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SEISMIC ANALYSIS ON SYMMETRIC AND ASYMMETRIC HOSPITAL BUILDING USING NBC CODE

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ABSTRACT

Symmetric and asymmetric structure models are very much common nowadays in rural as well as urban areas. This is due to the land scarcity problem, Increase in population, and vast increase in land cost. Due to various reasons such as; Site conditions, Barriers, operation needs, and many others, many structures cannot be regular or symmetrical in shape, size, stiffness, etc., and many more. A structure with asymmetric or irregular configuration might be designed or constructed to meet all the required codal requirements. But the behavior and performance of asymmetric or irregular structures will not be good as the symmetric and regular configurations. It is often suggested to designers and contractors to avoid such asymmetric and irregular configurations but due to various reasons, irregularity in the design and structural components might not be avoidable. This report aims to differentiate the seismic performance of two 15 Bedded Hospital buildings in Morang District, Nepal (Symmetric and Asymmetric Configuration). Models of rectangular shape (at Gramthan Rural Municipality, Morang District, Koshi Province, Nepal) and L-Shaped (at Dhanpalthan Rural Municipality, Morang District, Koshi Province, Nepal) buildings are designed and considered for analysis in Etabs 2016 software, Using NBC Code for the seismic analysis. After the analyses of these two models, various parameters such as displacement values, drift values, storey shear, base shear, overturning moment and stiffness, etc. were exported from the Etabs 2016 software and then the values were organized, analyzed, and compared. It can be concluded from the results that symmetrical shape structures have better results than asymmetric shape structures i.e. superior to asymmetric shape structures in the view of resistance.

Keywords- *Symmetric and Asymmetric Building, Displacement, Drift, Base Shear, Seismic Wave*

1. Introduction

Earthquake is a vital phenomenon which may result serious problems to all the available living and non-living things. Earthquake is powered by sudden release of huge stored energy at or in the crust of earth that results in propagates of Seismic waves. The shape of our planet is mainly decided by movement of the tectonic plates. Shaking of ground or displacement of ground and sometimes tsunamis are results after the Earthquakes. Earthquake may lead to death of peoples, Infrastructure collapse, Loss of economy and destruction of property etc.

The word Earthquake, It is mainly used to describe or memorized any seismic activity whether it is a natural phenomenon or it is an event induced by the humans. Naturally occurring earthquakes are mainly related to movement of the tectonic nature. Such natural earthquakes are commonly known as tectonic earthquakes. Earth's lithosphere is the rigid outermost shell of the planet, which are broken into several seven or eight major plates and many minor plates. Plate's relative motions are important phenomenon because it determines the type of plate boundary. The types are; convergent, divergent, or transform. Relative motions of the plates among themselves are typically ranges from null to 100 mm yearly. Plate boundaries when passes each other, frictional stress are created. Frictional stress at some time exceeds a value which is critical value, a sudden failure occurs. Fault plane is a plane along which failure occurs. Earthquakes are thus caused by release in the elastic strain energy and thus seismic waves are radiated.

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Due to several reasons nowadays floating columns are being constructed in several countries for various purposes. Floating column means columns, rests on the beam and then load transferred from the beam to the column situated at lower level than beams. Buildings having the floating column are at risk during seismic activity Floating columns causes discontinuity of the load transfer path. The building containing floating columns should be designed and analyzed very accurately[1,2]. A building having only column in ground floor i.e. without any partition walls and upper floors with partition wall shows different characteristics. Ground floor without the partition wall has greater horizontal movement than upper floors. Hence, Ground floor i.e. floor containing only columns and no partition wall are soft floor or flexible ground floor[3]. Load transfer path of the building structure must be cleared i.e. load transfer to the ground should be happened in short, easy and safe manner without interruption in the load transfer path. Asymmetric building may disturbs or interrupts the load transfer path. Hence the geometry, mass and connections of the element plays vital role in the stability of the building structure at the time of seismic activity or earthquake[4]. In case of building structure having floating column and also containing shear wall, it shows the efficient and good result in comparison with building without shear wall in case of drift, lateral displacement and displacement. Also in case of floating column building structure, vertical irregularity shows good characteristics than the simple floating column building structure. In case of floating column building structure, it can also be seen that the case will be adverse when floating columns are situated at the periphery of the building structure. And most adverse and negative impact will be there when the floating columns are situated at the periphery of the building structure at longer sides[5]. Previous design concept or standards are focused on providing the full power to structure to withstand rare and strong earthquake. Hence, this concept is very expensive in nature. So the new concept of the design or analysis is to design or analysis the building structure in such a manner that the structure will not be collapsed fully during the rare and strong earthquake but the several permissible damage (structural component and non-structural component) are permissible. The permissible damage is such that it should be reconstructed and replaced. Under any Case the building should not be collapsed[6]. Floating columns or discontinuity in the load transfer path may be advantage for the architecture point of view. But it should be avoided due to high risk of collapse and failure of the structure. It also increases the value of bending moment, reinforcement requirement and shear etc.[7]. Steel structures are nowadays trending due to their flexibility and better characteristics than reinforced concrete and other load bearing structures. Steel structures are constructed by two methods of connections namely; rigid and flexible. Flexible connections may possess large drifts. More economical and better connections can be provided using flexible using. Proper designing of the steel frame structures are very efficient in taking large earthquake loads[8]. Strengthening the column by laminated CFRP on column and determine the effect on buckling of column with different slenderness ratio[9]. Due to various past experience and history, effective and efficient designs of the structures are very important. And earthquake resistant buildings are the need of the world today. There are a lot of software, calculation method and the codes are available in market, which is helpful for the design and analysis. In Etabs various process and values should be known before the analysis. Seismic zone factor, Importance factor, Soil type etc. values should be known. Also modeling of structure, load assignment, material defining etc. are important points should be considered during the analysis[10]. Analysis must be done for new proposed building as well as existing building also. To know the strength of the building, increasing the number of floors or renovation, the analysis of existing building is necessary thing. There are also many ways and methods for it for example; American Pre-standard FEMA, Pushover procedures, Greek retrofitting code etc. Pushover procedures are trending nowadays for existing building analysis due to its more accurate results[11].

