Seismic Response Study of RCC Structures

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Introduction

The subject entails analysing how rcc structures respond to earthquakes.

Sylhet, which is situated in one of South Asia's most seismically vulnerable regions, is the most seismically vulnerable city in Bangladesh. It is strongly advised to do a seismic performance analysis before designing safe and dependable construction systems for this site. Structural engineers must assess the system configuration both statically and dynamically to maximise the performance of the reinforced concrete (RCC) shape. In compliance with Bangladesh National Building Code (BNBC)-2006, the goal of this study is to perform static and dynamic evaluation on a single, conventional and strangely shaped RCC building frame while accounting for the same span for each body. Using ETABS v9.7.1 and SAP 2000 v14.0.0, this study examines four different ten-story RCC building frames (W-form, L-shape, rectangle, and rectangular) for Bangladesh's seismic zone 3. (Sylhet). Comparisons between the maximum displacement caused by static loading and the dynamic reaction spectrum of variously built structures have been investigated. According to the impacts assessed, the effects of seismic pressure for static load analysis are essentially equal to all other models except model 1. (W-shape). It has been found that the W-shape is more susceptible to seismic load scenarios. The displacements for building frames with unusual shapes are larger than those for buildings with conventional shapes, according to the response spectrum study. Overall, traditional buildings perform better than unconventional ones.

Important words: equal analysis of historical time, static assessment, and reaction displacement, formation of regular and non-regular forms, and spectrum analysis the introduction to seismic evaluation

Bangladesh is one of the countries with one of the greatest population densities in the entire planet. The United States is experiencing an increase in the construction of mid to high upward push houses due to its large population and low per capita region [1]. Because Bangladesh is located in a seismically active area of the world, it has become very difficult to design structures without considering earthquake stresses [2]. The stiffness, appropriate lateral strength and ductility, simple and regular layouts, and other aspects of a building affect how it responds to an earthquake [3]. When a disaster like an earthquake, hurricane, or tornado occurs, the weak points in a structure are where breakdown begins to happen. The structure's discontinuity in mass, stiffness, and shape is what causes this weakness [4,5]. They are these discontinuous forms, or aberrant systems. One of the main causes of building collapses during earthquakes is irregularities [4]. The configuration of a building is one of the most important aspects that considerably affects the damage caused by an earthquake shaking [6, 7]. The regularity and symmetry of the structure's regular shape, both in plan and elevation, have a substantial impact on how the structure responds to static and dynamic loading [8]. To ensure that the systems will operate as intended in the event of a significant earthquake, however, architects and engineers have been forced to build atypical structures due to the demand for modern technology and the growing population [9]. As a result, a more thorough structural assessment is now required. Therefore, seismic assessments must be performed for both frequent and uncommon medium- to high upward push buildings.

Bagheri et al. (2012) evaluated the damage to an irregular structure using static and dynamic evaluations [11] and found that the former revealed more displacement than the latter. It was highlighted in a study by Ravikumar et al. (2012) [3] that many irregular buildings performed well in India's challenging rock site. The implications of several vertical abnormalities on a structure's seismic response were discussed in Sharma's (2013) paper [4]. The seismic reaction was assessed using time history analysis and response spectrum analysis, but static analysis did not receive the same treatment. He found that irregularly shaped structures were more susceptible to displacements than ones with regular shapes.

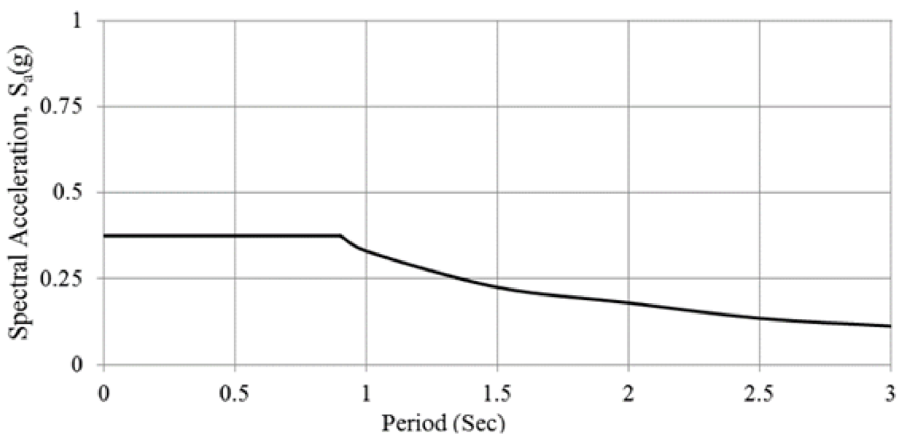

Table 1. Comparison of base shear of a RCC building having six internal floating at different heights

