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# *COMPARATIVE STUDY OF RESPONSE OF FIVE STOREY MOMENT RESISTING REINFORCED CONCRETE FRAME BUILDING WITH AND WITHOUT COLUMNS IN GRIDLINES*

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***Abstract*—In the last decades the problem of structural regularity has been analyzed in a large number of papers, which pointed out the negative effects of the lack of regularity on the elastic and inelastic seismic response of structures and suggested design approaches able to limit the risks connected to it. Nearly all the seismic codes include general definitions of structural regularity and provisions aiming at limiting negative effects of irregularity.**

***In other hand, the perfect regularity in the building sometimes impossible due to the requirements and as well as particularly in countries like Nepal, most of the times, the shape of the land depicts the shape of the building. Therefore, in this paper, authors try to capture the seismic response due to the irregularity caused by the layout of columns not in perfect grid line. For this regular 5 storey building with 16numbers of column was first analyzed by using equivalent lateral load method . Later on, four different cases of irregularity caused by columns not in grid line were studied. The first case has 2 number of columns (12.5%) in offgrid, the second has 4 number of columns(25%) in offgrid all are in y-direction, the third case has 4 number of columns(25%) 2 in each direction are offgriid, the fourth case has 6 nubers of columns(37.50%) in offgrid. All the four cases then analysed and compared the modal and seismic responses.***

***Time Period of building increases when building is irregular due to the stiffness of building decrease when the columns are in offgrid. We can't say that building is irregular by just look at it even 37.50% column in offgrid doesn't affect the regularity of the building but it affect response of building towards seismic load and increase the demand of structural elements.***

***Keywords*—Plan Irregularity, Column layout, offgrid, Torsional irregularity**

## I. INTRODUCTION

Configuration of buildings is related to dimensions, building form, geometric proportions and locations of structural components. The configuration of a building will influence the seismic performance of a building, particularly regarding the distribution of seismic loads.

From past earthquake experiences, it can be stated that the buildings with simple configurations and which are symmetrical are more resistant to earthquake shaking while designed buildings with an irregular configuration failed to perform well in earthquake. That is why **Er. Henry Degenkolb,** USA stated that"If we have a poor configuration to start with, all the engineer can do is to provide a band aid-improve a basically poor solution as best as he can. Conversely, if we start off with a good configuration and reasonable framing system, even a poor engineer cannot harm its ultimate performance too much"

Buildings with irregularity in plan appeals to be more susceptible to large deformations and damage when they are subjected to strong ground motion than those with regular plan due to the additional accidental torsion forces resulting flow the existing eccentricity between the center of mass and center of rigidity of the resisting elements. Therefore, nearly all the seismic codesinclude general definitions of structural regularity and provisions aiming at limiting negative effects of irregularities.

In another hand, the perfect regularity in the building sometimes impossible due to the requirements and as well as particularly in countries like Nepal, the shape of the land depicts the shape of the building. There are various causes of irregularity that we encounter in reality. One of the causes is the irregular layout of the columns in the plan. Therefore, an attempt has been done to study the change in the seismic response of the irregular buildings caused by the irregular layout of the columns in the plan.

For this regular 5 storey building with 16numbers of column was first analyzed by using equivalent lateral load method. Later on, four different cases of irregularity caused by columns not in grid line were studied. The first case has 2 number of columns (12.5%) in offgrid, the second has 4 number of columns (25%) in offgrid all are in y-direction, the third case has 4 number of columns (25%) 2 in each direction are offgriid, the fourth case has 6 number of columns (37.50%) in offgrid. All the four cases then analysed and compared the modal and seismic responses.

## II. Description of Studied Building

The studied building is situated in Kathmandu city. The building is 5 storey regular building with 16 numbers of column in a floor. The structural span is 4.5m in x direction and 4.0m in y direction. The building has plan dimension 13.95m * 12.45m

### *A. General Description of Building*

Building Type:- Residential Building

Structural System:- RCC Spaced Frame

Plinth Area Cover:- 173.678Sq m

Type of foundation:- Raft foundation

No of storey:- 5

Floor height: -2.85m

Seismic Zone:- V(according to IS code)

## III. ANALYSIS OF OFFGRID MODELS

In order to compare the response of building with and without columns in grid line we make the four models in which columns are not in the grid. These models are analyzed with the help of SAP 2000. In offgrid models there may exists plan irregularity. Critical checks i.e. torsional irregularity and storey drift are done as per **IS 13920:2016.** Response of these models i.e. storey drift, time period, mode participation factor(MPF), base shear are compared with the building with column in gridline.