For the new proposed building also numerous methods are present there. According to the clause and requirements the process can be chosen. The buildings are mostly designed for two types of load. Gravity loads and earthquake or wind load are the main loads to be considered. P-d value nowadays is not recommended by the codes. In low rise building p-d value are negligible. But for the tall buildings p-d value are significant and must be checked[12].

Equivalent static method, response spectrum method, seismic coefficient method and time history method etc. are method for the analysis of the building structure. According to their selection criteria, we should choose the method of analysis. Elastic equivalent method is widely used and easy to proceed than others. It is not a dynamic method. Response spectrum method is dynamic approach and gives more accurate result than the equivalent static method Since the earthquake loads are dynamic in nature[13]. Time history method is also the dynamic approach. And the time history method is better than the response spectrum method. Response spectrum method over estimates the stress but it is quicker in resources and time. For very important, tall and irregular structures time history method is applied[14,15]. As per the records of Seismic activity, In Nepal divesting seismic wave (Earthquake) is inevitable and likely in future several times,

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approximately every 75 years after the risk of disaster to comeback is more acute in the urban centers including Kathmandu, the capital. There are a lot of studies and research conducted and still happening for Nepal. Comparative vulnerability studies of earthquake prone countries (UNDP/BCPR, 2004) ranked Nepal, in terms of relative vulnerability to earthquakes, as the 11th most vulnerable in the world.

Hospitals should play important role at the time of disaster period. Hospitals must provide all the important health facilities at the time of emergency condition or disaster period more efficiently than in normal condition. Due to the performance at the critical time, hospitals in Nepal and all other countries should prepare to respond in such disaster situations. Previous studies and research are estimated that more than 50% of hospitals building would be damaged causing population injured and even death. And major hospitals are also of out of function at and after the earthquake.

Interpolate Earthquake are known as the earthquake occurring near or at the boundaries of the tectonic plates. Magnitude and intensity are the two prime components to be measured for the earthquake. Magnitude scale and intensity scales are used for the measurements. Ritcher scale are well known example of the magnitude scale, which measures original force of the earthquake. Mercalli intensity scale are known example of the intensity scale, which measures shaking intensity of the earthquake. Examined the" Seismic Response on Asymmetric Buildings". In this research paper, poor performance of the building structure under the loads such as seismic load asymmetric nature is a major reason. Asymmetric nature in the building may lead to the lateral deflection to increase in the value, member forces to increase in the value and the building collapse possibility to increase. In this research paper, the asymmetric multistoried building's seismic behavior and also design are studied. Torsion effects in buildings are also considered and investigated. There is increase in the value of shear in columns. Columns at the outer frame of the building need some special attention. Also the setbacks of building are analyzed for torsion[16]. Asymmetric building for various earthquake resistance factors". In this paper, Seismic activity caused by the earthquake at earth surface is an important concern in seismic prone areas. Special design of the structure needed for the structure, which lies at seismic zones. The main objective of this paper is to focus on design of structure for the earthquake resistant for better performance of the structure during seismic activity.

In this research paper, plan with the irregularity stiffness and strength considered. And the study also conducted for the performance of the asymmetric structure. Comparative analysis and discussion made on the results of the structures between the normal building and the building designed with earthquake resistant using relevant software. In this research paper, author clears the vital importance among normal and earthquake resistant structure. It is also shown on the research paper that suitable selection of parameters for the earthquake resistant structure is important factor[17]. Study of seismic response of symmetric and asymmetric base isolated building with mass asymmetry in plan". In this research paper, symmetric building and asymmetric building's mass asymmetric nature is evaluated. Multi storied symmetrical building and multi storied asymmetrical buildings are reference model for the research paper. The research paper also studies tensional effect in seismic activity. Mass irregularity or eccentricity of 5, 10, 15, 20 percentile are considered along longitudinal direction as well as both direction. The researcher used SAP 2000 software for the design purpose and results also exported using the same software[18]. The torsion behavior of the asymmetrical buildings". In this research paper, Structural damage or failure during the seismic activity i.e. earthquake is due do one most important factor, which is torsion behavior of the building at the time of the earthquake. Author analyzed effects on the structural behavior due to the torsion effect. In this, two cases are imagined. They are; One considering torsion and other without considering torsion. The results are then compared in term of percentile of the reinforcement in column[19]. Asymmetric Building plans are more vulnerable to damages when earthquake or seismic activity occurs. It might be seen as past histories and also from many researches and design conducted. Torsion is developed in the case of asymmetric plans. Centre of rigidity and center of mass of asymmetric building are unable to coincide, due to which torsion is induced. The difference in distance between the center of rigidity and center of mass, commonly known as eccentricity, and the value must be estimated.

There is other kind of torsion available in the structures, which is induced due to sources other than eccentricity, which is known as accidental torsion. Accidental torsion values are difficult to measure. For example; rotational components present in the ground motion, distribution of live load unfavorable, difference among computed or measured and actual or real stiffness values, mass values, yield strength values of the elements. Mentioned factors give rise to coupling in a building which hence results in non-uniform distribution.

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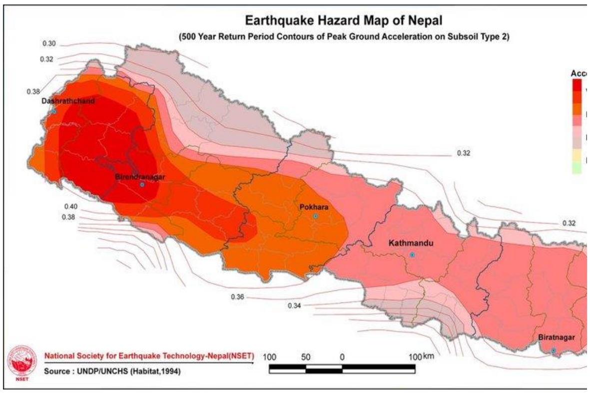

Fig. 1: Earthquake hazard map of Nepal

As studies and evidences of past, almost every type of disaster is prone for the Nepal. From all the disaster listed, the earthquakes are highest concern than all. Hospitals must prepare structurally and non-structurally for such disaster conditions or situations. This project highlights on the process and mythologies adopted to make the hospital building very safer structurally, enabling to cope with disaster.

