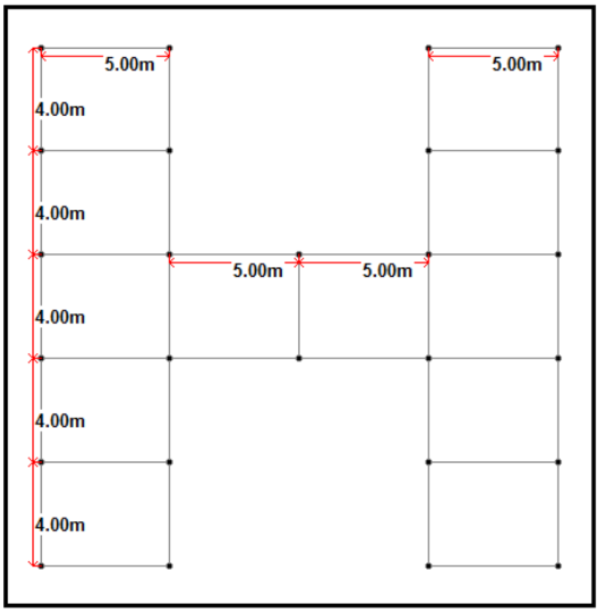

Figure 4: H Shape (S-3)

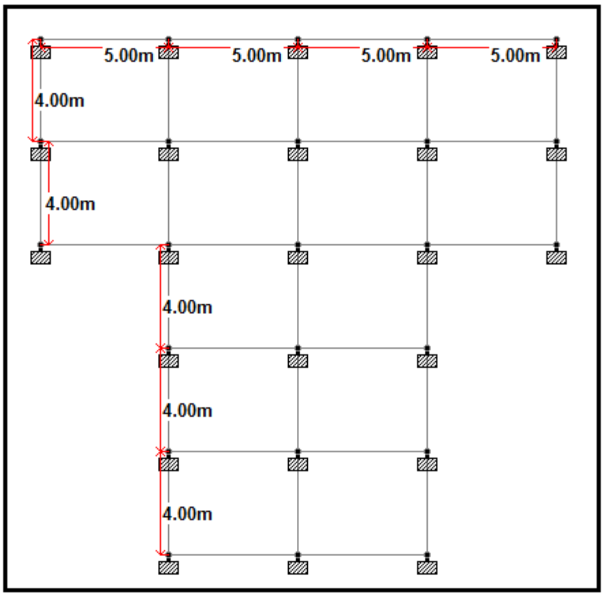

Figure 5: T shaped (S-4)

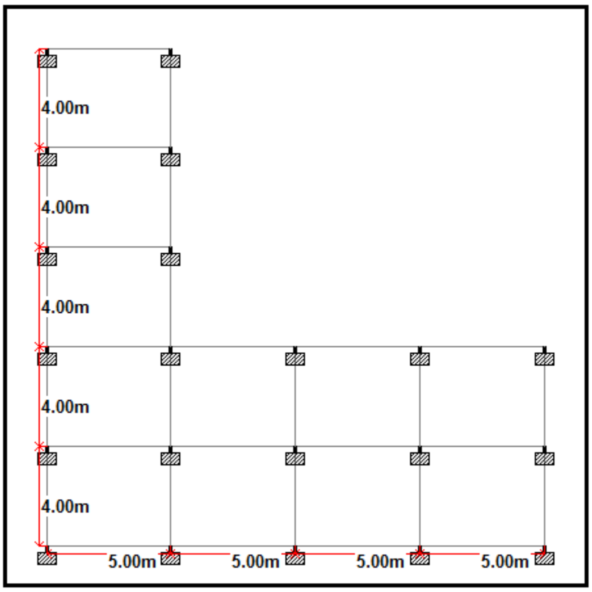

Figure 6: L Shape (S-5)