**Grid model** = 16 numbers of columns in a floor

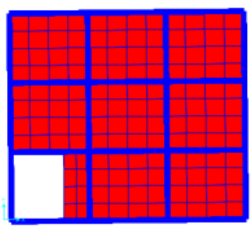

Fig. 1. Building with column in Grid(Grid Model)

**Offgrid model 1** = two columns are shifted from the regular grid i.e. 12.5%

**Ogggrid model 2** = four columns are shifted from the regular grid, all columns are shifted towards the y-direction as in fig above. i.e. 25%

**Offgrid Model 3** = four columns are shifted from the regular grid, two columns are shifted towards x-direction and two columns are shifted towards y- direction i.e. 12.5 % column are shifted in each direction. There is 25% amount of columns are shifted in offgrid model 3

**OffgridModel 4** = 6 columns are shifted from regular grid, four columns in y-direction and two columns in x-direction i.e. 25% in y-direction and 12.5% in x-direction. There is 37.5% amount of columns are shifted from regular grid in offgrid model 4

1. Offgrid Model 1(12.5%)
2. Offgrid Model 2(25%,in y-direction)
3. Offgrid Model 3(25%, 2 in each direction)
4. Offgrid Model 4(37.50%)

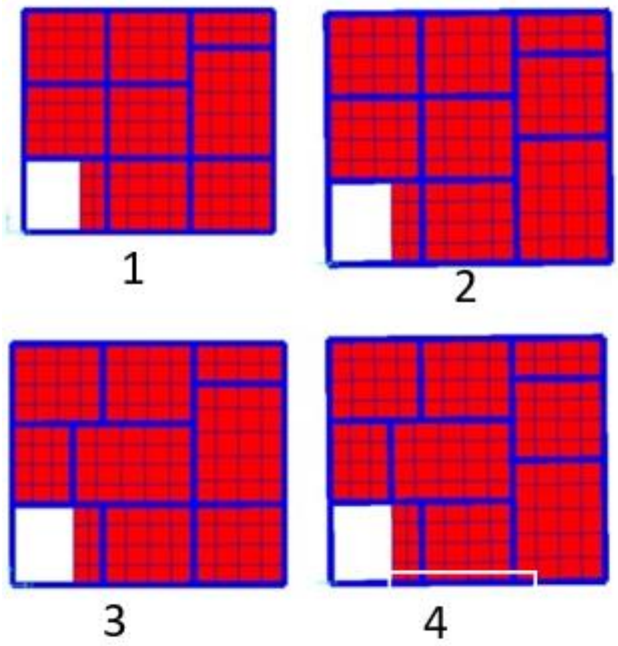


Fig. 2. Four off grid models

Distance up to which columns are shifted is maintained in such a way that span(l) / effective depth (d) of beam doesn't exceeds the permissible value i.e. beam shouldn't failed in preliminary design. In our case we shift all the columns by 2m

All the models are torsionally regular as per **IS 13920:2016** even though models are seen irregular.