Active tectonic plates as well as complex geometry make highest risk profile at Nepal. Asymmetric buildings must be designed and constructed at Nepal due to various major reasons such as; high angle slopes, unplanned settlements, rapidly increasing populations, architectural view, low level of awareness, complex geology etc. Earthquakes are major concern for Nepal, as Nepal is place at seismically active area. A study and research study identifies that there are nearly 92 faults in Nepal. There are different types of loads acting directly or indirectly to the any type of structure. The common loads which might be present in the any kind of structures differ for the building is used for which case i.e. residential, industrial, commercial, social welfare etc. Some common loads are vertical or gravity loads, horizontal loads and longitudinal loads. Dead load, live load and impact loads are categorized as vertical loads. Earthquake load and wind load are categorized as horizontal loads. All types of load should be accurately calculated and then designed for the structural safety of the infrastructures. Earthquake or seismic loads are categorized as the horizontal loads, caused by the shaking of earth surface i.e. earthquake and must b computed. For example the monolithic RC structures located at the zone II, and III the seismic forces are not critical for less than five storey building with importance factor one. Among all loading effects for e.g., wind loads, blast loads, wave loads (excluding tsunami or flood loads), snow loads, dead loads, live loads, earthquake shaking i.e. earthquake is the most severe.

The main objective of the project work is for model both the Symmetric 15 Bedded Hospital Building structure and Asymmetric 15 Bedded Hospital Building structures in Etabs 2016 software and then perform seismic analysis by static methods of analysis in accordance with the Nepal Building Code (NBC:105:2020). Other objectives of the study are; to compare the results of seismic response on Symmetric 15 Bedded Hospital Building and Asymmetric 15 Bedded Hospital Building structures, to study effect and deviation of storey drift, displacement, base shear, overturning moment, storey shear, stiffness etc. for both symmetric structure as well as asymmetric Hospital buildings.

2. Materials & Methods

Symmetric 15 Bedded Hospital Building and Asymmetric (L-Shape) 15 Bedded Hospital Building are modeled and analyzed using Etabs 2016 software in accordance with NBC Code of Nepal. The Etabs 2016 software is used mainly for the design and result analyzing for the two selected hospital building plans. The results are then compared and analyzed. The other components of the buildings are as follows.

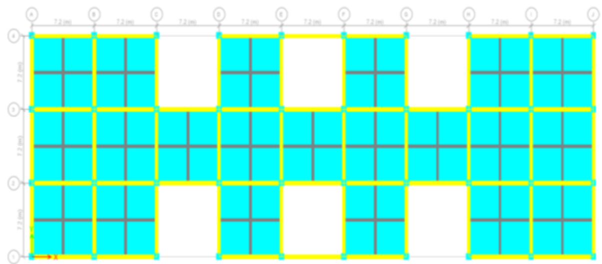
Fig. 2: Symmetric 15 Bedded Hospital Building Plan

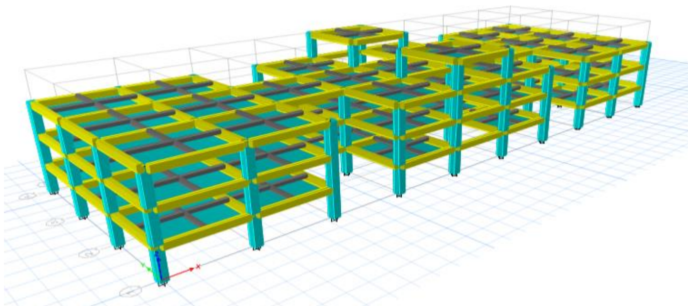
Fig. 3: Symmetric 15 Bedded Hospital Building 3D Frame

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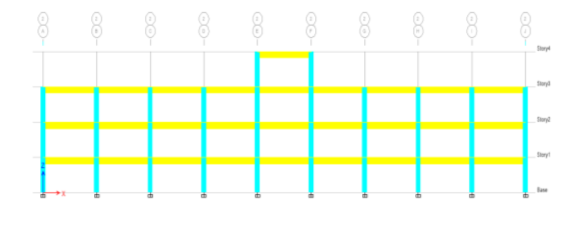