Model	X-Direction	Z-D
A	457.83	4
B-1	459.18	4
B-2	458.76	4
B-3	459.33	4
B-4	461.66	4

Table 2. Comparison of base shear of a RCC building having six external floating at differen t heights

Model	X-Direction	Z-D
A	457.83	41
C-1	461.54	41
C-2	461.18	4(
C-3	459.57	4(
C-4	424.47	41

Table 3. Comparison of base shear of a RCC building having six internal & external floating at di fferent heights

Model	X-Direction	Z- D
A	457.83	4
D-1	461.97	4
D-2	461.04	4
D-3	464.02	4
D-4	454.50	4

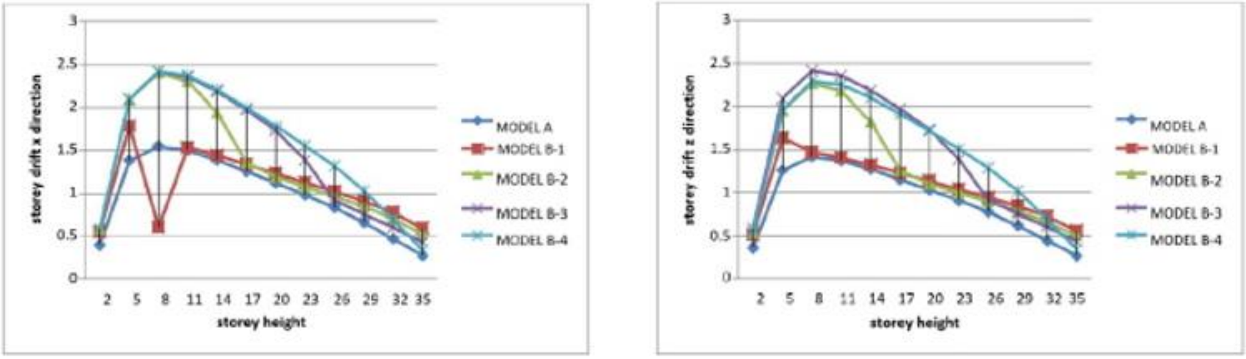

Figure 3. An examination of the correlation between x- and z-axis storey drift and height respectively.

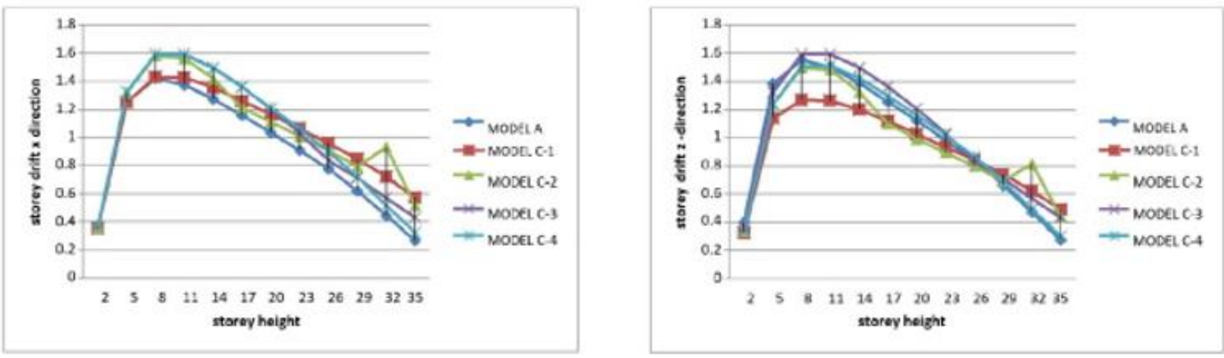

Figure 4. Examining the correlation between x- and z-axis storey drift and height.

