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# Analysis and Design of Hospital Building Using Response Spectrum Method

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**ABSTRACT:** Seismic protection of hospital building is at most important as they belong to lifeline structures. Proper definition of seismic load is essential for earthquake protection of structural components. To ensure safety against seismic forces of multi-storied building, there is need to study of seismic analysis to design earthquake resistance structures. We considered the hospital building of G+ 6 storey structures for the seismic analysis and it is located in zone V. The total structure is analyzed by using ETABS software, where response spectrum analysis is done and different seismic parameter values as storey shear decreases as increase in storey height, base shear is maximum at the base, displacement increases as the increase in storey height and drift value increases upto the certain limit and decrease till the end, the mode number increases with decrease in time period, stiffness decreases with increase in structure height.

**KEYWORDS:** Seismic parameter, response spectrum analysis method, ETABS, Hospital building.

## I. INTRODUCTION

Natural disasters are originated from natural event, causes loss of life and property. The most common natural disasters are earthquake, flood, storm, tsunami etc. Nepal is the one of most seismic regions of the world. Nepal is located between Indian plate and Eurasian plate. Indian plate is compress 4mm every year so geologist predict major earthquake occur at every 70-80 years (Chaulagain, 2015). This leads to the losses of life, damages on public and residential buildings. Vulnerability is the susceptibility to damage the given society. According to the United Nations, Nepal is the 11th-most earthquake prone country (Ramesh B. Malla, 2014). Therefore, earthquake vulnerability in Nepal is great concern. Unplanned urbanization in city place, inappropriate construction technology and poor construction material are also the major reason for high vulnerability of Nepal. Implementation of code in the field is also causes of vulnerability.

Considerable losses of property and life take place by past earthquake in Nepal. About 9,000 people died, many thousands people were injured and more than 6,00,000 structure in Kathmandu and other nearby towns were either damaged or destroyed by earthquake 2015 April 25 in Nepal (Rafferty, 2015). Earthquake force is random in nature and cannot be predicted so proper design and analysis of structure is required. We cannot make earthquake proof building but we can make earthquake resistance. The process of making or designing earthquake resistance building is known as resilience. For existing building retrofitting technique is used to make earthquake resistance and for new construction building proper use of building code and analysis during design is done. Many researches are focused on seismic risk reduction. Main aim of this research is maintained and increases the resilience and sustainability.

## II. NEED OF STUDY

Hospital is the healthcare institution where treatment is provided as per patient need with medicine and medical equipment. Due to the different causes like accident, natural disaster, pollution, food poisoning etc. different people suffer from different disease and goes to hospital for their treatment. People density at hospital is high.

During natural disaster like flood, volcano, earthquake, tsunami, landslide immediate response and treatment is required. If the earthquake stored energy is released in the form of seismic wave which may damage, cracked the structural component of hospital building and it becomes non-functional. An injured person does not get the immediate treatment and may losses their life, to reduce and overcome the problem; the hospital building structure should be designed to resist the seismic impact with minimum damaged to the hospital structure itself and the individuals that are within the building.



**Objective**

1. To study seismic performance of the hospital building using design codal provisions IS 1893:2016.
2. To determine storey shear and base shear of the building by the aid of response spectrum analysis
3. To validate storey displacement, drift value and model time period of the building.