Fig. 4: Symmetric 15 Bedded Hospital Building Elevation at one specific grid

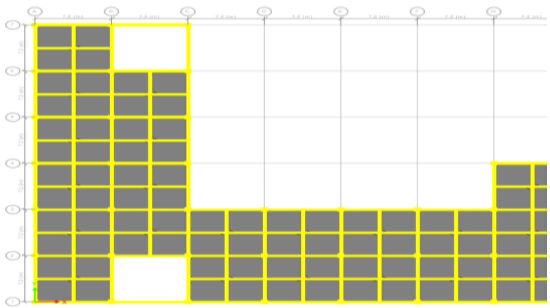

Fig. 5: Asymmetric 15 Bedded Hospital Building plan

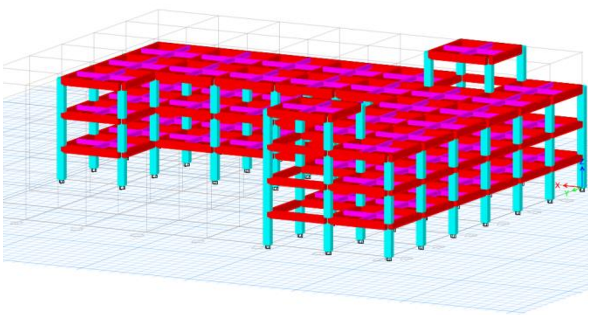

Fig. 6: Asymmetric 15 Bedded Hospital Building 3D Frame

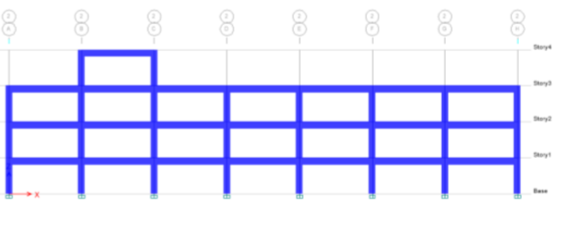

Fig. 7: Asymmetric 15 Bedded Hospital Building Elevation at one specific grid

a. ***Symmetrical 15 Bedded Hospital Building***
Shape: Rectangular with the voids
Dimensions: 21.6 x 64.8 (Outer Grids distance)
Slab Spans: 7.2 x 7.2 C/C
No. of Grids in X-direction: 10
No. of Grids in Y-direction: 4
Storey Height: 3.6m
Storey number: G+3
Location: Morang district
Column Size: 650 x 650
Beam size: 450 x 700
Secondary beam size: 250 x 350
Slab thickness: 150mm

b. *Asymmetrical 15 Bedded Hospital Building*
Shape: L shape
Dimensions: 43.2 x 50.4 (Outer Grids distance)
Slab Spans: 7.2 x 7.2 C/C
No. of Grids in X-direction: 8
No. of Grids in Y-direction: 7
Storey Height: 3.6m
Storey number: G+3
Location: Morang district
Column Size: 650 x 650
Beam size: 450 x 700
Secondary beam size: 250 x 350
Slab thickness: 150mm

2.1 *Modeling of both the structure plans in etabs 2016 software's using NBC code:*

Table 1: For the modeling of two hospital building plans, symmetric and asymmetric buildings following data are considered.

SEISMIC COEFFICIENT AS PER NBC 105:2020		
Seismic zone factor	Z	0.3
importance factor	I	1.5
Height of Building	h	14.4
Soil type considered	-	B
Period of Vibration	-	-
For reinforced moment Resisting frame	Kt	0.075
T1= 1.25*Kt*h^0.75	-	0.693016
Lower period of the flat part of the spectrum	Ta	0
Upper period of the flat part of the spectrum	Tc	0.7
Peak spectral Acceleration Normalized by PGA	PGA	2.5
coefficient to control the descending branch of the spectrum	K	1.8
Calculation of Spectral Shape Factor's (T)	-	-
Since Ta <=T1<= Tc	-	-
Ch(T)	-	2.5
Elastic site spectra for the horizontal loading (clause 4.1.1 NBC 105:2020)	-	-
C(T)=Ch(T)*z*I	-	1.125

Elastic site spectra for the SLS state (Clause 4.2 NBC 105:2020)	-	-
Cs(T1)= 0.2*C(T)	-	0.225
Horizontal Base shear coefficient for equivalent static method:	-	-
Ref Table 5-2 of NBC 105:2020	-	-
Ductility factor for the ULS state	Rμ	4
Over strength factor for ULS state	Ωu	1.5
Over strength factor for SLS state	Ωs	1.25
Horizontal Base Shear coefficient at the ULS state	-	-
Cd(T1)=C(T)/Rμ *Ωu	-	0.1875
Horizontal Base Shear coefficient at the SLS state	-	-
Cd(T1)=Cs(T)/Ωs	-	0.18
Exponent related to structural period	K	1.02926

2.2 ***Load Combination considered in the analysis using NBC 105:2020***
1.2 DL (Dead load) + 1.5 LL (Live load)
DL + λLL +/- Ex
DL + λLL +/- Ey
Where,
λ = 0.6 used for storage facilities
= 0.3 used for other usage

2.2.1 ***Loads***
Dead loads

Masonry 19KN/m3
Floor Finish: 1.5 KN/m2
RC Elements unit Weight 25KN/m3
Live load: 2 KN/m2 on all floors except roof*1.5KN/m2).
Lateral loads: Earthquake Loads as per NBC: 105:2020

2.2.2 ***Material properties***
Concrete grade used for analysis: M25 in case of beam and Column and M20 for Slab
Steel grade used: Fe 500
Modulus of Elasticity of concrete (Ec) :5000√fck N/mm2
Modulus of Elasticity of Steel (Es):2x105 N/mm2

2.3 ***Seismic Design***

2.3.1 ***Structural analysis of the building for seismic load is primarily-*** concerned for the safety of the structure during earthquakes or seismic activity. Serviceability and financial is also concerned which doing analysis. There is requirement for the knowledge for the large inelastic behavior and also cyclic deformations. The behavior of the structure under seismic load behaves different than the wind load, gravitational load etc. Analysis in comprehensive way needed for the seismic output. Detailing of the components should be strict for implementation. It also needs the appropriate output beyond the elastic limit. Building design after seismic analysis have mainly focuses on the decreasing or nullifying the danger of lost of life, economy and infrastructure when earthquake arises. All available building code enables or helps us for the inelastic dissipation of energy.

Nepal Building Codes (NBC) is technical documents which focus on historical serviceability and faults of buildings. Nepal building code (NBC) is developed by the urban development and building construction office. In Nepal the codes are adopted at the year of 2003. The all types of codes mainly focus on preventing from the failure. It also focuses on safe side of the structure under maximum earthquake for lifetime.

Clauses presents are focused on the principle of the performance of structure successfully in the areas of very high earthquake activity. And it also depends on the combination of various factors such as; ductility, strength, in the construction details. The presence of fully balanced, interconnected, and complete lateral force resisting system. In the poor seismic areas the ductility need can be decreased. And for actual reason, strength can be replacing ductility absence. Structures performance can be outstanding if brittle lateral load-resistant as soon as structures are never passed beyond the elastic range of resistance.