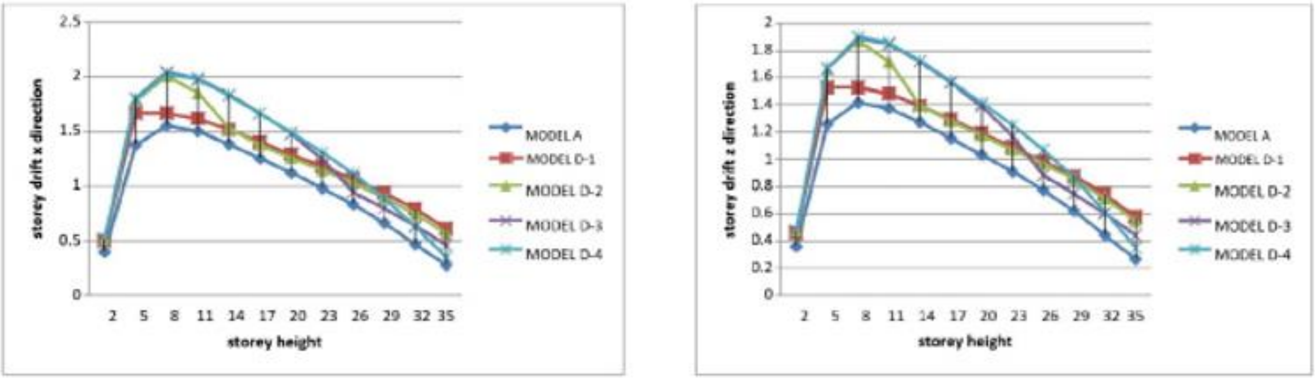

Figure 5. The x- and z-direction drift of multiple stories compared with their combined height.

Table 4. Comparison of time period (sec) for model A and B

Mode	Model A	Model B-1	Model B-2	Model B-3	Model B-4
1.	1.70636	1.9113	2.062	2.14872	2.1756
2.	1.68499	1.88351	2.01603	2.08801	2.10766
3.	1.63125	1.73651	1.79927	1.84114	1.87261
4.	0.55514	0.60634	0.63464	0.6644	0.69847
5.	0.5489	0.59868	0.62471	0.65187	0.67995
6.	0.53128	0.56751	0.57989	0.59455	0.60744

Table 5. Models A and C are timed and compared for length of runtime (in seconds).

Mode	Model A	Model B-1	Model B-2	Model B-3	Model B-4
1.	1.70636	1.9113	2.062	2.14872	2.1756
2.	1.68499	1.88351	2.01603	2.08801	2.10766
3.	1.63125	1.73651	1.79927	1.84114	1.87261
4.	0.55514	0.60634	0.63464	0.6644	0.69847
5.	0.5489	0.59868	0.62471	0.65187	0.67995
6.	0.53128	0.56751	0.57989	0.59455	0.60744

Table 6. Models A and C are timed and compared for length of runtime (in seconds).

Mode	MODEL A	MODEL D-1	MODEL D-2	MODEL D-3	MODEL D-4
1.	1.70636	1.91178	1.93966	1.97534	1.98342
2.	1.68499	1.88292	1.90665	1.93106	1.9349
3.	1.63125	1.78958	1.81768	1.82853	1.81527
4.	0.55514	0.59787	0.61975	0.6357	0.64229
5.	0.5489	0.59054	0.61135	0.6255	0.6288
6.	0.53128	0.57128	0.58068	0.58779	0.59253

Table 7. Deflection value taken under critical load combination at corner nodes

Nodes	361	366	385
MODEL A	144.432	144.363	144.432
MODEL B-1	167.331	167.205	167.331
MODEL B-2	192.767	192.635	192.767
MODEL B-3	213.907	213.771	213.907
MODEL B-4	224.903	224.758	224.903

Table 8. Deflection value taken under critical load combination at corner nodes

Nodes	361	366	385
MODEL A	144.432	144.363	144.432
MODEL C-1	151.827	151.94	151.827
MODEL C-2	153.489	153.613	153.489
MODEL C-3	153.434	153.565	153.434
MODEL C-4	152.158	152.304	152.158

Table 9. Deflection value taken under critical load combination at corner nodes

Nodes	361	366	385	390
MODEL A	144.432	144.363	144.432	144.363
MODEL D-1	173.87	173.912	173.87	173.912
MODEL D-2	179.823	179.872	179.823	179.872
MODEL D-3	188.316	188.369	188.316	188.369
MODEL D-4	190.732	190.76	190.732	190.76

