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Seismic Analysis of RC Frame with Diaphragm Discontinuity

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Abstract *: Seismic analysis is a subset of structural analysis which involves the calculation of the response of a structure subjected to earthquake excitation. This is required for carrying out the structural design, structural assessment and retrofitting of the structures in the regions where earthquakes are prevalent. The influence of diaphragm openings on the seismic response of multi-storeyed buildings played a major role in reducing the base shear, hence attracting lesser seismic forces. An attempt is made to try to know the difference between a building with diaphragm discontinuity and a building without diaphragm discontinuity.*
This present paper makes a humble effort to portrait the behavior of multi storied buildings with diaphragm openings under earthquake static analysis and response spectrum analysis using STAAD.Pro. To achieve this objective various models with varying percentages of diaphragm openings were analyzed and compared for seismic parameters like base shear, maximum storey drifts, shear force, Bending Moment and Axial Force.

Keywords*: Diaphragm Discontinuity, Earthquake Static Analysis (ESA), Response Spectrum Analysis (RSA), Base Shear, Storey Drift.*

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I. Introduction

In structural engineering, a diaphragm is a structural system used to transfer lateral loads to shear walls or frames primarily through in-plane shear stress. Lateral loads are usually wind and earthquake loads. Two primary types of diaphragm are rigid and flexible. Flexible diaphragms resist lateral forces depending on the area, irrespective of the flexibility of the members that they are transferring force to. Rigid diaphragms transfer load to frames or shear walls depending on their flexibility and their location in the structure. Flexibility of a diaphragm affects the distribution of lateral forces to the vertical components of the lateral force resisting elements in a structure. According to IS-1893:2002: Diaphragms with abrupt discontinuities or variations in stiffness, which includes those having cut-out or open areas greater than 50 percent of the gross enclosed diaphragm area, or changes in effective diaphragm stiffness of more than 50 percent from one storey to the next. Various seismic data are necessary to carry to carry out the seismic analysis of the structures These data are accessible into two ways viz. in deterministic form or in probabilistic form. Data in deterministic form are used for design of structures etc whereas data in probabilistic form are used for seismic risk analysis, study of structure subjected to random vibration and damage assessment of structures under particular earthquake ground motion. Major seismic input includes ground acceleration/velocity/displacement data, magnitude of earthquake, peak ground parameters, duration etc.

In the present study, a typical multi storey building is analyzed using commercial software STAAD Pro for earthquake static analysis and response spectrum analysis. All the analyses have been carried out considering and ignoring the diaphragm discontinuity and the results so obtained have been compared. This study is done for RC framed multi-storey building with fixed support conditions. This study briefly explains the linear static and linear dynamic analyses as recommended in Indian Standard IS 1893: 2002

II. Earlier Research

Earlier Research focuses on recent contributions related to diaphragm and past efforts most closely related to the needs of the present work. A brief review on diaphragm discontinuity of previous studies is presented here. Literatures show the effect of diaphragm discontinuity on the seismic response of selected multi storey buildings.

Rajesh Kadiyala et. al. (2016) attempts to investigate the proportional distribution of forces due to earthquake for each story. It has been observed that the story drift, displacement and other response entities are depend on the lateral storey stiffness distribution. A regular G+5 reinforced concrete (RC) buildings are modeled with and without diaphragm discontinuity and are analyzed by computer software SAP2000 (V14). In the later stage, these buildings have been modified as irregular ones in both plane and elevation. Responses quantities like;

modal properties, stiffness, story displacement, drift and forces are estimated and compared for both the building configurations. It is observed that though there is no significant variation in time periods but in irregular buildings, there is greater contribution of Responses quantities from higher modes. A study on story drift and displacement entities gives an idea on the attack of the buildings subjected to earthquake. Maximum base shear occurs in the mass irregularity building when compared to other models because of heavy mass are provided in mass irregularity building along X-X and Y-Y direction considering zone II . Maximum lateral displacement is obtained mass irregular building and less in vertical geometric irregularity building shows less displacement. Hence vertical irregularity building shows better performance in zone II .