### *A. Data analysis and results*

1. Grid Model i
2. Offgrid Model 1
3. Offgrid Model 2
4. Offgrid Model 3
5. Offgrid Model 4

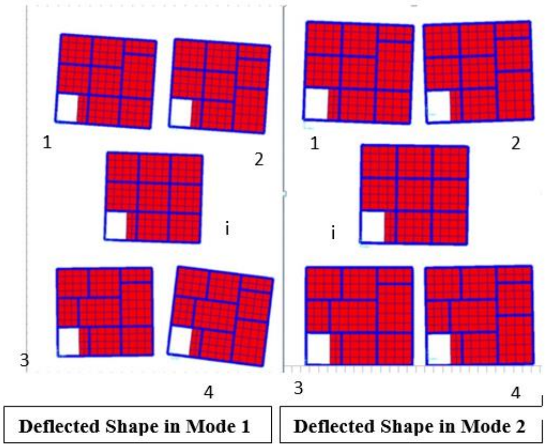


Fig. 3. Deflected shape in mode 1 & mode 2

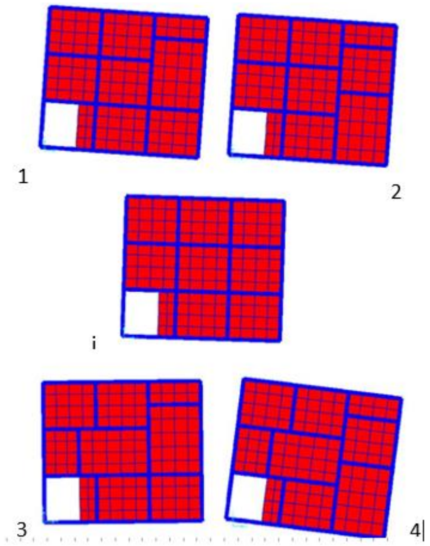


Fig. 4. Deflected shape of different models in mode 3

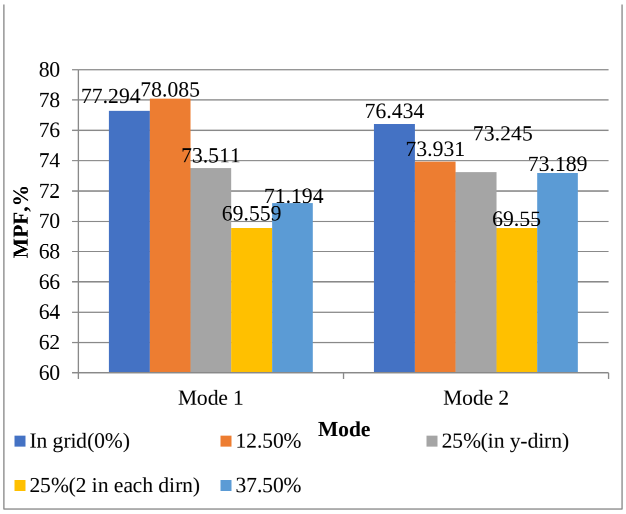


Fig. 5. Mass Participation Factor comparison for different models in mode 1 & 2

In building with column in gridline, the first mode governs the response of building. When 12.5% of columns are shifted throughout the height of building, governing mode is still mode 1 but in the case of 25% column shift, both mode i.e. mode 1 and mode 2 are govern the response. When 37.5% columns (25% in y- direction and 12.5% in x-direction) are shifted, mode 2 is more significant than mode 1 and hence, is responsible for the response.

Time period of building is increased when the columns are offgrid from the regular grid. Time period of building with 25% column shift in y-direction is maximum as compared with the other models. But when the 2 columns are shifted in both the direction rather than only one direction to make the 25% offgrid the time period of building with column shift in both directions is low as compared with column shift only in one direction. This may be due to when column are shifted in only one direction this lead to the considerable decrease in the stiffness of the building as compared with column shift in both direction. From analysis we can say that when columns are shifted in both direction with unequal number in both direction causes the considerable change in the overall stiffness(decrease)as compared with when the equal number of column are shifted in both direction through equal distance . This is the main reason behind the time period of building with 25 % offgrid.

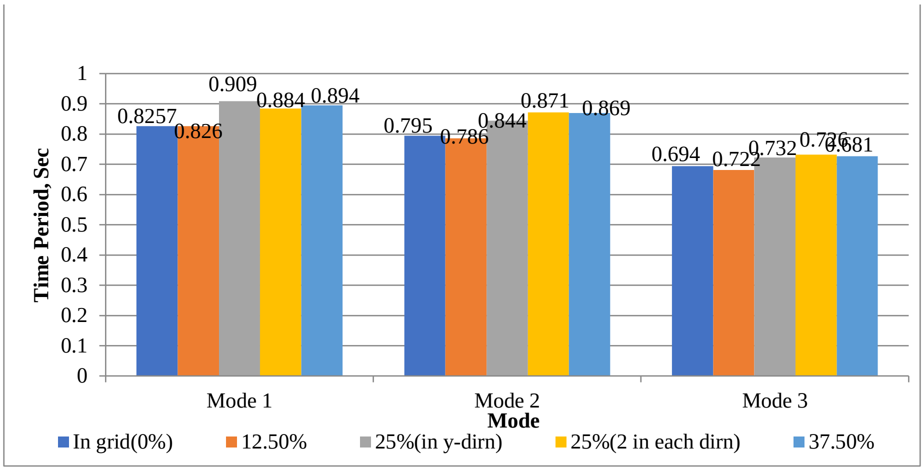


Fig. 6. Time period comparison for different modes of different models

## IV. Inter Storey Drift Ratio Comparison

TABLE I. CHECK FOR STOREY DRIFT(EQX)

| Floor | In grid(0%) Storey drift ratio | 12.50% Storey drift ratio | 25%(in y-dirn) Storey drift ratio | 25%(2 in each dirn) Storey drift ratio | 37.50% Storey drift ratio |
|---|---|---|---|---|---|
| 1 | 0.1492 | 0.1532 | 0.1675 | 0.1619 | 0.1737 |
| 2 | 0.2488 | 0.2578 | 0.2974 | 0.2847 | 0.3067 |
| 3 | 0.2469 | 0.2570 | 0.3007 | 0.2872 | 0.3109 |
| 4 | 0.1998 | 0.2086 | 0.2464 | 0.2353 | 0.2576 |
| 5 | 0.1284 | 0.1349 | 0.1620 | 0.1537 | 0.1720 |