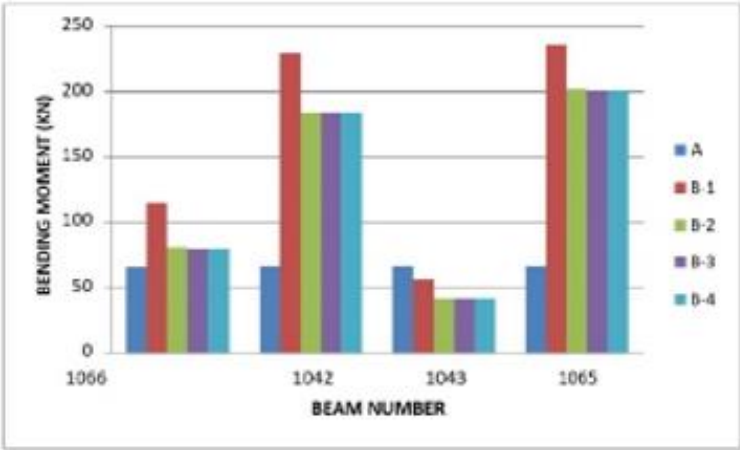

Figure 6. First-floor bending moment comparison between Model A and Model B beams.

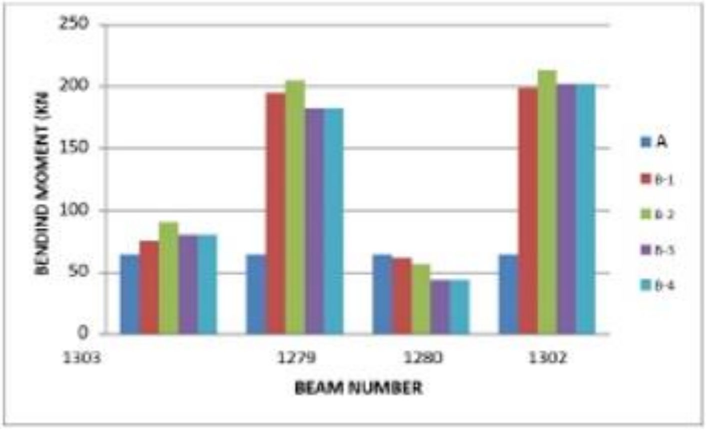

Figure 7. Comparison of bending moment for beams of model A and B on fourth floor.

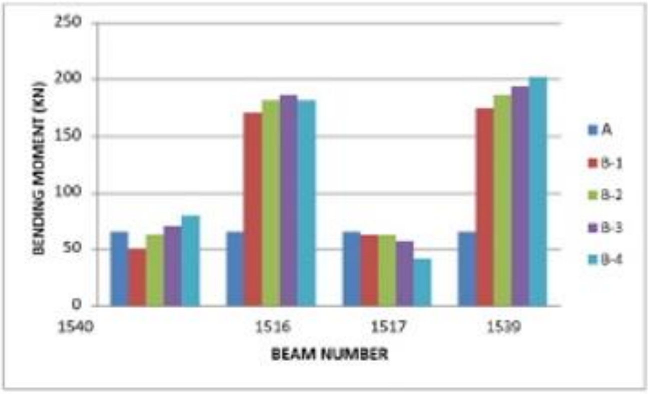

Figure 8. Model A and B beams' bending moments in comparison on the seventh floor.

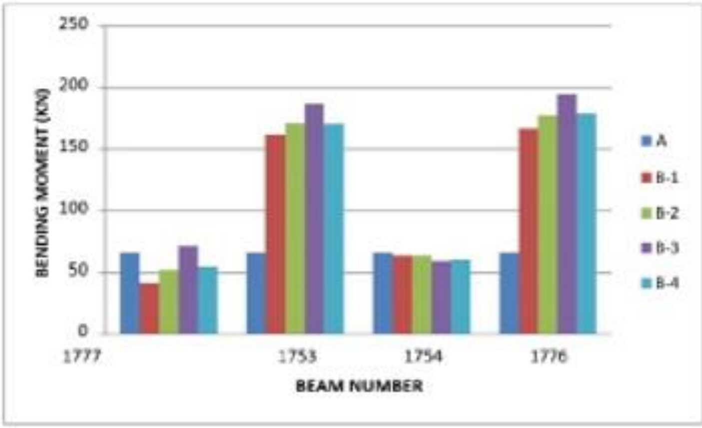

Figure 9.A model A beam's and a model B beam's bending moments compared at floor ten.