Babita Elizabath et. al. (2016) provided slab openings as discontinuity at different locations such as at center, at corners and at periphery. In each case linear and nonlinear analysis(push over analysis) are done in ETABS software. Dead load and live load are considered as per IS 875:1987 part I and part II respectively. Earthquake load is consider as per IS 1893: 2002. From the graphical representation of axial forces for different load combinations, Model 3 having opening located at periphery are more effective for resisting lateral forces. Comparing on the basis of bending moments shear force and story drift also Model 3 is more effective than the other three models. Lateral displacement for model 3 is lesser compared to model 1 and model 2. So the openings are more effective to be located at periphery. Comparison has been done for the linear and nonlinear analysis. Around 4% variation has been shown for linear static analysis and response spectrum analysis. 7% variation has been shown for linear static analysis and pushover analysis.

Osama Maniar et. al. (2015) investigated diaphragms with abrupt discontinuities or variations in stiffness, which includes those having cut-out or open areas greater than 50 percent of the gross enclosed diaphragm area, or changes in effective diaphragm stiffness of more than 50 percent from one storey to the next. Earth quake load is considered as per IS: 1893-2002. (Moment resisting frame with response reduction factor of 4, zone III & 5% damping is provided.).The building is analyzed for static load using The load combinations are considered as per IS: 875 (part 5) for DL, LL, WL & EQ loads. Twenty five percent of imposed load has been accounted along with dead load for seismic weight calculation of building as per IS: 1893(2002). Analysis shows the behaviour of building is better when diaphragm discontinuity is closer to the centre of the building. For G+7 building with diaphragm discontinuity modal mass participation is almost same for all models. Therefore diaphragm discontinuity does not have much effect on modal mass participation.

P.P. Vinod Kumar et. al. (2015) makes a humble effort to portrait the behaviour of multi storeyed buildings with diaphragm openings under non-linear static (pushover) analysis using ETABS – 2013. To achieve this objective various models with varying percentages of diaphragm openings were analyzed and compared for seismic parameters like maximum dead load, base shear, maximum storey drifts, modal time period and pushover results. Analysis shows influence of diaphragm openings on the seismic response of multi-storeyed buildings played a major role in reducing the base shear, hence attracting lesser seismic forces. Provision of diaphragm opening alters the seismic behaviour of the buildings. Models with symmetrical opening in both directions expressed similar response for all the parameters while models with change in the symmetry behaved different.

III. Structural Modelling

A building plan was taken in seismic zone III for seismic analysis of the building (G+12) with diaphragm discontinuity. The basic specifications of the building are: Plan Size - 48 m x 42 m; Beam Size - 350 mm × 650 mm; Column size - 650 mm × 650 mm; Storey Height = 3.3 m; Materials used are M25 & Fe415; Depth of slab 150 mm; floor finish - 1kN/m^2, Imposed load 3 kN/m^2; Unit weight of concrete 25 kN/m^3

The building was modelled in STAAD-Pro for all types of models which have different percentage of diaphragm discontinuities.

Model Number	Opening Prcentage
Model 1	0 %
Model 2	4 %
Model 3	16 %
Model 4	24 %
Model 5	36 %