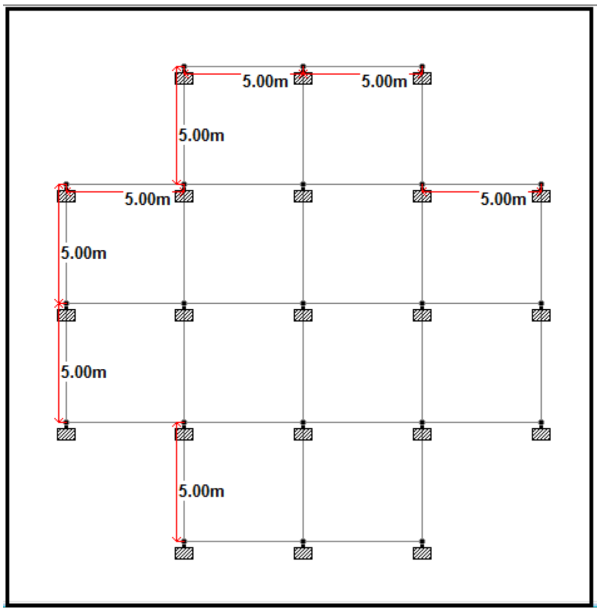

Figure 8: Plus (+) Shape (S-7)

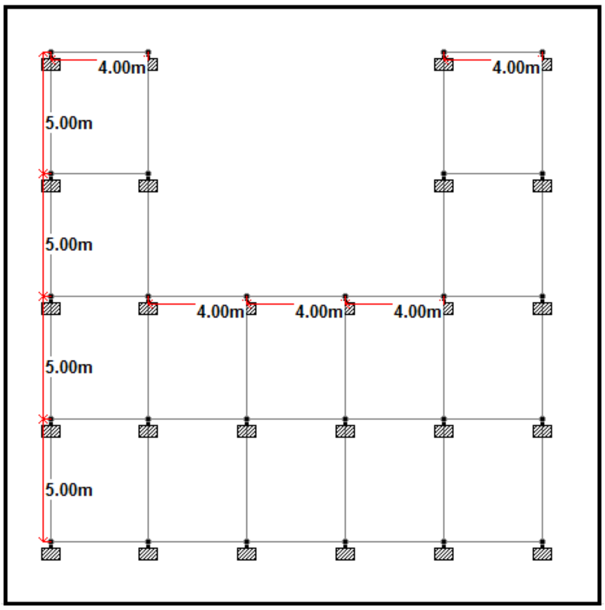

Figure 7: C shaped (S-6)

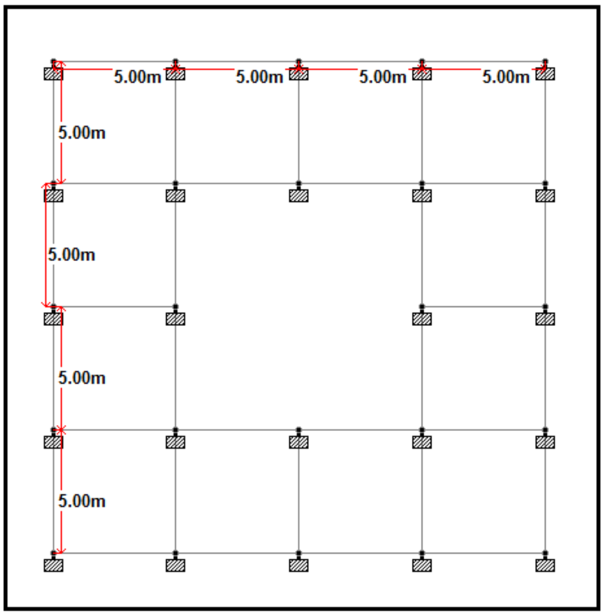

Figure 9: Square with Core (S-8)