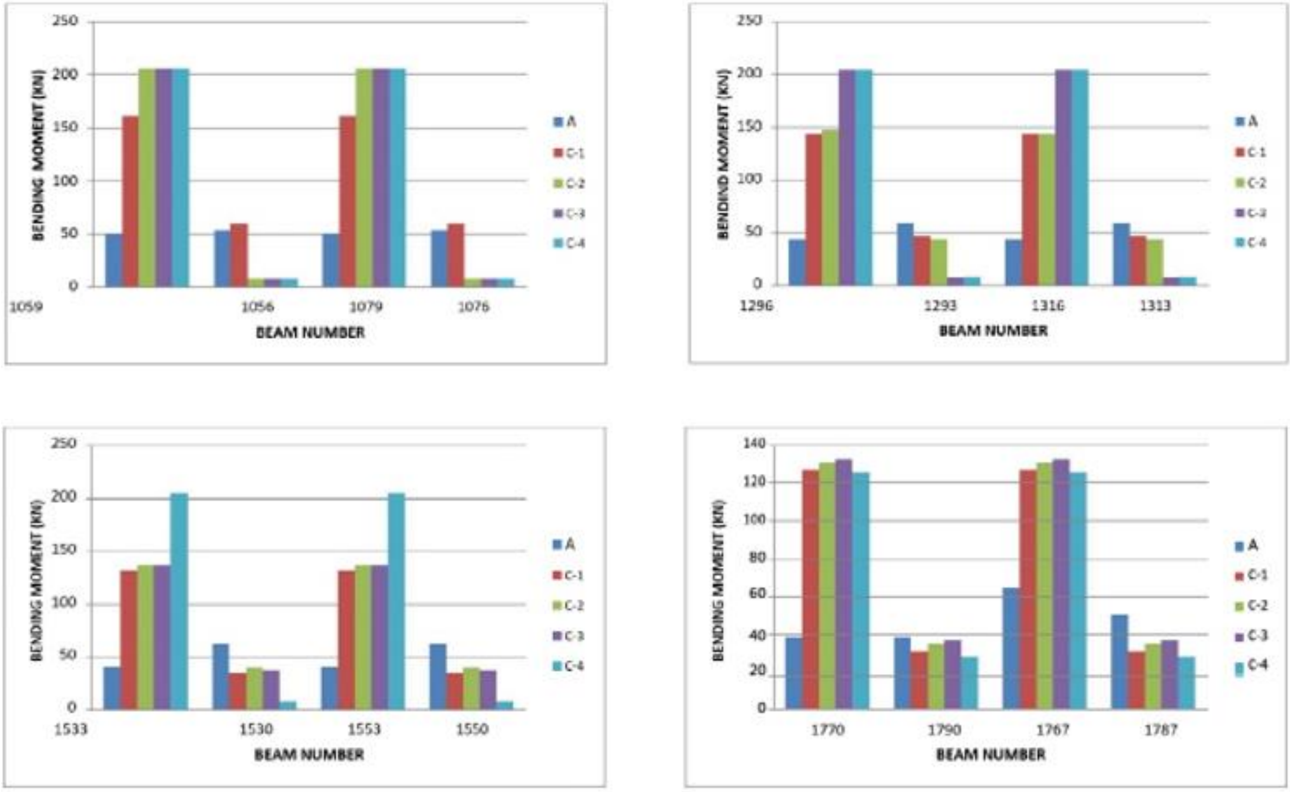

Figure 10. The beams' bending moments in Models A and C are compared..