Let us assume the simpler shape response of the building, behavior of the building at the time of the seismic activity can easily be understood. The base of the structure might shift as the direction of the ground movement or shaking. The above portion of building (Other than base) tends to resist the movement and results in the structure distortion. Also the above portion of building (Other than base) is unwilling for the movement with the direction of the seismic force. Dynamic load in the building includes both the wind load and the seismic load. But the way of action of both the loads and forces are vastly differences. Seismic load triggers the structure of building to oscillate continuously and shaking continuously at the base of the structure. Wind loads are external type of load. It is related to the buildings exposed surface. Wind loads design are assurance about safety of building structure. And the earthquake loads are internal acting type of loads. It is produced by distortion by resistance to the seismic motion or earthquake motion. Seismic design does not need to produce the safer design.

2.4 ***Building Behavior***
Any structure (symmetric or asymmetric) during the seismic activity is subjected to vibration. External pressure such as wind load is unable or it do not destroy the structure. But due to the internal forces such as earthquake the building can be destroy due to uncertain or continuous vibration of the base surface of the

building structure. A rise in the mass of the building has two main impacts. First impact is buckling and other impact is increase in the force. Buckling causes bent of the member and results in plumb out. Ground movement is responsible for triggered the dynamic deformities. In seismic design motion duration also plays important role. Since the motion duration of the seismic activity is important factor, but it is not considered presently in the analysis and design. Mostly the vertical load is responsible for the collapse of the any kind of structure. Buildings are fall down mostly than fall over. The respond of the low rise building and the tall building are different.

Type of foundation, building mass, ground acceleration and dynamic feature affects the earthquake magnitude of inertia force. Flexibility and rigidity of the foundation affects the acceleration, which results in inertia force. Building may have acceleration same as the ground if the building superstructure and its substructure are rigid. And if the building superstructure and the sub structure are some flexibility present then the inertia force appears to be somewhat less than the acceleration and mass of the structure. The inertia force is given by; F=ma. Low rise building are rigid than the tall buildings. Low rise building is hence experience highest acceleration than the tall or high rise building. On the other hand tall building are flexible than low rise building, which results in the less acceleration than the low rise structure. If the building natural period of vibration is nearly close to the ground seismic waves for a long period of time encounters very much large forces. Hence it can be concluding that the foundations, response of building structure, ground acceleration are function of the lateral force magnitude. Response spectrums are the term known for inter-relationship between ground motion and the structure behavior.

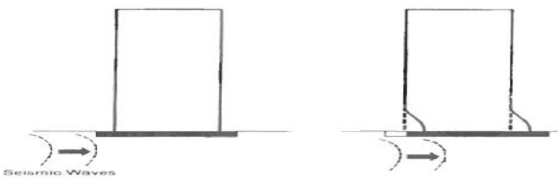

Fig. 8: Effect of earthquake on a building structure.

2.5 *Dynamic Analysis*

Symmetrical shape buildings consists uniform stiffness, mass distribution. Symmetrical shape buildings are consist predictable characteristics. The opposite condition arrives in the asymmetric shape building structure. Dynamic analysis is mostly used for the analysis of the asymmetric shape structure. Dynamic analysis is mostly used for the analysis of response characteristics. The response characteristics are; Lateral force vertical distribution, motion due to torsion effect, storey shear and deformations. Generally two methods for the dynamic analysis are commonly known they are;

2.5.1 *Response spectrum analysis*

As per the NBC code, the Modal Response Spectrum Method can be used for the all types of building structures. It also can be used for the structures where Equivalent Static Method is not applicable. A three dimensional analysis shall be performed for torsion ally sensitive structures.

This method adopted when the other factors (not basic makeup) influenced the factors. Modal approach, superposition method are the major alternative for this strategy. Natural vibration has its own mitigation model. The models can also be used to find out the independent response. The model hence resulted merged for creating complete response. SDOF oscillator examination with all characteristics to reflect the mode and also the earthquake intensity, each modal response can be computed.

Very weak vibrations are also creating seismic activity. Hence the few modes at first only need some consideration, other does not need special considerations in response. Displacement, reaction force, evolution are recorded by the full modal analysis. High reaction somewhat speeds during the seismic activity i.e. earthquake are sufficient. Hence Full response history is not necessary for analysis. If we can know the each vibration response of the SDOF oscillator then high reaction mode can be evaluated directly in earthquake response spectrum. By combining the maximum values of the models, approx. value of the response generated.

Line response modal analysis is the technique which may be applied efficiently to 3-dimension structural systems. However, it's use frequently restricted by considering limiting to lateral movement inside. Planar models are modals which are analyzed independently and are acceptable for the two orthogonal directions. The results obtained from the two investigations are merged. This is the method which often used for study of the structure dynamic response, which includes unequal or discontinuous parts in the behavior. These type of buildings are generally unequal in height.

2.5.2 *Elastic time-history method*

As per the NBC code of Nepal, the elastic time history analysis might be used for the all kinds of structures, It verifies that the specific response parameters are within or exceed the limits of acceptability assumed during design. A three dimensional analysis shall be performed for torsion ally sensitive structures.

Time- history methods of the analysis have advantage than modular spectral analysis. It is labor intensive work to find the reaction at different periods. It is done if it is very important to find out the time dependent impact to the structure. A building responds to the ground motion after subjected to seismic motions at ground surface. There are two type of structure. Firstly, single column structure which contains large mass at

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top. And secondly, it contains a frame with rigid beam and flexible column. Stiffness in the system is force divided by displacement caused by the corresponding force. If mass is deflected and then released, it vibrates with its frequency, commonly known as natural frequency. Vibration period is reciprocal of the natural frequency. Vibration period symbolize for the movement of the mass to complete one cycle.