**III. METHODOLOGY**

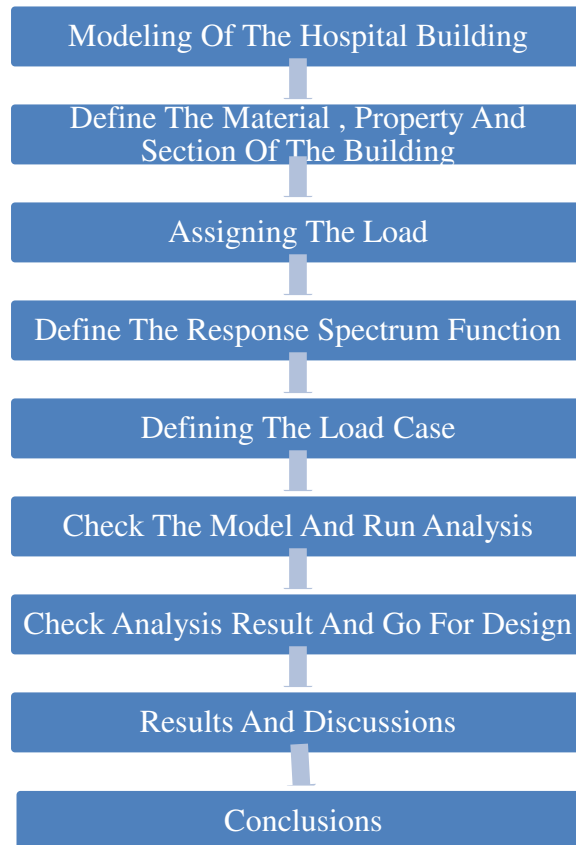


FIGURE 1: FLOW CHART OF METHODOLOGY

**IV. MODELING**

Modeling parameters and materials of all structural members used in the structure are calculated. Modelling of structure is done in ETABS is used. The static loading values on the structure are taken from IS875:1987 (part1 & part2). Earthquake load considered as per IS 1896-2016. The materials used in structures are confirmed to IS456-2000.



**Building Plans and Geometry:**

Model 1: G + 6 storey hospital building

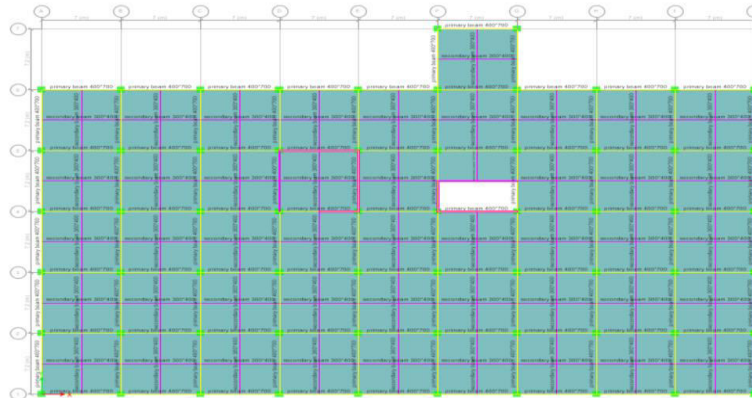


FIGURE 2: TYPICAL FLOOR PLAN.

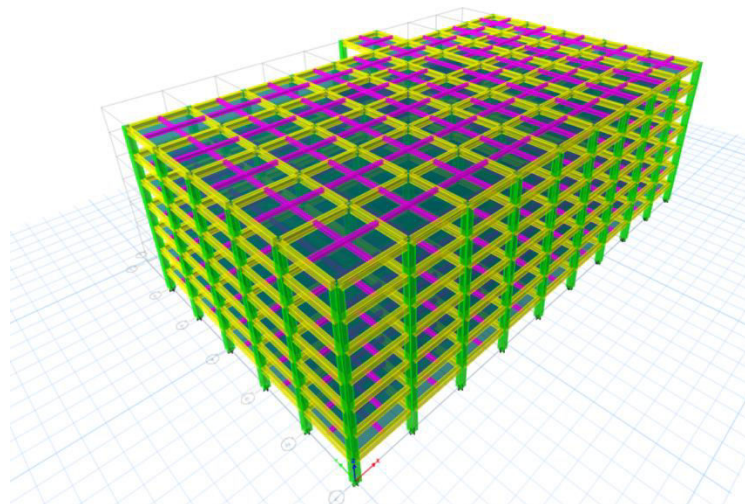


FIGURE 3: 3-D VIEW OF THE HOSPITAL BUILDING

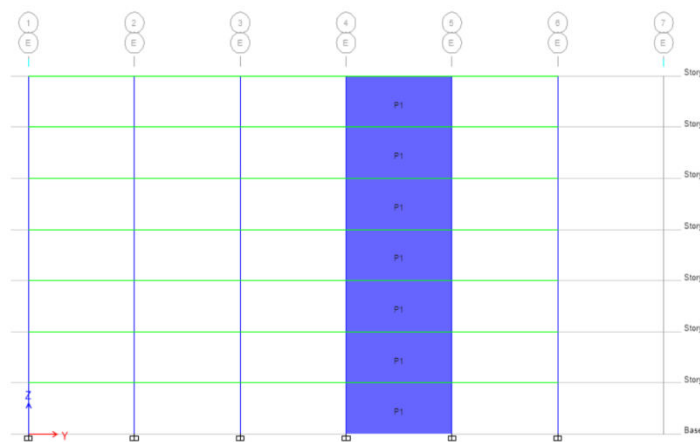


FIGURE 4: SHEAR WALL OF BUILDING

**Loads Considered**

Following loads have been considered in the analysis of the structure as per IS 456-2000 and IS 1893-2002.