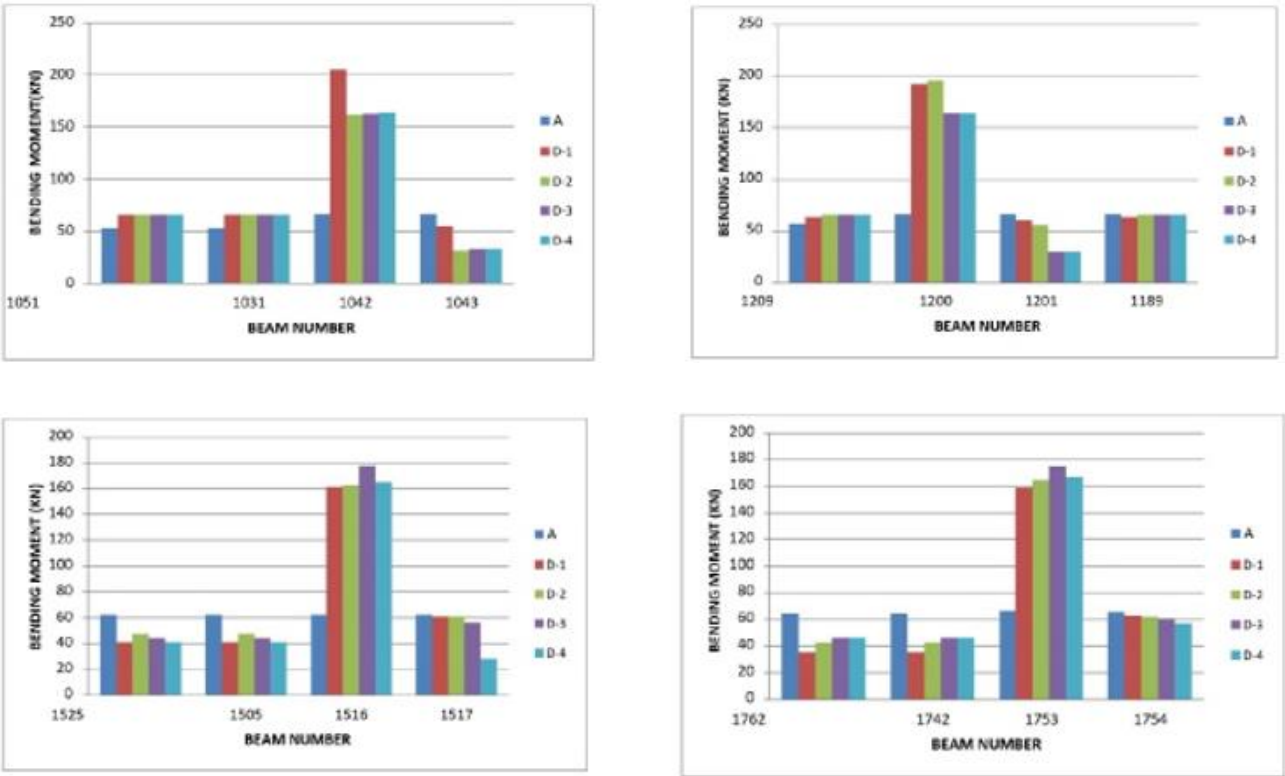

Figure 11. Beam bending moment analysis, contrasting models A and D.

The objective of this analysis is to evaluate how BNBC-2006 compliant RCC multi-story building frames' seismic response is impacted by shape. Response spectrum analysis, equal static, and time records were all used to derive the storey displacements. The outcomes are compared in order to choose the structural performance materials and methods. 1. Techniques for seismic assessment

With the help of the excellent earthquake engineering tool known as seismic evaluation, homeowners can better understand how their properties will respond to seismic excitations. Although homes used to be constructed specifically for gravity masses, seismic evaluation has only lately evolved [4]. Earthquakes typically take place in the structural design and analysis fields. This finding uses a variety of seismic load analysis methodologies, some of which are detailed below.

static analysis is the same

When assessing all of the systems exposed to seismic load, the dynamic character of the load must be taken into account. But most regulations allow the evaluation of typical, low- to medium-upward-push buildings using the same linear static techniques. Estimating the base shear force and how it is distributed over each level can be done using the calculations provided in the code [12]. The model's displacement request should then be assessed using a coding test [8]. This displacement drawback is allowed with Figure 2.1 from BNBC-2006 shows that for a fundamental length of vibration of 0.7 seconds (where h is the peak of the structure or shape), the corresponding values for I and II are 0.04h/R 0.005h and 0.03h/R 0.004h.

