Dominant Loading in 5- to 30-Story Reinforced Concrete Frame Buildings and Its Influence on Structural Member Sizing

Irhad Mrkonja[1*)], Ahmed El Sayed[2)], Sanin Džidić[3)]

[1*)]Department of Civil Engineering, Faculty of Engineering, Natural, and Medical Sciences, International Burch University, Francuske revolucije bb, 71210 Ilidža, Bosnia and Herzegovina, Irhad.mrkonja@ibu.edu.ba; 0009-0005-5318-4469

[2)] Department of Civil Engineering, Faculty of Engineering, Natural, and Medical Sciences, International Burch University, Francuske revolucije bb, 71210 Ilidža, Bosnia and Herzegovina, Ahmed.elsayed@ibu.edu.ba; 0000-0002-1668-8861

[3)] Department of Civil Engineering, Technical Faculty, University of Bihać, Irfana Ljubijankića bb 77000 Bihać, Bosnia and Herzegovina, ninsa_d@hotmail.com; 0000-0002-8269-6667

https://doi.org/10.29227/IM-2025-02-02-010

Submission date: *2025-08-12* | Review date: *2025-08-27*

Abstract

In this work, reinforced concrete frame buildings (frame structures), with 5 to 30 floors were analyzed in order to determine how the dominant design load shift with increasing building height, The study focuses on the identification of the number of floors where the controlling variable load moves with the gravity-inducted (own and live) load on lateral forces (wind and seismic forces) and examines the implications of this shift on the dimensioning of structural elements. Using computer models in software ETABS/TOWER and applying EUROCODE standards (EN 1991 for permanent and EN 1992 for concrete design), a series of buildings with only a central reinforced concrete core (surrounding elevator shafts and staircases) and without additional shear walls was evaluated under combined load scenarios. The analysis identifies a critical building height (within 5- to 30-storey range) where loads begin to govern design, replacing gravity loads as the primary driver for column sizing and reinforcement requirements. The results show that below this threshold height, column design is determined by vertical loads, with cross-sectional requirements increasing towards the lower floors due to accumulated gravity loads. Above the threshold, in taller buildings, lateral displacement and stability requirements dominate the design. This change loads to a significant increase in the required column dimensions and reinforcement – especially in the lower floors – to meet the strength and stiffness criteria. The transition in dominant loading significantly affects the distribution of internal forces and the amount of reinforcement required along the height of the building. These findings highlight the importance of recognizing the height at which lateral loads become critical in the design process, as they implicitly affect material utilization and structural efficiency in frame structures of medium and high-rise buildings.

Keywords: *high-rise structures; seismic load; wind load; reinforced concrete frame; structural design; Eurocode*

1. Introduction

Rapid urban population expansion and the resulting demand on constrained space have had a significant impact on the city's residential growth. As a building's height rises, the structural system that resists lateral loads takes precedence over the system that resists gravity stresses. The ability to provide structural efficiency, i.e., the use of skeletal frames is one of the most important characteristics that makes tall buildings of ever-growing heights physically feasible **[1] [2]**.

The main factor in the development of new structural systems that result from structural engineers' ongoing efforts to build taller structures while minimizing deflection and maximizing material efficiency is how tall buildings withstand wind and earthquakes **[3]**.

The tall towers required less support from a vast masonry mass thanks to the skeletal system. It also permitted the installation of a simple curtain wall system and daylighting inside. Later, a rigid moment-resisting frame (MRF) was created, allowing for taller and lighter structures because the beam-to-column joints are permanently attached **[4]**.

Under lateral loads from a big earthquake, a structure's predicted displacement can be significant. If adjacent structures or physically independent elements of the same structure are not sufficiently separated, they may "pound" against one another during an earthquake. This impact generates significant shears and bending moments in the impacted columns, which may cause the columns to break and the structure to collapse. [5]

After World War II, Bosnia and Herzegovina became a place where there were various opportunities in many fields, and architecture and engineering were highly ranked in terms of development projects. It was precisely such a situation and numerous new opportunities that were extremely interesting for numerous highly educated experts from many European architectural schools. Sarajevo, the capital of the Republic of Bosnia and Herzegovina, was the center of new technological achievements, and it is not at all surprising that the first tall building was built in Sarajevo [6].

The location of the territory of Bosnia and Herzegovina is known as a seismically active area, and strong, very strong and devastating earthquake epicenters have been recorded. There are also different seismogenic zones where these earthquakes originate. There are four seismically active levels based on the depth of the hypocenter of the earthquakes that occurred in Bosnia and Herzegovina: 1. between 0 and 10 km; 2. between 11 and 20 km; 3. between 21 and 30 km; and 4. above 30 km. The first seismically active level (0–10 km) has the most earthquakes, while the 11–20 km level had the highest magnitudes (Banja Luka and Treskavica). In the region of the carbonate platform (Outer Dinarides), great seismic activity was observed. The epicentral areas of Jajce, Sarajevo, Treskavica, Prača and the stretch from Žepče to Zenica are well defined in the central parts of the Bosnian Dinarides. The strongest earthquake of magnitude 6 was recorded on Mount Treskavica. Banja Luka, Derventa, Tuzla and Skelani are the most significant

epicentral areas in the interior of the country. In 1969, the Banja Luka region experienced an earthquake of magnitude 6.6 [7] [8].