- 1. Dead Load (DL)
- 2. Live Load (LL)



3. Floor Finish Load (FF)
4. Wall Load (WL)
5. Earthquake load in +ve X-direction (Eqx)
6. Earthquake load in -ve X-direction (-Eqx)
7. Earthquake load in +ve Y-direction (Eqy)
8. Earthquake load in -ve Y-direction (-Eqy)

**WALL LOADS**

TABLE 1: WALL LOAD

Type of wall	Applied Loads (KN/m)
External Wall	14
External Wall with openings	For safety reason, same as without opening
Partition wall	7
Partition wall with opening	For safety reason, same as without opening
Parapet wall	4

**Live Loads**

TABLE 2: LIVE LOAD

Location	Applied loads (KN/m <sup>2</sup> )
Rooms	4.0
Toilet/Bathrooms/Kitchens	4.0
Balcony/Stairs	4.0
Terrace/Roof	4.0

**Seismic Parameters**

TABLE 3: SEISMIC PARAMETERS

Method adopted for design	Seismic Coefficient Method
Response function	IS 1893:2002
Seismic Zone	Zone V
Zone Factor	0.36
Soil Type	Type II
Importance factor	1.2
Response Reduction factor	5

**LOAD COMBINATION**

TABLE 4: LOAD COMBINATION

LOAD COMBINATION	REMARKS
1.5(DL+LL)	DL – Dead load of the structure
1.5(DL±EQX)	LL - Live load of the structure
1.5(DL±EQZ)	EQX – Earthquake load along X direction
0.9(DL±1.5EQX)	EQZ - Earthquake load along Z direction
0.9(DL±1.5EQZ)	WLX – Wind load along X
1.2(DL+LL±EQX)	
1.2(DL+LL±EQZ)	



V. EXPERIMENTAL RESULTS

**Storey displacement**

Storey displacement is the lateral displacement of the story relative to the base. The lateral force-resisting system can limit the excessive lateral displacement of the building. The result shown for earthquake load cases RSA-X & RSA-Y. The storey displacement is within the permissible limit  $H/250 = 22400/250 = 89.6$  mm.

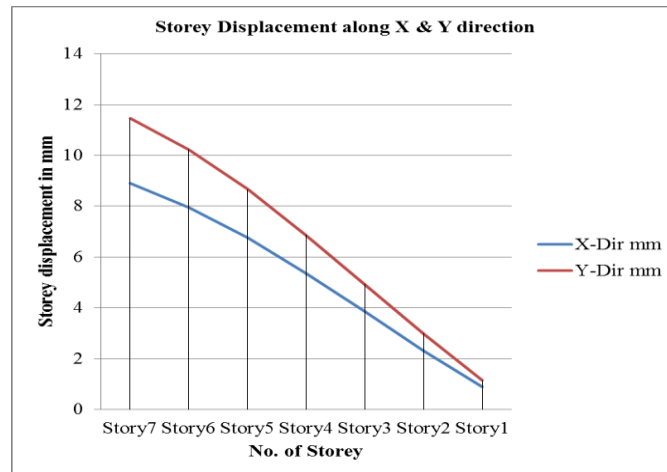


FIGURE 5: STOREY DISPLACEMENT

TABLE 5: STOREY DISPLACEMENT

Storey	X-Dir	Y-Dir
	mm	mm
Storey7	8.913559709	11.45347091
Storey6	7.959170652	10.22181294
Storey5	6.763296789	8.666417165
Storey4	5.375163658	6.874507016
Storey3	3.858849138	4.934032368
Storey2	2.313122937	2.996048072
Storey1	0.886779799	1.141132881

- Storey displacement of storey 7 is 8.913 and 11.453 in X & Y direction meanwhile storey 1 is 0.886 and 1.141 in X & Y direction ; as a result 90% decrement in storey displacement from storey 7 to storey 1 both the direction .
- As per the above graph it is observed that storey displacement increases with the increase in storey height in X and Y direction for earthquake load cases RSx and RSy.
- Storey displacement of building is within the permissible limit.