Analysis of past events

Time records analysis is a useful method for investigating structural seismic reactivity [13]. When the base is subjected to a specific ground motion time history, the shape's dynamic behaviour at each instant is calculated. Records of ground motion from earthquakes other than herbal earthquakes can be employed for temporal analysis [11,14]. Ground motion data from the Loma Prieta earthquake in 1989 in the Los Angeles region has been used because it is likely that no recorded evidence exists for earthquakes that have not occurred in the Bangladesh region [15]. An increase in earthquake magnitude to 7 increases the probability of ground displacement during the next 50 years to 2%. Between 0.39 and 0.41 grammes is the PGA's acceptable range. In this paper, SAP 2000 was used for the time series analysis. Inside you'll find information regarding this recent earthquake.

The geology, tectonics, seismology, and soil properties of a given site are all that need be considered when developing a site-specific response spectrum, as stated by BNBC-2006. Since there isn't a specific response spectrum for this particular website, the normalised response spectra for a damping ratio of 5% will be utilised.

Examining the Spectrum

BNBC-2006 states that a reaction spectrum tailored to the local geology, tectonics, seismology, and soil conditions is required. Unless a site-specific response spectrum can be obtained by dynamic analysis, the normalised response spectra with a damping ratio of 5% must be used [8]. The experimentally-used BNBC response spectrum curve is depicted in Figure 1. SAP-2000 is used for response spectrum analysis.

With 5% dampening, the BNBC response spectrum curve is shown in Figure 1.

This section will discuss the results and findings.

STAADPRO-2008 was used to conduct the analysis, and the results were compared to those obtained from a previous evaluation of the building frames using the stiffness matrix method. Some thoughts on these results follow.

When compared to the maximum percentage increases of 1.13 percent at the roof of the sixth floor of the external floating column and the maximum percentage decreases of -7.28 percent at the roof of the ninth floor of the same column, as shown in Initial Base Shear Table 2, this is a striking difference. The data in Tables 1-3 show that the base shear value for both interior and exterior floating columns dropped by 0.72% at the bottom floor, but increased dramatically by the ninth story. This is due to the rise in horizontal seismic coefficient caused by the increasing spectral acceleration (Ah).

There are six different internal floating floor heights shown in Table 1 and their effect on the base shear of an RCC building is compared.

An RCC building's base shear is compared in Table 2 to that of six different external floating floors of varying heights.

The base shear for an RCC structure with six internal and external floating floors at different heights is compared in Table 3.

Figures 3-5 depict the drifts that would occur in each scenario according to B. Storey Drift. At the minimum design force, IS 1893:2002 requires that storey drift not exceed 0.004 times the storey height. To determine if a structure is up to code, an analysis is run on a generic building that does not contain any internal floating columns and the results are compared to the requirements. Figures 3-5 show how the drift (in centimeters) and storey height (in meters) change for a building with exterior floating columns at different heights.

Figure analyses and illustrates drift along the x and z axes as a function of floor level. 3.

The relative height of two adjacent stores is used to compare the amount of drift in the x and z axes in Figure 4.

Figure 5 shows a comparison between the x and z-axis storey drift and the building's height. C. Chronological Range

Tables 4 through 6 show that floating adds significant time to the building's base lifespan. Maximum time period increases of 27.52% and 16.06% apply, respectively, when comparing model A to model B on the ninth story roof and model A to model D on the ninth floor roof, respectively. (Table 6). Table 5's bar graphs show that the external floating column G+10 building has expanded by 5.5%.

Table 4 displays a comparison of the two models' runtimes (in seconds).

Table 5 compares the duration (in seconds) for models A and C.

Table 6 compares the lengths (sec) of the models A and D.

Deflection (D) (D)

The four corner nodes (361, 366, 385, and 390) of each model, as well as the deflection value reached under a certain load combination, are shown in Tables 7 to 8. The inclusion of floating obviously increases the building's deflection. According to Table 7, there is a 55% deflection increase between Models A and B, whereas there is a 32.05% deflection increase between Models A and D. (Table 9). Model C outperforms Model A in the external floating column G+10 building by 6.23%. (Table 7).

Table 7. Corner node Deflection Value and Critical Load Combination

Table 8 displays the deflection value at corner nodes under extreme load conditions.

Deflection values at corner nodes under critical loads are listed in Table 9.