The action of wind on a structure is calculated as the product of the aerodynamic wind pressure, the force or pressure coefficient and the area of the structure exposed to the wind. In Bosnia and Herzegovina, the JUS regulations [9] for wind loading of structures are still applied. Since its inception, the rule, which is divided into four parts, has incorporated the latest engineering knowledge on the effect of wind on structures. The basic wind speed is the primary quantity used to calculate the average aerodynamic wind pressure, which is the subject of the first part. Meteorological stations in Bosnia and Herzegovina provide it in tabular and cartographic format. In Bosnia and Herzegovina, BAS EN 1991-1-4 [9], which specifies the effect of wind on structures, was introduced as a result of the transition to EUROCODE and EN building codes. The "basic value of the basic wind speed" is the fundamental parameter as defined by that regulation and is listed in the National Annex to the rule as a map or table. The definitions from both standards state that the relevant parameter is the average wind speed on rocky terrain (type II according to BAS EN 1991-1-4) at a height of 10 meters, with a return time of 50 years. However, a significant difference lies in the averaging interval. The new standard BAS EN 1991-1-4 requires an averaging interval of 10 minutes, while the JUS regulation required an averaging interval of 1 hour [9]. This was resolved in the absence of a National Supplement by applying an averaging time interval factor to the basic wind speed figures from the JUS standard [10] .

2. Research Methodology

In this research, a computer-assisted qualitative comparative research methodology was used with the aim of determining the value of internal forces, namely normal forces (N), bending moment (M), total displacement of the structure (d_{top}) and relative displacement of the structure - drift (d_r), for a building with regular floor plan dimensions of 23.4 m x 24.2 m, and variable heights, from 5 floors to 30 floors, which ensures coverage of the heights of the tall buildings category **[11]**. The goal of a typical residential building is to find the breaking point, i.e. the breaking floor height, when the lateral loads become dominant, i.e. when the dimensions of the construction elements and reinforcement in the reinforced concrete sections, in this case in the columns, increases solely due to the effects caused by the seismic effect or wind as the dominant load. The TOWER software was used for the modeling and analysis of structural elements, and the EUROCODE standard, which is used for structural design and gives limits on the total displacement of the structure (d_{top}) and the relative displacement of the structure - drift (d_r) **[12]**.

3. Structural Materials

The search for better and more efficient building materials is of course connected with the construction of tall buildings, i.e. structures, Figure 1. The height and shape of building structures, as well as their energy efficiency, are greatly influenced by technological progress in engineering materials in general. In the first time, the material steel was the one that took the first place in the construction of buildings because concrete technology was not well developed, and the concrete that was produced at that time was much weaker than steel. Now concrete is gaining importance and popularity as the most important structural component for structures like these. [11]

Examples of tall structures that use a combination of concrete and steel technologies are: in Malaysia in Kuala Lumpur, the Petronas Twin Tower; in Dubai, United Arab Emirates, Burji Khalifa and Princess Tower; in the USA in New York, One57; and in Saudi Arabia in Riyadh Kingdom Center. Of the 100 tallest buildings in the world today, nine are made of steel, thirty are made of reinforced concrete, five are made of steel and reinforced concrete, and fifty-six are made of composites. As physical science has advanced, so has the emergence of new types of intelligent materials, especially those that improve the light, acoustic, thermal, and electrical environments of buildings. [12]

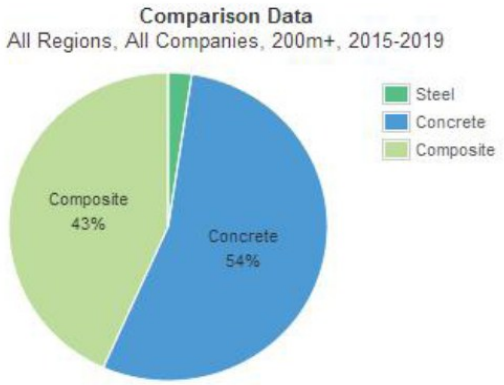

Fig. 1. Comparison of systems made of different materials used in the construction of high-rise buildings (above 200 m) in the period 2015-2019. and based on the CTBUH global database of high-rise buildings [11].

4. Structural loading

Appropriate structural solutions in terms of stiffness and stability have always been a challenging task from a structural point of view for tall buildings. Of course, while permanent and live loads are the primary determinant of height in the design of low-rise buildings, the attention of structural engineers is focused on checking and controlling the horizontal movements of the building. The taller the building, the more sensitive it is to horizontal forces arising from earthquakes and wind. When certain stiffening components are lacking, the cross-sectional dimensions of columns increase to the point where they are no longer acceptable from an architectural point of view. Therefore, newer structural systems - which have progressed from rigid frames, core-outriggers, tubes and diagonal structures - often replace older solutions that offer gravitational or vertical load-bearing capacity. The concept that a building can be described as a single element protruding from the ground has led to the latest architectural styles, which later enabled the implementation of simpler structures in a single rigid element, such as a cantilever system. This shows that the choice of an appropriate model that can accurately define the force path within the bracing and reproduce the real behavior of the building with a high degree of accuracy is a fatal issue in structural design. [13].