**Storey Drift**

Storey drift is the lateral displacement of a floor relative to the floor below. Here the Storey Drift shown in Fig. Lateral load is considered to design of all models. The result shown for earthquake load RSX & RSY. As per IS 1893-2016 permissible storey drift should not exceed 0.004 times the storey height.

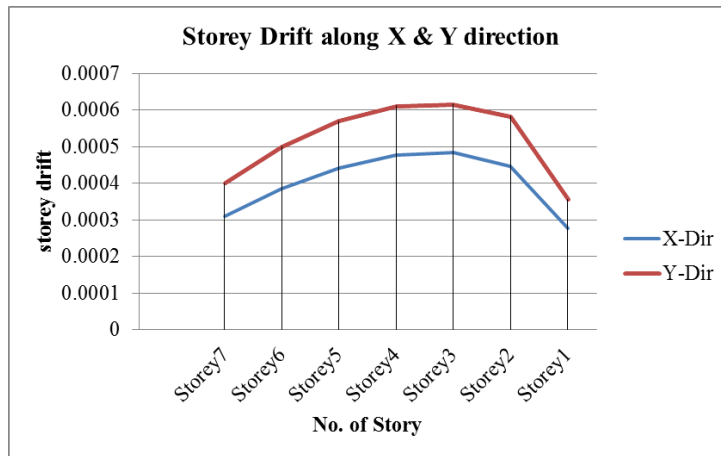


FIGURE 6: STOREY DRIFT RATIO

TABLE 6: STOREY DRIFT

Storey	RSx-Dir	RSy-Dir
Storey7	0.0003101	0.000401548
Storey6	0.00038429	0.000501069
Storey5	0.000441282	0.000570679
Storey4	0.000477964	0.00061233
Storey3	0.000484495	0.000617309
Storey2	0.000446035	0.000583358
Storey1	0.000277119	0.000356604

- As per above graph it is observed that storey drift is maximum in third storey which is increased by 74.83% and 73.1% as compared to Storey 1 in X-direction & Y-direction.

**Storey Shear**

Here the storey shear result of the model is shown in below fig. Lateral load is considered to design of models. The result shown for earthquake load cases RSx and RSy in the dynamic analysis.

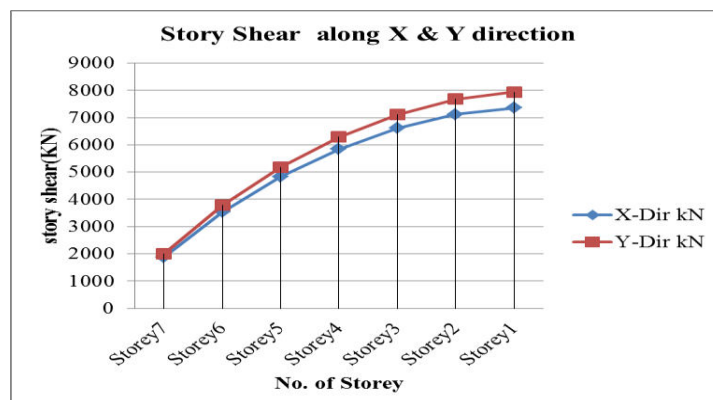


FIGURE 7: STOREY SHEAR



TABLE 7: STOREY SHEAR

Story	RSx-Dir	RSy-Dir
	kN	kN
Story7	1882.400503	2004.163815
Story6	3537.620934	3779.259467
Story5	4835.593484	5184.201478
Story4	5847.043886	6282.807333
Story3	6605.890347	7113.01017
Story2	7119.996604	7674.833726
Story1	7356.936866	7936.514032

- As per above graph it is observed that 74.41% and 74.74 % storey shear decreases with increase in structure height in X and Y direction for RSx and RSy load cases respectively.