Beam bending moment, or E. (6) Figures (9) (9) bar charts are used to display the results of the bending moment (in kN-m) in beams.

The bending moment in beams is compared between Models A and B.

For model B, the bending moment is displayed graphically at the column levels of 1, 4, 7, and 10 stories. This is depicted in (Figures 6-9). Options for common beams are considered. The first floor has four members with the numbers 1042, 1043, and 1065. Members 1302, 1303, 1279, and 1280 have been selected for the fourth floor. A total of 1539, 1540, 1516, and 1517 were selected for the seventh floor.

Figures 6-9 show that the bending moment is increased when floating columns are present. This is due to the lateral load stressing the beam and increasing the bending moment, both of which were made worse by the model's inadequate formation plan. The beam bending moment of the B-4 model building is the lowest of all the buildings displayed in the bar charts. Based on a comparison of the data, we may deduce that the bending moment of the model B building is lowest on the tenth floor and largest on the first. Member 1517 has therefore experienced a maximum discount of 38.8 percent. Member 1065 has the highest possible gain percentage, at 71.89%.

Beams on the ground floor of Models A and B are compared in Figure 6 for their bending moments.

Figure 7 compares the fourth-floor bending moment for model A and B beams.

In Figure 8, we see a contrast in the bending moments experienced by beams of Model A and Model B on the seventh floor.

Bending moment comparison for model A and B beams at the 10th floor is shown in Figure 9.

Different beam bending moments are shown for Models A and C.

Figure 10 shows that floating columns increase the bending moment. This is because the lateral load stressed the beam, increasing the bending moment, due to the model's inadequate formation plan. The beam bending moment is shown to be lowest for the C-4 construction in the bar charts. Research indicates that the bending moment for a model C building is highest on the ground floor and lowest on the tenth storey. As a result, we've lost as much as 51.13 percent of member number 1780. Among all members, 1059 has the most potential for development, at 71.89 percent. Figure 10 depicts beam bending moments for models A and C.

The bending moment of beams in Models A and D are compared.

Bending moment is seen to rise due to the presence of floating columns in Figure 11. This is because the lateral load stressed the beam, increasing the bending moment, due to the model's inadequate formation plan. Based on the presented bar charts, it is clear that the D-1 model has the lowest beam bending moment. The model D building's first floor has the lowest bending moment and the highest bending moment, as shown by the comparison. As a result, we've lost as many as 51.13% of our original membership (1043)! Member 1042 has a maximum growth potential of 71.89 percent.

The bending moment in beams for models A and D is shown in Figure 11.

Conclusions

The following conclusions are given after the software has examined several interior column arrangements in the construction plan:

1. When compared to models without floating columns, models with floating columns in the lower floor showed increased base shear. The addition of floating columns causes the spectral acceleration to increase, which in turn causes the horizontal seismic coefficient to increase (Ah).
2. The placement of the floating columns varies in models C and D, which causes the storey drift for each model to exceed the allowed limit.
3. The addition of floating columns significantly extends the overall lifespan of the structure.
4. It was noticed that the addition of floating columns increased the deflection in the corner nodes. The architecture with an internal floating column had the biggest increase in deflection, while Model C had the least.
5. When floating columns are present, the bending moment increases. This is because the model's poor formation plan caused the lateral load to stress the beam and raise the bending moment.
6. Because buildings have internal and external floating columns, they are not appropriate for seismic zones IV and V. Only internal floating columns should be built if the stated architectural specifications must be followed because they are more dependable than external floating columns.

The next most frequent type of structure is one with both interior and external floating columns, however exterior floating columns are the least desired. Internal floating columns are a feature of the most common structure. As a result, internal floating column structures have worked admirably and have been given sound advise. A ground-level internal floating storeyed building has also been proposed as a better option for the location of the floating column.

Reference

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3. Pages 1482-1489, 2015 Volume 2 Issue 4 International Research Journal of Engineering and Technology Patil, U.P. and Hallur, S.S. 5 Evaluation of the Seismic Response of RC Frame Buildings with Floating Columns on Varying Soil Conditions In 2014, volume 4 issue 1 of the International Journal of Current Engineering and Technology had an article titled "Seismic analysis of G+5 framed structure with and without employing floating columns," which presented the results of such an analysis. All three names are P. Nautiyal, S. Akhtar, and G. Batham.

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