4.1 Combination of actions

The regulations on the loading of structures provide adequate combinations of loads on which the structure is based, as well as the structure as a whole, must be designed. There are various situations, including those in which it is necessary to take a large number of combinations into consideration. For example, one load case for the ultimate permanent and useful load only, four groups of four load cases for different combinations of permanent load, variable and wind load and for the ultimate limit state, and one load case for the long-term serviceability limit state (permanent load plus variable load). These cases and combinations were considered in 18 load combinations to which each of the towers of the Dubai, Emirates project was subjected (Poulos and Davids, 2005) [14].

4.2 Seismic actions

As tectonic movements, even minor ones, can happen anywhere, there is also the possibility that an earthquake can happen practically anywhere, so structures should be designed with a certain level of protection against seismic phenomena, such as reserve ductility and redundancy, in order to avoid collapse of structures. As it is usually expected, it is assumed that a building in a seismically active area can suffer a number of minor earthquakes, along with several moderate ones, one or more than one major earthquake, and perhaps even one very strong one, during its lifetime. Parameters such as: building mass, ground acceleration, shape and proportions of the object, and the dynamic response of the structure, influence how seismic forces are distributed. Again, if you look at it from the other side, additional design considerations are necessary, if there are unavoidable irregular shapes in the structure, to take into account the load transfer in case of sudden changes in the stiffness or resistance of the structure itself. If the aforementioned is taken into account, then two methods are used to calculate the seismic load, which take into account the construction parameters, as well as the historical frequency of earthquakes in that era. The magnitude and duration of seismic effects are greater than those of wind effects [15]. Eurocode 8 standards are applied for design and construction in seismic areas in European countries. The aim of these standards is to ensure the following in the event of an earthquake:

- to protect human lives,
- limit damage and
- ensure the usability of facilities that are important for the protection of people.

Eurocode 8 prescribes two limit states, namely: load limit state (ULS) and serviceability limit state (SLS). ULS are those associated with collapse or other forms of structural failure, which may endanger people's safety. SLS are those associated with damage after which the defined usability requirements can no longer be met [16].

4.3 Wind actions

Unlike seismic loads, wind loads should be taken into account regardless of where the building is located. As the pressure changes in the atmosphere, it encourages the movement of air, i.e. the creation of wind. The very surface of the earth and man-made structures create turbulence and eddies close to the ground, while air circulation is relatively unchanged at higher altitudes. Phenomena known as "vortices" occur when wind blows over an obstacle, such as buildings or bumps in the ground itself. Since the wind is a dynamic load that changes with height, as well as with position, even during short periods of time, it becomes a very complicated load. When designing tall buildings, Eurocode requires the consideration of two additional wind effects in addition to direct load effects, namely vortex shedding and galloping. Impact, Flicker and Ovaling are effects that are related to the wind and must be taken into account [17].

Wind is the strongest and most unpredictable factor affecting tall buildings. The mast itself, anchored to the ground, swaying in the wind, and bending it, is called a tall building. It is very important to limit this movement, which is also called wind drift. This wind drift, or rather its value, should not be greater than the height of the building divided by 500 for a well-designed tall structure. The wind load on buildings increases significantly as the height of the building increases. Also, the wind pressure increases as the square of the wind speed, and both the speed and the gust of wind increase with height. As a result, the effects of wind on tall buildings become more dangerous as the structure grows. With advances in analysis itself, or rather analysis techniques, and improvements in architectural treatments and the strength of materials, tall buildings have become even lighter and more efficient. This has actually made them more susceptible to deflections and even swaying under the action of the wind. Wind remains a complex phenomenon, mainly for two fundamental reasons, even with the achievements of computers, or rather sophisticated engineering computer applications. Rather than being constant and beneficial, wind loads fluctuate rapidly, sometimes even suddenly, producing effects that are far greater than those produced by gradual application of the same loads. They also limit the accelerations of buildings to below what is noticeable to humans. More research is needed into the nature of wind and its interaction with tall buildings, particularly with respect to permissible deflections and occupant comfort, although our progress and our understanding of the full complexity of wind and the tolerable human tolerance to it is still evolving [15].

5. Design Models

For the purposes of calculating and searching for the dominant load, and through the influence values in the elements, four building models are presented, selected reinforced concrete frame with a core with structural regularity, 5, 10, 20 and 30 floors, not including the basement and ground floor. The following data that will be listed in the next part of the text refers to all models. The base of the basement, as well as the base of the ground floor, are irregularly shaped, the approximate floor plan dimensions of which are 31,45 m x 49,30 m. The bases of all other floors are the same with dimensions of 23.4 m x 24.2 m. The structures of the buildings consist of:

a) vertically reinforced concrete elements:

- walls at basement level, thickness d=30 cm,
- the walls of the core, which is located around the stairs and around the elevators, with the thickness of the walls on three sides d=20 cm and d=30 cm on one side (elevator side). These walls go unchanged to the top of the building.
- columns placed in axes, horizontally, B, C, D, E, or vertically in axes 2, 3, 4 and 5. The dimensions of the columns are 40x150 cm from the basement to the second floor, and from the level of the second floor they decrease to dimensions 30x150 cm.

b) horizontal reinforced concrete elements:

- beams, dimensions above 30x70 cm and 30x50 cm above the basement, 30x55 cm and 20x55 cm above the ground floor and 30x50 cm and 20x50 cm above all other floors.
- slabs, foundation slab with a thickness of d=80 cm, slabs above the basement and ground floor d=25 cm and slabs above all

other floors d=20 cm. The presentation of the characteristic bases - plans of the formwork of the structural elements is given in Figure 2. and Figure 3. Permanent and variable effects and material properties, as well as sections of reinforced concrete load-bearing elements, are the same for all building models, and are taken according to Eurocode regulations [18]. To determine and compare the values of internal influences, normal forces (N), bending moment (M), total displacement of the structure (d_{top}) and relative displacement of the structure - drift (d_r), for a building with regular floor plan dimensions of 23.4 m x 24.2 m, one of its characteristic floors, in addition to permanent and variable effects, seismic and wind effects were also taken into account, according to Eurocode regulations [12] [19]

It should be noted that the facility for which the static calculation and finding of the dominant load is performed is located in Sarajevo, Bosnia and Herzegovina.