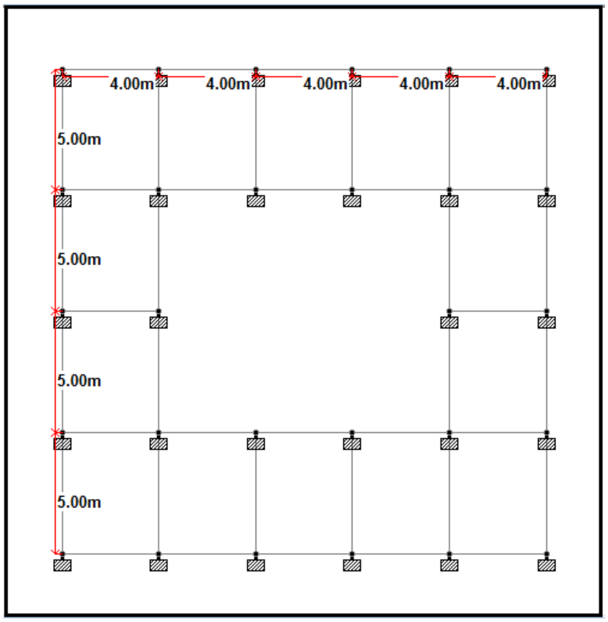

Figure 10: Rectangle with Core (S-9)

4. RESULTS

In STAAD-PRO V8i software, I compared Lateral Displacement and Storey Drift of all 9 models with regard to each other. By comparing the results, one may quickly assess the structure's performance and forecast the best shape among all those that withstand earthquake forces. Below is a detailed analysis of each graph .