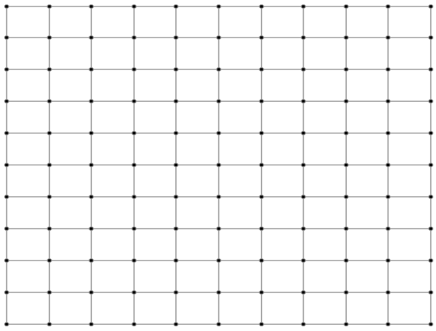

Figure 1:- Plan of Model 1

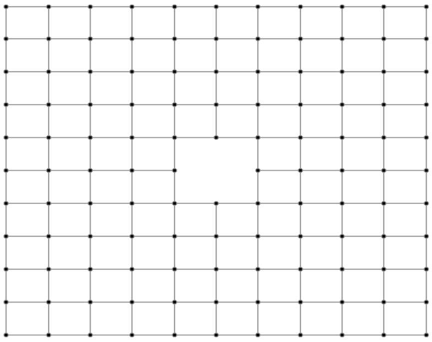

Figure 2:- Plan of Model 2

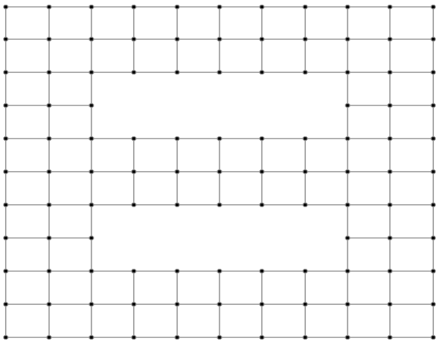

Figure 3:- Plan of Model 3

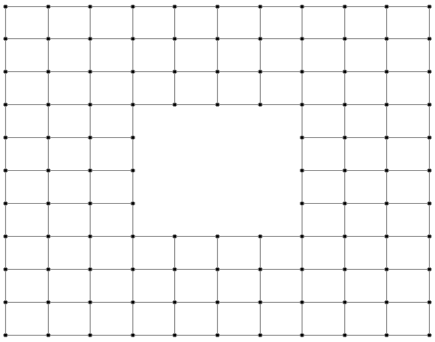

Figure 4:- Plan of Model 4

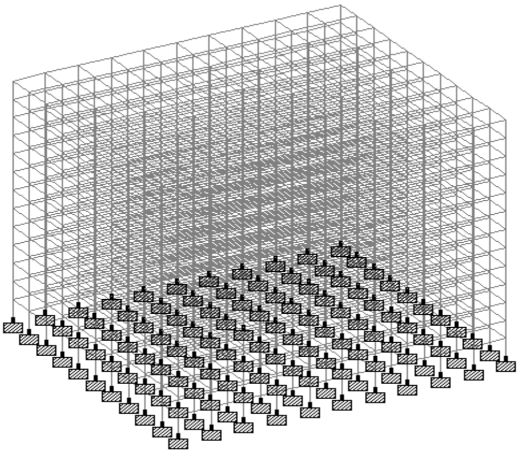

Figure 4:- Plan of Model 5

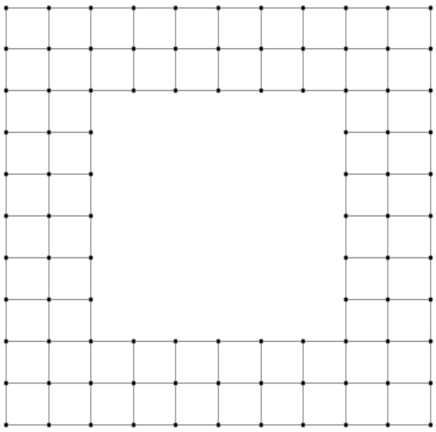

Figure 6:- Typical 3D View

IV. Result And Discussion

Results discussed in the present study are in terms of;

1. Base Shear
2. Maximum Storey Drifts
3. Maximum Shear Force
4. Maximum Bending Moment
5. Maximum Axial Force

1. Base Shear (In KN)

MODELS	ESA	RSA
Model 1	5601	5636
Model 2	5572	5569
Model 3	5404	5217
Model 4	5356	5341
Model 5	5091	5066

Figure 7:- Base shear comparison for G+12 Multi-Storey Building

2. Maximum Storey Drifts (in mm)

MODELS	ESA		RSA	
	EQ X	EQ Z	EQ X	EQ Z
Models - 1	7.1	6.4	4.2	4.0
Models - 2	7.2	6.5	4.3	4.1
Models - 3	7.6	6.9	4.4	4.2
Models - 4	7.4	7.3	4.5	4.4
Models - 5	8.9	8.0	5.3	5.0

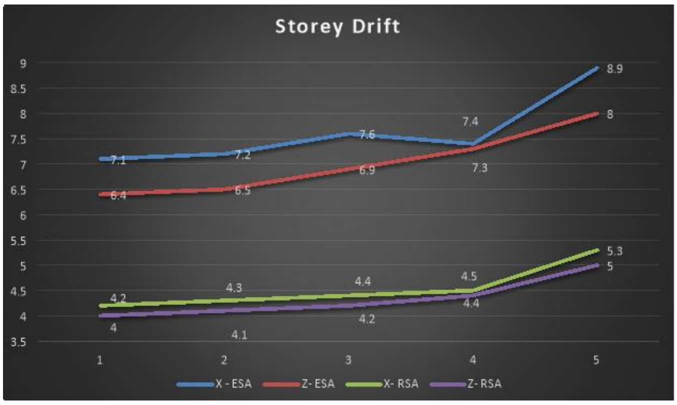

Figure 8:- Storey Drift comparison for G+12 Multi-Storey Building

3. Maximum Shear Force (in KN)

MODELS	ESA	RSA
Model 1	97.98	53.63
Model 2	138.32	82.59
Model 3	250.47	166.98
Model 4	164.65	102.48
Model 5	374.86	199.05