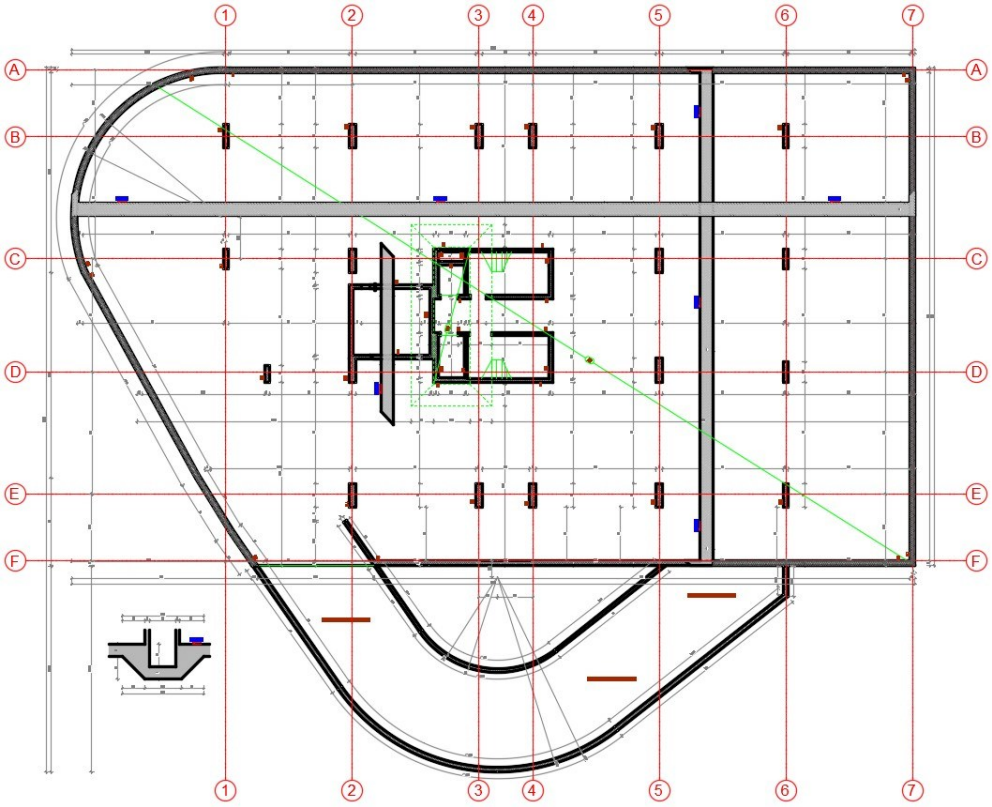

Fig. 2. Layout for foundation slab for all models

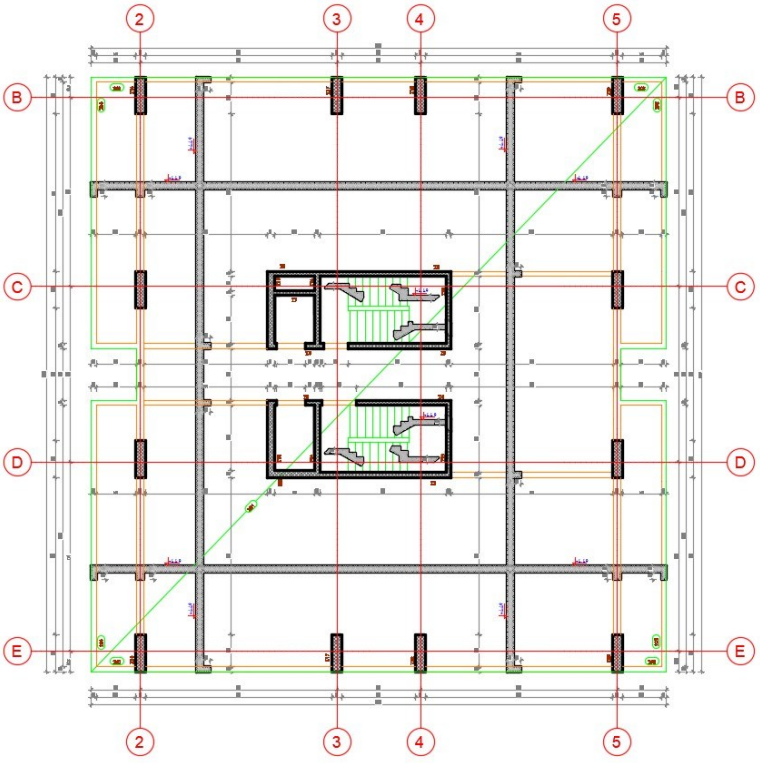

Fig. 3. Layout of the characteristic floor position for all models

5.1 Model 1: High-Rise, Reinforced concrete building B+G+5, H= 19.89 m – from ground level

Floor height of the basement h_B =3.43 m, floor height of the ground floor h_G =4.59 m and floor height of the upper floors h_F =3.06 m.

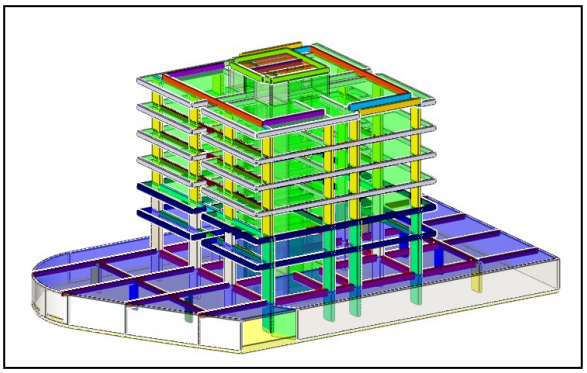

Fig. 4. Model 1: B+G+5

5.2 Model 2: High-Rise, Reinforced concrete building B+G+10, H= 35.19 m – from ground level

Floor height of the basement h_B =3.43 m, floor height of the ground floor h_G =4.59 m and floor height of the upper floors h_F =3.06 m.

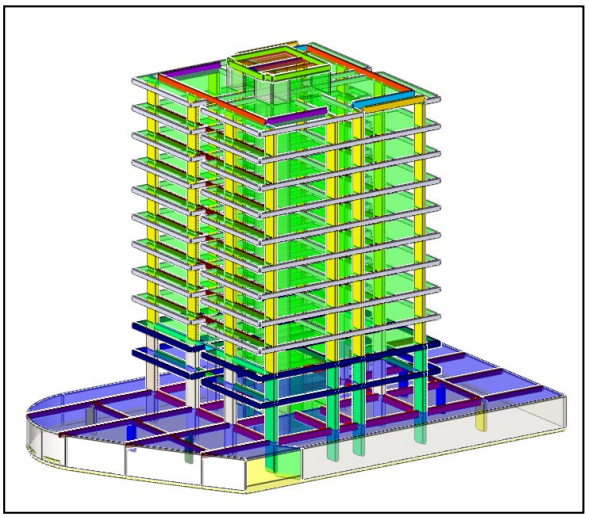

Fig. 5. Model 2: B+G+10

5.3 Model 3: High-Rise, Reinforced concrete building B+G+20, H= 65.79 m – from ground level

Floor height of the basement h_B =3.43 m, floor height of the ground floor h_G =4.59 m and floor height of the upper floors h_F =3.06 m.

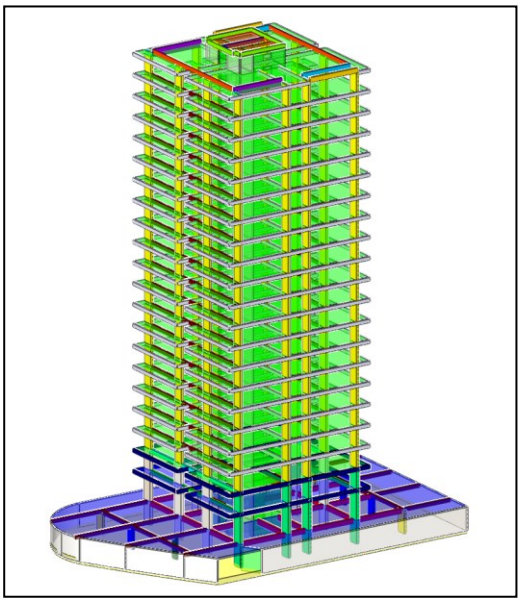

Fig. 6. Model 3: B+G+20

5.4 Model 4: High-Rise, Reinforced concrete building B+G+30, H= 96.39 m – from ground level

Floor height of the basement $h_{B.}$=3.43 m, floor height of the ground floor $h_{G.}$=4.59 m and floor height of the upper floors h_F =3.06 m.