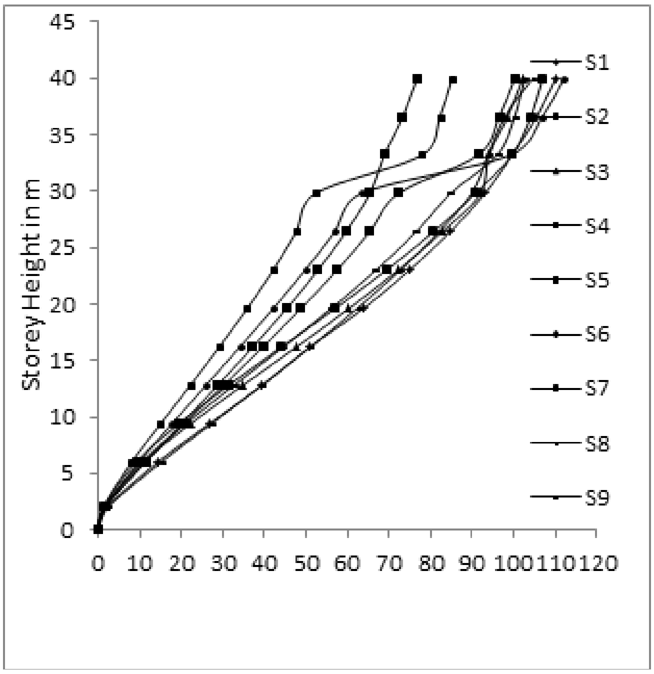

Figure 11: Nodal Lateral Displacement in X-Direction

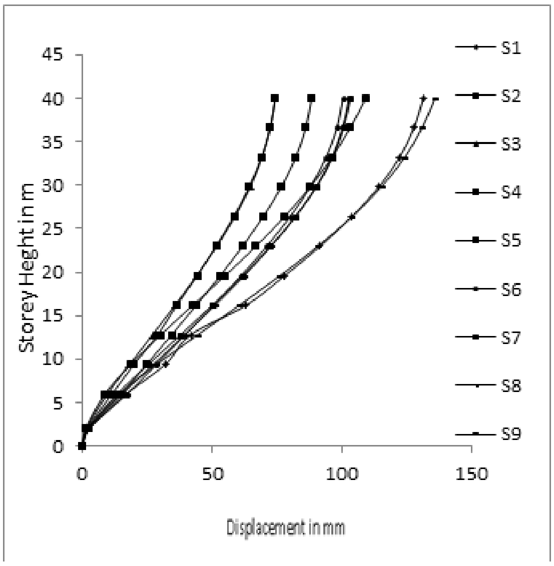

Figure 12: Nodal Lateral Displacement in Y-Direction

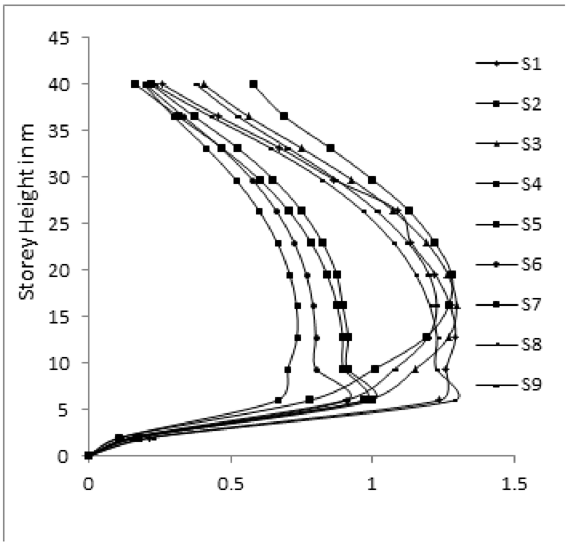

Figure 13: Storey Drift in X-Direction

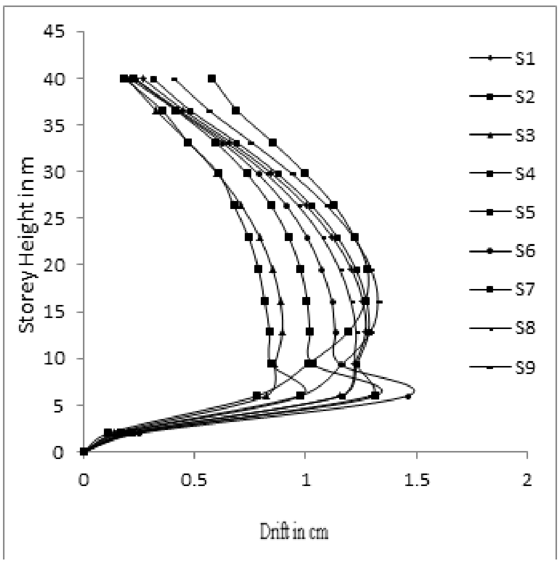

Figure 14: Storey Drift in Y-Direction

With plan irregularity, the structure's reaction to seismic pressures changes. The behaviour of the structure in response to these loads is monitored. For storey Drift and lateral Displacement, I plotted graphs of individual structure. As a consequence, plus shape structures displaced more, which might be attributed to their lighter weight and thin geometry when compared to other building types. Under the specified loading circumstances, complex shaped structures showed a substantial reaction in terms of Nodal displacement and storey drift when all of the aforesaid elements were taken into account. As a result, we may conclude that basic form geometry of structures should be used to reduce the impacts of seismic activities .

5. CONCLUSION

All around the globe, researchers are trying to make low cost and well planned technology for earthquake resistant construction by using easily accessible resources. Like, in Peru, by reinforcing wally with plastic mesh researchers have made much strongertraditional adobe structures much. In India, Bamboo have been used by engineers to strengthen concrete. And in Indonesia, few homes are build in a way so that they can stanf on efficient bearings made by old tires that are filled with either sand or stone. New innovative watts are in progress and researchers are working everyday on many new technologies that are being tested many times before running into practice. In the previous phase of the performance study, effects on selected models were displayed in the form of a graph and bar chart by comparing various parameters such as nodal displacements and storey drifts. As a result of the findings, the following conclusions may be drawn :

1. Considering the influence of lateral displacement on various forms of the structure's building. In contrast to other remaining basic shaped buildings, plus-shape, L-shape, H-shape, E-shape, T-shape, and C-shape buildings have displaced more in both directions (X and Y) (Core-rectangle, Core-square, Regular building)
2. While collecting the results from both software as per (IS 1893-2002), the storey drift, which is an important parameter to understand the structure's drift demand, is taken into account. The limiting value of drift for the given structure as per (7.11.1) is 16 cm, which is not exceeded in any of the structures, but L-shaped and C-shaped models showed larger drift than other shaped models .
3. Taking into account all of the previous findings based on the examination of irregular structures, we can conclude that simple geometry attracts less force and performs better during earthquakes. Complex geometries will inevitably be omitted, but they can be sorted into simpler ones by using seismic joints to decrease earthquake effects .

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Corresponding Author

Kakade Mahesh kumar Anant*

Ph.D. Student, Kalinga University, Raipur