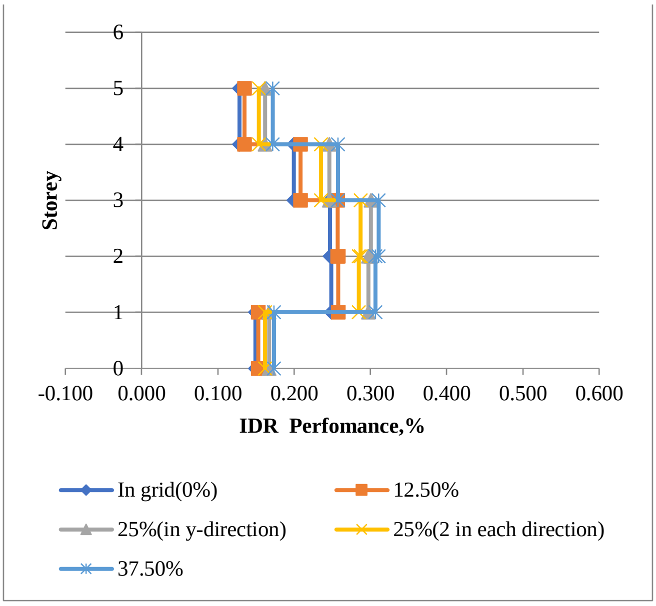


Fig. 7. Inter Storey Drift Ratio, EQx

TABLE II. CHECK FOR STOREY DRIFT(EQY)

| Floor | In grid(0%) Storey drift ratio | 12.50% Storey drift ratio | 25%(in y-dirn) Storey drift ratio | 25%(2 in each dirn) Storey drift ratio | 37.50% Storey drift ratio |
|---|---|---|---|---|---|
| 1 | 0.1399 | 0.1363 | 0.1491 | 0.1572 | 0.1737 |
| 2 | 0.2283 | 0.2220 | 0.2560 | 0.2750 | 0.3067 |
| 3 | 0.2249 | 0.2214 | 0.2567 | 0.2788 | 0.3109 |
| 4 | 0.1816 | 0.1828 | 0.2111 | 0.2313 | 0.2576 |
| 5 | 0.1156 | 0.1215 | 0.1392 | 0.1543 | 0.1720 |

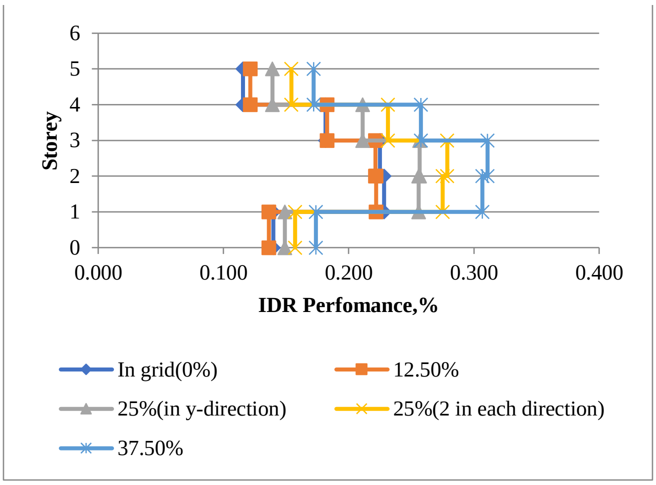

Fig. 8. Inter storey Drift EQy

From inter storey drift curve we can say that the value of storey drift increases with the increase in % of column shift. For equal amount of column shift(25%) when equal number of column shift in both direction the floor displacement is low as compared with unequal number of column shift in both direction.

## CONCLUSION

This paper tries to provide guidelines on the subject “structural regularity”, which may be used both from researchers and practical engineers.Just because up to 37.5% column shift doesn’t really affect the building’s torsional regularity, doesn’t mean we have the license to shift the columns by that amount. Offgriding may also cause difficulty in selecting the column layout and laying the foundation. Offgriding columns in the structure decreases the overall stiffness of the building and makes it more vulnerable to seismic load as compared to the building with column in gridline.

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