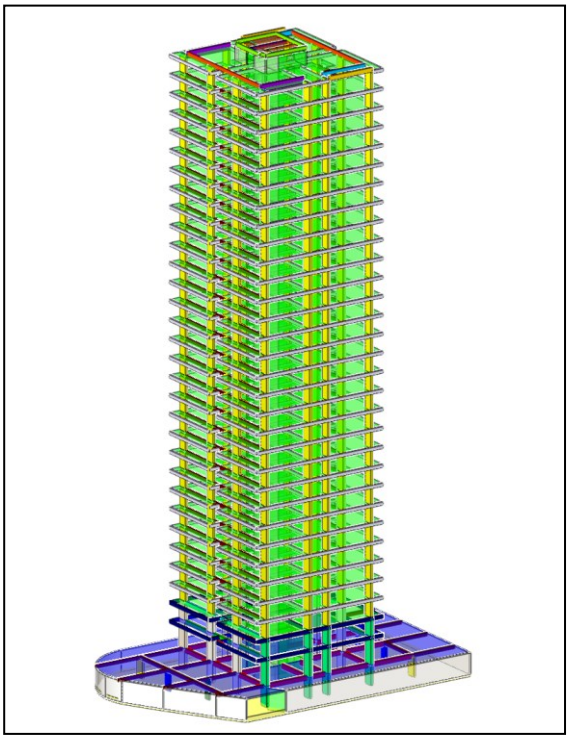

Fig. 7. Model 4: B+G+30

6. Results of static calculation

For the objects in question with the parameters mentioned earlier and the models presented and the characteristic formwork of the structure, below are the results of the static calculation for one characteristic column in the "4-E" axis, in which the values of the cross-sectional values are shown, namely, normal forces (N), bending moment (M), total displacement of the structure (d_{top}) and relative displacement of the structure - drift (d_r). It should be noted that the total displacement of the building depends on:

- the seismic zone and quality of the soil in which the foundations of the building will be located,
- constructive system of the building,
- the number and dimensions of load-bearing elements,
- the appearance of the object in the floor plan, i.e. (non) matching of the center of mass of the object with the center of rigidity, the shape of the object in height,
- height of the building, etc.

For the object in question and the analysis, seismic conditions for the area of the city of Sarajevo were used, according to Eurocode 8, i.e. PGA was taken as 0.16 g, which can be seen in Figure 8, from the Seismic hazard map for Bosnia and Herzegovina [20] [21].

The constructive system of the analyzed models is a skeletal system with a reinforced concrete core placed so that the object's center of mass coincides with the center of rigidity, which makes it impossible to rotate the mass around the rigidity in the event of an earthquake. Minimal random eccentricities are taken into account.

The results obtained from the analysis carried out on 4 numerical models are shown in the tables below along with other influences and the values of the total displacement of the building in relation to the foundation.

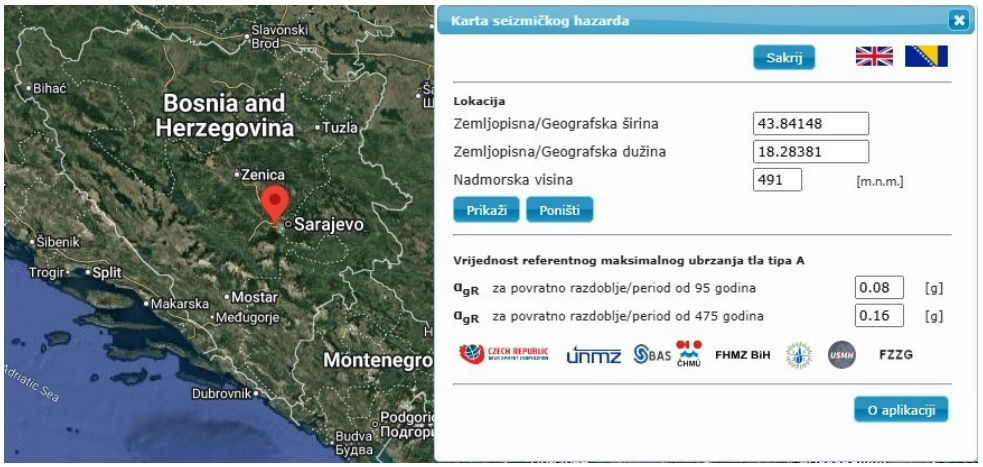

Fig. 8. Interactive Map of Seismic Hazard for Bosnia and Herzegovina

Tab. 1. Results in grid "4-E" for Model 1: B+G+5

O.N.	LOAD CASE	INTERNAL INFLUENCES N1 (KN)	M2 (KNm)	d_{top} (mm)	d_r (mm)
1	Dead	-2.087,91	-142,20	3,25	1,66
2	Live	-405,04	43,76	0,54	0,24
3	Snow	-5,45	-9,51	0,14	0,02
4	Wind	-10,30	-7,30	0,94	0,09
5	Ex	-215,53	-115,65	22,77	2,27
6	Ey	-216,58	101,41	23,36	2,32