2.6 *Equivalent Static Method*

Firstly, the base shear designed shall be evaluated for the building (considering it as a whole). Then this designed shear must be distributed to the various levels of the floors. Various levels here must be corresponding to the center of mass. Finally the design seismic load for each floor level must be distributed to the lateral loads individually by considering the diaphragm action of the floors.

$$VB = AhW$$

Here,

VB = design base shear (along principle direction)

Ah= acceleration coefficient (Horizontally)

W = Seismic weight

2.7 *Seismic Design Force*

Shaking actions due to earthquakes are time variant action as well as random phenomenon. The codes available are represent the inertia force induced to the earthquakes are net effect of shaking randomly in the form of static lateral force design. This force is known as Seismic designed base shear force. This also remains first involved in the earthquake design of building as force based. This force mainly depends on the seismic activity at site represented by zone of seismic action factor. It also increases the design forces to the elastic range extent so that to reduce the damage. Importance factors are term code tend to adopt. Net shaking of the structure mostly happens by the combined effect of the earthquake energy at different frequencies and natural periods. Flexibility factors of the structure are the term used by the codes. For designing normal buildings, this should be economical. Damages are allowed by the codes to some extent for reducing the cost of construction. Response reduction factors are the term used by the codes. It is larger for the ductile structure and the lower for the brittle structure. Due to different kind of uncertainties involved, the upper limits are unknown. Therefore, the designs of the effect of the earthquakes are not earthquake proof analysis or design. It is rather based on the concept of probability of exceed.

2.8 *Seismic Zoning Factor (Z)*

The country, Nepal is subdivided into many zones as per seismic activity. It is based on seismic hazard locally. The seismic factor are nearly constant within the zones. Factor (Z) i.e. seismic zoning factor represents mostly the peak ground acceleration for almost 475 years of the return period. Z value can be then obtained from Table presented below for selected areas.

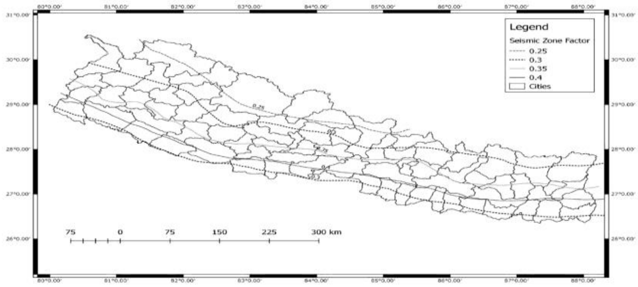

Fig. 9: Seismic zoning factor Nepal as per NBC Code

2.9 *Importance Classes and Importance Factor (I)*

There are many categories in which buildings are divided as per their function, use. Into four categories the buildings are divided for the importance factor as per NBC Code.

Table 2: Importance factor for structure at Nepal as per NBC Code

Importance Class	**Types of Building**	**Importance Factor**
I	Ordinary building not belonging to other catagories.	1
II	Buildings whose seismic resistance is of imortance in view of the consequences associated with a collaps, e.g. schools, assembly halls, important governmental buildings etc.	1.25
III	Buildings whose integrity during earthquake is of vital importance for civil protection e.g. hospitals, fire stations, power plants, telephone exchange, police stations, desinated emergency shelters etc.	1.5
IV	Monumental structures with cultural heritage	1.5

3. Results

In the current paper, symmetric and asymmetric 15 bedded hospital models at Morang district of reinforced

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concrete buildings were examined by using an equivalent static approach in accordance with NBC 105:2020 using the Etabs 2016 software.
In these 15 Bedded hospital models, the parameters such as; displacement, base shear, drift, stiffness, storey shear, overturning moment, and lateral loads were observed, analyzed and shown graphically.

3.1 *Storey Drift*
In this study, Drift are compared for symmetric and asymmetric 15 Bedded Hospital Building under both the direction. As per NBC Code the drift value should not increase more than 0.00625 mm for ultimate limit state. The results hence obtained are within the permissible limits (presented in table). After comparison between the symmetric and asymmetric 15 bedded hospital building, it is clearly seen than drift value for asymmetric hospital building is more. Also symmetric hospital building are safe under the drift criteria whereas asymmetric hospital building are fails to satisfy the permissible storey drift limit at second storey level.

In X-direction-

Table 3: Drift value at X-direction for the both models

Storey level	Symmetric	Asymmetric
4	0.001282	0.003551
3	0.003265	0.005229
2	0.004385	0.006413
1	0.002897	0.003965
0	0	0

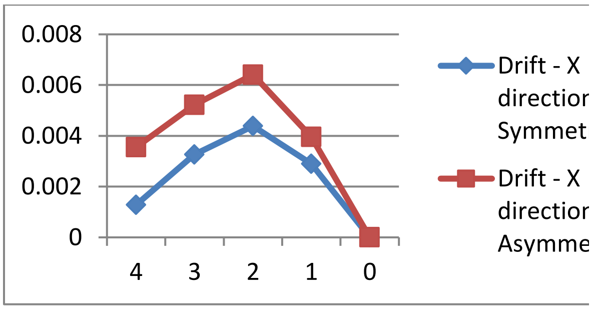

Fig.10: Drift value at X-direction for the both models

In Y-direction-

Table 4: Drift value at Y-direction for the both models

Storey level	Symmetric	Asymmetric
4	0.001459	0.002961
3	0.00402	0.005217
2	0.005346	0.006547
1	0.003498	0.004098
0	0	0

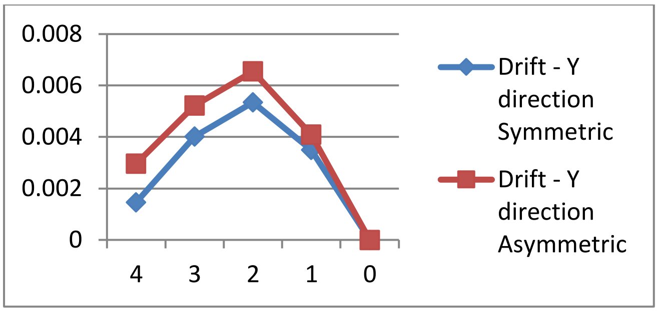

Fig. 11: Drift value at Y-direction for the both models

3.2 *Base Shear*
Total design lateral force or shear force due to earthquake at the base of a structure. Ground shaking i.e. earthquake is very random and time dependent. NBC code represent the forces as the ultimate limit state form of design equivalent static method.