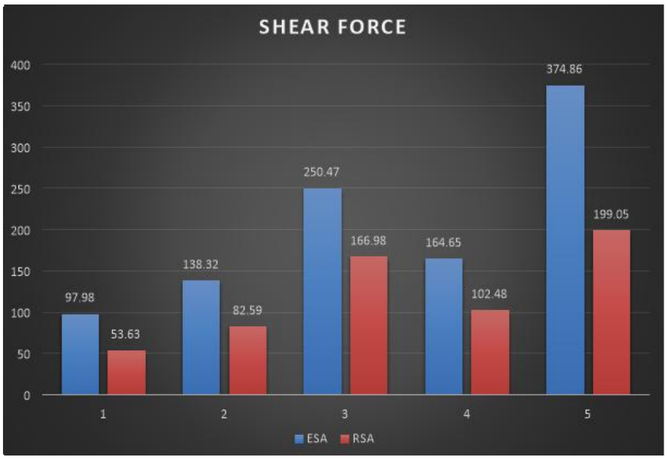

Figure 9:- Shear Force comparison for G+12 Multi-Storey Building

4. Maximum Bending Moment (in KN-m)

MODELS	ESA	RSA
Model 1	247.51	164.87
Model 2	249.99	164.81
Model 3	275.37	170.52
Model 4	266.87	175.78
Model 5	369.77	220.65

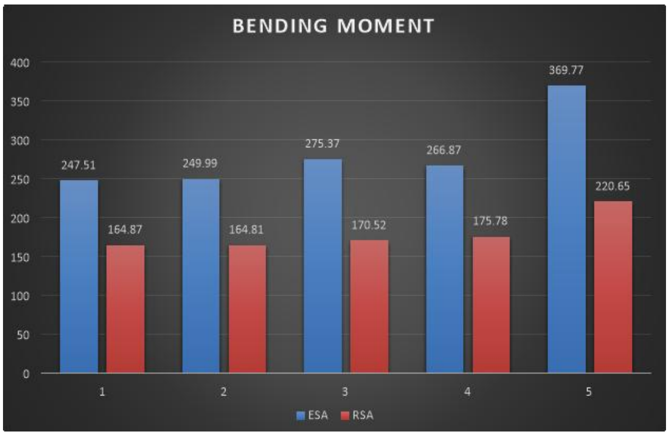

Figure 10:- Bending Moment comparison for G+12 Multi-Storey Building

5. Maximum Axial Force (in KN)

MODELS	ESA	RSA
Model 1	3047.62	2031.74
Model 2	3708.92	2472.61
Model 3	6437.29	4291.53
Model 4	4394.35	2929.57
Model 5	9323.60	6215.73

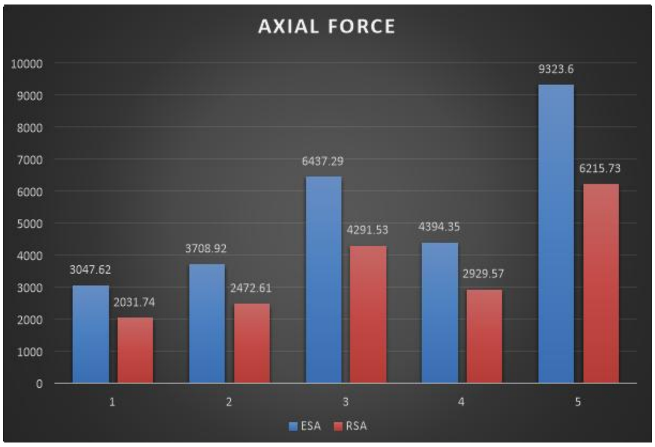

Figure 11:- Axial Force comparison for G+12 Multi-Storey Building

V. Conclusion

1. It can be seen from the results that bases shear in the buildings calculated from the earthquake static analysis is higher than the response spectrum analysis.
2. Provision of the diaphragm opening alters the seismic behaviour of the buildings. Models with a symmetrical opening in both directions expressed similar response for all the parameters while models with change in the symmetry behaved differently.
3. The increase in the opening percentage, increase the storey drift in all the models.
4. It can be seen from the results that storey drift in the buildings calculated from the earthquake static analysis is higher than the response spectrum analysis.
5. For model 4 with 24 % opening have less value of maximum shear force as compare to model 3 with 16 % opening.
6. Shear force, bending moment and Axial Force obtained from the earthquake static analysis is higher as compared to response spectrum analysis.