Tab. 2. Results in grid "4-E" for Model 2: B+G+10

O.N.	LOAD CASE	INTERNAL INFLUENCE N1 (KN)	M2 (KNm)	d_{top} (mm)	d_r (mm)
1	Dead	-3.862,52	-213,12	4,14	0,54
2	Live	-672,86	49,26	1,03	0,12
3	Snow	-28,70	-3,22	0,06	0,01
4	Wind	-2,80	-1,04	-0,79	-0,07
5	Ex	-368,82	-145,43	52,25	4,45
6	Ey	618,68	1.476,23	4,66	0,13

Tab. 3. Results in grid "4-E" for Model 3: B+G+20

O.N.	LOAD CASE	INTERNAL INFLUENCE N1 (KN)	M2 (KNm)	d_{top} (mm)	d_r (mm)
1	Dead	-6.960,76	-482,10	18,10	1,30
2	Live	-1.183,56	63,53	4,33	0,30
3	Snow	-29,93	-3,36	0,13	0,01
4	Wind	-196,75	-45,32	39,52	1,80
5	Ex	-630,53	-185,84	136,12	6,58
6	Ey	1.308,87	1.660,02	9,17	0,09

Tab. 4. Results in grid "4-E" for Model 4: B+G+30

O.N.	LOAD CASE	INTERNAL INFLUENCES N1 (KN)	M2 (KNm)	d_{top} (mm)	d_r (mm)
1	Dead	-20.249,32	-1.167,95	508,25	20,45
2	Live	-3.422,77	-174,10	92,04	3,69
3	Snow	-59,60	-4,66	1,56	0,07
4	Wind	-1.233,31	-120,80	166,10	5,43
5	Ex	-3.386,16	-421,30	470,18	16,64
6	Ey	4.124,72	2.825,71	22,97	0,24

6.1. Results presented in diagrams

Although the impact values given in the tables are clear for each model, i.e. the number of floors of the building, as well as for each load, in the following text we will also present the impact values graphically. In the graphic representations, all influence values are entered with a positive sign so that the given diagram gives a realistic representation of the relationship of influence values. The diagram is designed so that the given models are marked with different colors, which is shown below each graphic. Within each load, the models for which the impacts are shown are grouped, so it is easy to see which model has the greatest impact for a given load. So, on the horizontal line, the loads are given, which are numbered from 1 to 6, and on the vertical line, the impact values are given for them and the relevant units of measurement, which are also indicated in the title of the individual graph itself.

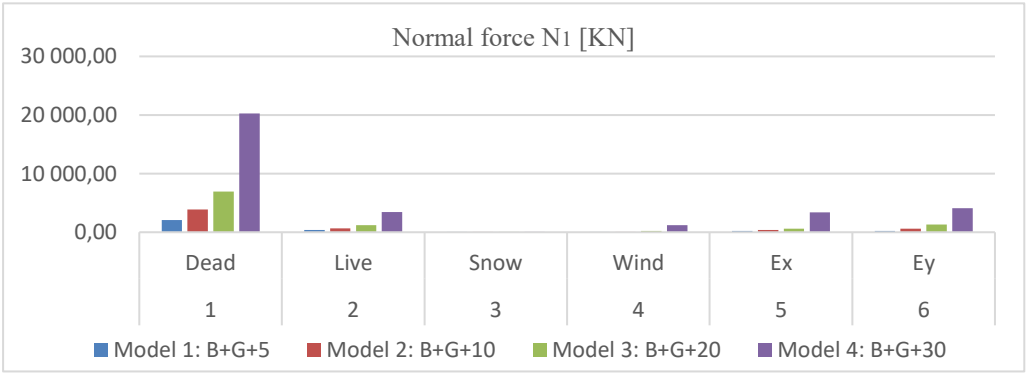

Fig. 9. Graphical representation of the value of Normal force for given models and given loads

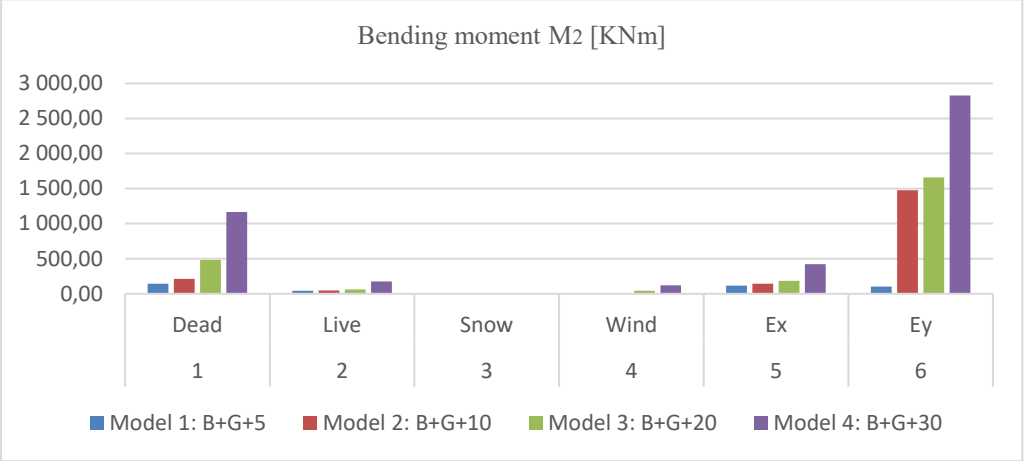

Fig. 10. Graphical representation of Bending Moment values for given models and given loads