For the ultimate limit state,
the horizontal base shear coefficient (design coefficient), Cd (T1), shall be given by:
$Cd\ (T1) = C(T1)\ R\mu \times \Omega u$
Where,
C (T1) = Elastic Site Spectra
Rμ = Ductility Factor
Ωu = Over strength Factor for ULS

Table 5: Base shear value at X-direction for the both models

Storey level	Symmetric	Asymmetric
x	9135.5039	8741.6713
y	9135.5039	8741.6713

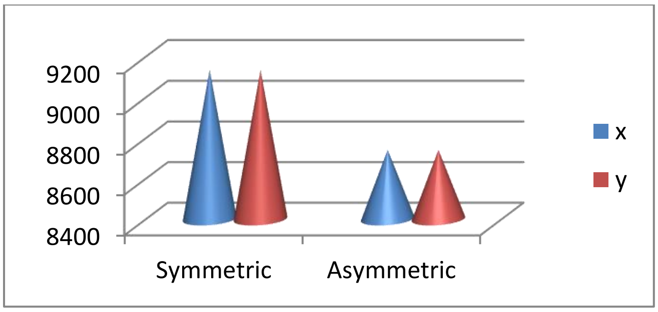

Fig. 12: Base shear value at X-direction for the both models

3.3 *Storey Shear*

In X-direction-

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Table 6: Storey shear value at X-direction for the both models

Storey level	Symmetric	Asymmetric
4	0	-417.3866
3	-4512.4561	-4539.4661
2	-7615.2531	-7359.8111
1	-9135.5039	-8741.6713
0	0	0

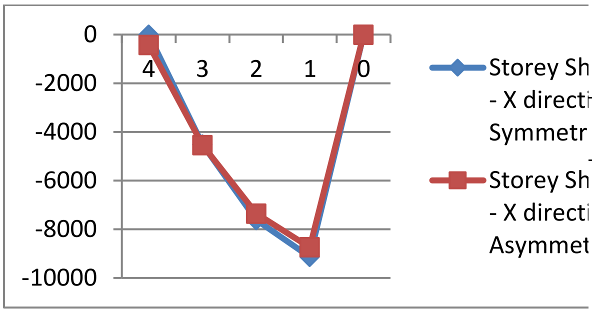

Fig. 13: Storey shear value at X-direction for the both models

In Y-direction-

Table 7: Storey shear value at Y-direction for the both models

Storey level	Symmetric	Asymmetric
4	0	-417.3866
3	-4512.4561	-4539.4661
2	-7615.2531	-7359.8111
1	-9135.5039	-8741.6713
0	0	0

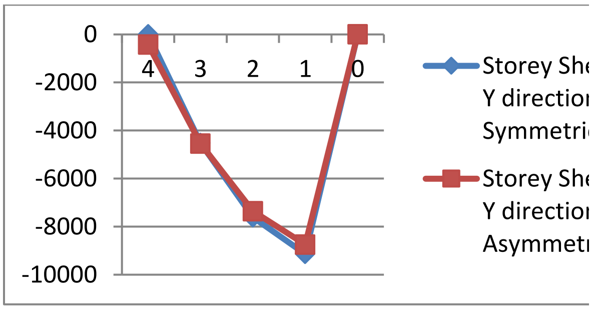

Fig. 14: Storey shear value at Y-direction for the both models

3.4 *Displacement*

In this study, Displacement are compared for symmetric and asymmetric 15 Bedded Hospital Building under both the direction. As per NBC Code the drift value should not increase more than 90 mm for ultimate limit state. The results hence obtained are within the permissible limits (presented in table). After comparison between the symmetric and asymmetric 15 bedded hospital building, it is clearly seen than displacement value for asymmetric hospital building is more. Also both symmetric and asymmetric 15 bedded hospital building are safe under the displacement criteria.

In X-direction-

Table 8: Displacement value at X-direction for the both models

Storey level	Symmetric	Asymmetric
4	42.584	68.967
3	37.976	56.184
2	26.221	37.36
1	10.432	14.272
0	0	0

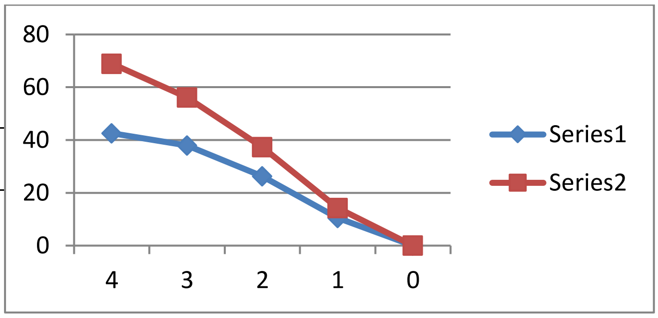

Fig. 15: Displacement value at X-direction for the both models

In Y-direction-

Table 9: Displacement value at Y-direction for the both models

Storey level	Symmetric	Asymmetric
4	44.445	59.742
3	46.318	57.102
2	31.844	38.32
1	12.595	14.752
0	0	0

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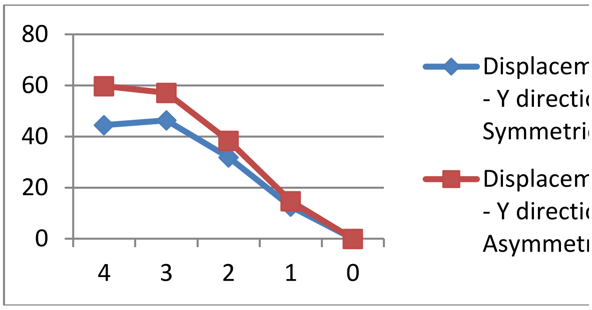