**Modal Periods and Frequencies**

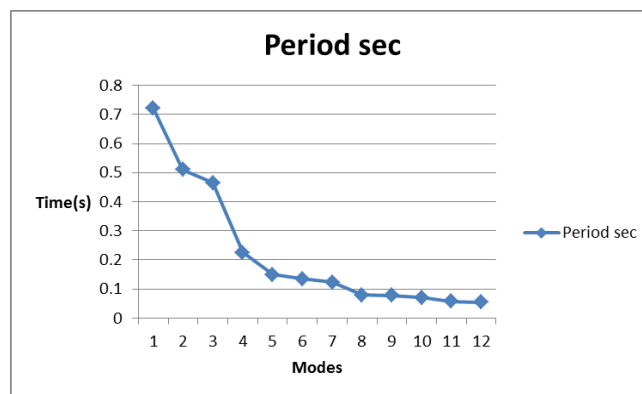


FIGURE 8: MODAL PERIOD

TABLE 8: MODEL PERIOD AND FREQUENCIES

	Mode	Period	Frequency	Circular Frequency	Eigenvalue
		sec	cyc/sec	rad/sec	rad <sup>2</sup> /sec <sup>2</sup>
Modal	1	0.721	1.387	8.713	75.9162
Modal	2	0.511	1.958	12.3046	151.403
Modal	3	0.465	2.15	13.5118	182.5689
Modal	4	0.226	4.432	27.8448	775.3308
Modal	5	0.15	6.658	41.8366	1750.2998
Modal	6	0.135	7.421	46.6292	2174.2842
Modal	7	0.123	8.15	51.2056	2622.0121
Modal	8	0.08	12.524	78.6896	6192.0502
Modal	9	0.078	12.744	80.0701	6411.217
Modal	10	0.07	14.328	90.0254	8104.5681
Modal	11	0.057	17.391	109.2733	11940.6633
Modal	12	0.054	18.667	117.2884	13756.5657





- As per above graph it is observed that as the mode number increases with decrease in time period respectively.
- When the seismic weight of the structure increases, model time period decreases and vice versa.

**Stiffness of Building**

It is the measurement of how much force is required to displace a building by certain amount. Amount of load in different storey is obtained below

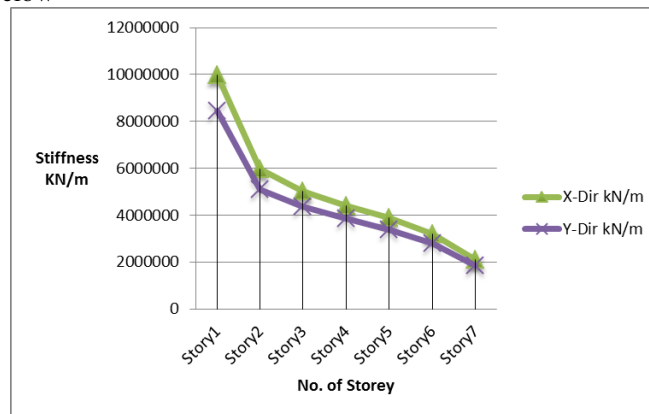


FIGURE 9: STIFFNESS VS NO.OF STOREY GRAPH

TABLE 9: STIFFNESS OF BUILDING

Story	X-Dir kN/m	Y-Dir kN/m
Story7	2094021.59	1859151.574
Story6	3208625.887	2791285.522
Story5	3880887.594	3368744.131
Story4	4404389.724	3833987.231
Story3	5001877.437	4355713.444
Story2	5976129.882	5075797.351
Story1	9971595.266	8450293.54

- As per above graph it is observed that 79% & 78 % stiffness decreases with increase in structure height in X and Y direction for RSx and RSy load cases respectively.

VI. CONCLUSION

**Storey Displacement**

- Storey displacement of storey 7 is 8.913 and 11.453 in X & Y direction meanwhile storey 1 is 0.886 and 1.141 in X & Y direction; as a result 90% decrement in storey displacement from storey 7 to storey 1 both the direction .
- As per the above graph it is observed that storey displacement increases with the increase in storey height in X and Y direction for earthquake load cases RSx and RSy.
- Storey displacement of building is within the permissible limit.

**Storey Drift**

- It is observed that storey drift is maximum in 3rd storey which is increased by 74.83% and 73.1% as compared to 1st Storey in X-direction & Y-direction.
- storey drift has not exceed 0.004 times the storey height which is permissible.

**Storey Shear**

- It is observed that 74.41% and 74.74 % storey shear decreases with increase in structure height in X and Y direction for RSx and RSy load cases respectively.



### Storey Shear

• It is observed that 74.41% and 74.74 % storey shear decreases with increase in structure height in X and Y direction for RSx and RSy load cases respectively.

### Modal Periods and Frequencies

• As per above graph it is observed that as the mode number increases with decrease in time period respectively.  
• When the seismic weight of the structure increases, model time period decreases and vice versa.

#### 5.1.5 Stiffness of Building

• As per above graph it is observed that 79% & 78 % stiffness decreases with increase in structure height in X and Y direction for RSx and RSy load cases respectively.

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