References

[1] Osama Mania1, Roshni J John, "Effect of Diaphragm Discontinuity on Seismic Response of Multistoreyed Building",International Journal of Emerging Technology and Advanced Engineering, ISSN 2250-2459, Vol. 5, No.12, pp. 130–135, 2015.

[2] P.P. Vinod Kumar, Dr. V.D. Gundakalle, "Effect of Diaphragm Openings in multi-storey RC framed Buildings using Pushover Analysis", International Research Journal of Engineering and Technology , ISSN 2395-0056, Vol. 2, No. 7, pp. 862–866, 2015.

[3] Rajesh Kadiyala, Tejaswi Kota, "Effect of Diaphragm Discontinuity of the Building", International Journal of Research in Engineering, IT and Social Sciences, ISSN 2250-0588,Vol. 6, No. 9, pp. 33–40, 2016.

[4] Babita Elizabath Baby, Sreeja S, "Analysis of Building with Slab Discontinuity", International Journal of Science and Research, ISSN 2319-7064, Vol. 5, No.9, pp. 999–1003, 2016.

[5] Kabade P P, Dr. Shinde D.N. "Effect of Column Discontinuity on Base Shear and Displacement of Structure", International Journal of Advancement in Engineering Technology, Management & Applied Science, ISSN 2349-3224, Vol. 1, No.2, pp. 133–140, 2014.

[6] Turgut Ozturk, "A Study of the Effect of Slab Gaps in Buildings on Seismic Response According to three Different Codes ", Scientific Research and Essays, ISSN 1992-2248,Vol. 6, NO. 19, pp. 3930–3941, 2011

[7] S.Varadharajan, V.K. Sehgal, and B.Saini "Review of different Structural irregularities in buildings", Journal of Structural Engineering, Vol. 39, NO. 5, pp. 393–418, 2012.

[8] Ashvin g. Soni, Prof. D. G. Agrawal, Dr. A. M. Pande, "Effect of Irregularities in Buildings and their Consequences" , International Journal of Modern Trends in Engineering and Research, ISSN 2349-9745, Vol. 2, No.4, pp. 14–21, 2015.

[9] Ravikumar C M, Babu Narayan K S, Sujith B V, Venkat Reddy D, " Effect of Irregular Configurations of Seismic Vulnerability of RC Buildings ", Architecture Research, Vol. 2 Issue 3, , pp. 20–26, 2012.

[10] Nemali Deepika, K. Sai Santosh "Effect of Diaphragm Discontinuity in the Seismic Response of Multi-Storeyed Building", International Journal & Magazine of Engineering and Technology, Management and Research, ISSN 2348-4845, Vol. 3 Issue 10, pp. 1456–1465, 2016.

[11] Tanveer Asif Zerdi, Zubair Ahmed, Mohammed Irfan, Tabraiz Zama "Siesmic Analysis of Multi-Storey RC Buildings in Different Terrain Conditions", Journal of Research), ISSN 2250-1991, Vol. 5, No.5, pp. 165–167, 2016.

[12] Nakashima, M., Huang, T. and Lu, L. W., "Effect of Diaphragm Flexibility on Seismic Response of Building Structures," 8th World Conference on EQ. Eng., SanFrancisco, CA, Vol. 4, pp. 735-742, 1984

[13] BIS, IS 456:2000, - Plain and reinforced concrete code of practice‖ Bureau of Indian Standards, Fourth revision.

[14] BIS, IS 1893 (Part 1): 2002, - Criteria for Earthquake Resistant Design of Structures Part-I General Provisions and Buildings‖, Bureau of Indian Standards, Fifth revision.

Reena Sahu . "Seismic Analysis of RC Frame with Diaphragm Discontinuity." IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) , vol. 14, no. 4, 2017, pp. 36–41.