Fig. 16: Displacement value at Y-direction for the both models

3.5 *Stiffness*

In X-direction-

Table10: Stiffness value at X-direction for the both models

Storey level	Symmetric	Asymmetric
4	0	43381.45
3	393519.946	313110.638
2	494244.37	407730.636
1	897205.391	773083.505
0	0	0

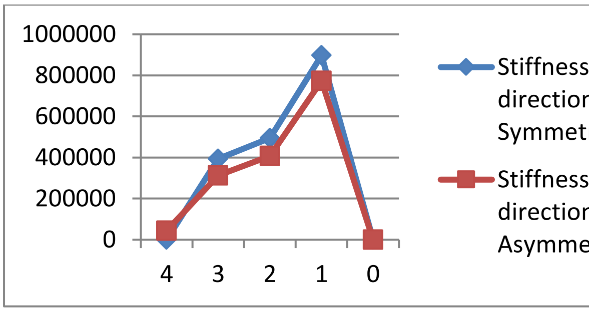

Fig. 17: Stiffness value at X-direction for the both models

In Y-direction-

Table 11: Stiffness value at Y-direction for the both models

Storey level	Symmetric	Asymmetric
4	0	42419.695
3	377546.892	316520.568
2	478125.521	409939.904
1	876401.492	774686.047
0	0	0

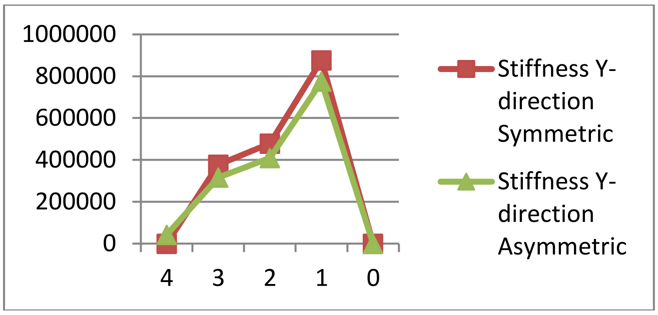

Fig. 18: Stiffness value at Y-direction for the both models

3.6 *Overturning Moment*

In X-direction-

Table 12: Overturning moment value at X-direction for the both models

Storey level	Symmetric	Asymmetric
4	0	0
3	0	1502.5918
2	16244.842	17844.6697
1	43659.7532	44339.9897
0	76547.5672	75810.0064

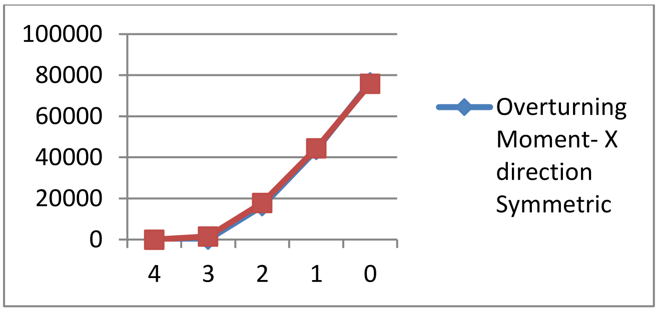

Fig. 19: Overturning moment value at X-direction for the both models

In Y-direction-

Table 13: Overturning moment value at Y-direction for the both models

Storey level	Symmetric	Asymmetric
4	0	0
3	0	-1502.5918
2	-16244.842	-17844.6697
1	-43659.7532	-44339.9897
0	-76547.5672	-75810.0064

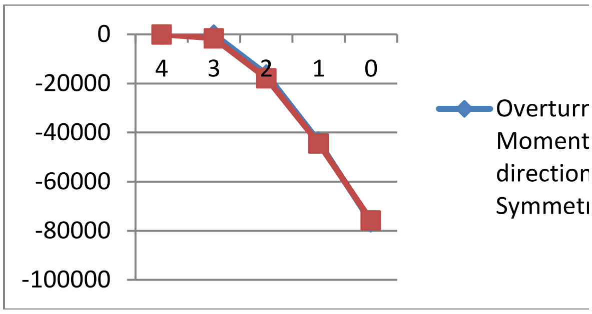

Fig. 20: Overturning moment value at Y-direction for the both models

4. Conclusions

After the seismic analysis outputs were obtained. The outputs or results are organized in excel sheet such as values of drifts, values of displacements, values of stiffness, values of base shear, values of storey shear etc. for the comparison. And the following points are concluded from the comparative study between the symmetric and asymmetric 15 bedded hospital building.

- The performance of the symmetric shape 15 bedded hospital building is better than the performance of the asymmetric shape 15 bedded hospital building.
- The value of the drift as per NBC Code lies below the value of 0.00625, which is satisfied for all the storeys of symmetric shape and asymmetric shape 15 bedded hospital building except in storey level 2 of asymmetric 1 bedded hospital building
- The value of drift when compared, it is found that it is more in case of asymmetric 15 bedded hospital building.
- The value of displacement also found to be high for the asymmetric building in comparison with symmetric 15 bedded hospital building.
- Stiffness value for the symmetric shape 15 bedded hospital building is more in comparison with the asymmetric shape hospital building in the both X and Y direction.
- Overturning moment's values are also less for the symmetric shape 15 bedded hospital building.
- Base shear value when compared and analysed, it is found that of Symmetrical structure value of base shear is more as compare to Asymmetrical structure.

Scope for further study

In this paper, only a equivalent static approach was carried out. Therefore, there is gap for other such as dynamic analysis to be carried out (Time history analysis).

In this paper, only two type of the 15 bedded hospital building plans are considered. And also the column and beam size are equal for all grids and level. But, the size can be vary depending upon the need and storey. So differ in component size as well as considering different plans the research has the opportunity for the research at future.

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Author contributions

First author: Conceptualization, Methodology, Investigation, Data curation, Writing – original draft.

Second Author: Conceptualization, Methodology, Supervision, Visualization, Resources, Writing – review & editing.

Third Author: Conceptualization, Methodology, Investigation, Data curation, Writing – original draft.

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Data Availability

All data generated or analyzed during this study are included in this article.

Declaration

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper

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