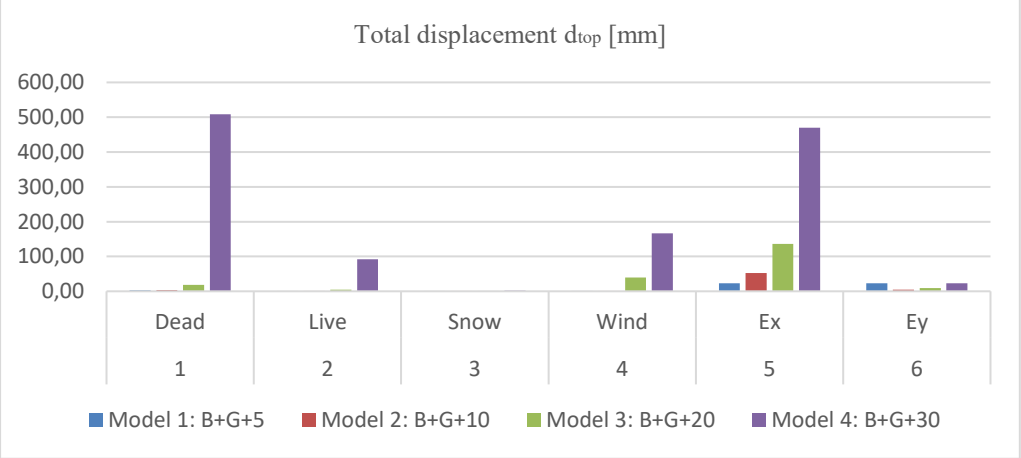

Fig. 11. Graphic representation of the value of the total displacement of the structure for the given models and the given loads

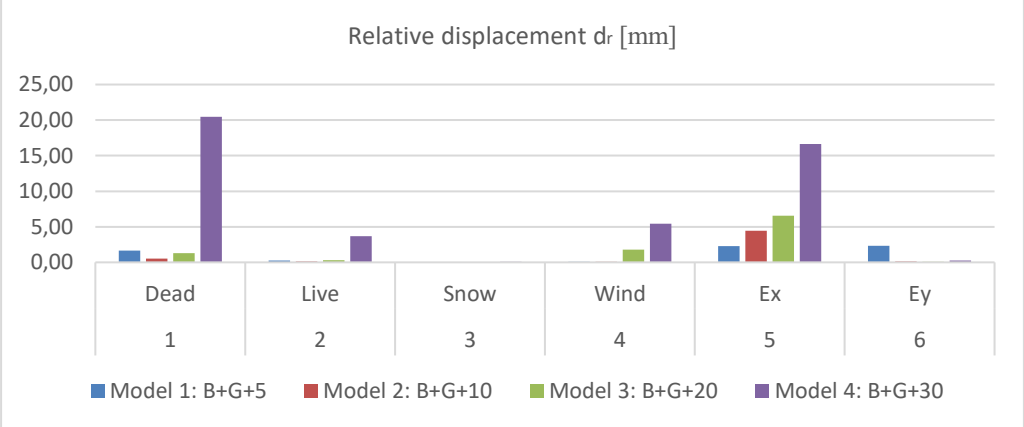

Fig. 12. Graphic representation of the relative displacement values - drift for given models and given loads

7. Conclusion

According to the visible results given in the tables and diagrams, it can be concluded that the value of the normal force (N_1) increases linearly with the increase in the height of the object for all given load cases. The value of the normal force from dead load is dominant for all models.

When it comes to the second observed cross-sectional value, the bending moment M_2, it can be seen from the tables and diagrams that only for Model 1 (B+G+5) the value of M_2 is higher for dead load, i.e. gravity load. As the number of floors of the building increases, so does the value of M_2 in favor of the lateral load, that is, the influence of the seismic force. As can be seen from the tables and diagrams, the value of the bending moment M_2 for Model 2 (B+G+10) is significantly higher for the seismic force E_y, in relation to permanent, i.e. gravitational loads, i.e. it has become the dominant load for this cross-sectional dimensions. It can also be concluded that for the storey which was not observed in this paper, but from the results obtained for the given models, for the storey B+G+7 the value of the seismic force E_y will be the dominant load which will give the highest value of the bending moment M_2.

The total displacement of the structure at the top, as well as the relative displacement - drift, were observed for one characteristic frame “4-E” and the values shown are given for one direction only. The dominant load, as could be assumed, for the value of the total displacement of the structure at the top d_{top}, is the seismic load, and that for the first three models, while for Model 4 (B+G+30)

the d_{top} value is on the dead load side. On Model 3, the d_{top} value due to the influence of wind is also higher than the dead load, while already on Model 4 the situation is completely different, where d_{top} is higher for the dead load.

The relative displacement d_r can be said to fully follow the curve of the total displacement of the structure for all models, and is also at the level of lateral, seismic action, except for Model 4, as in the case of total displacement, so the d_r value for wind load for Model 3 is higher than the dead load.

Acknowledgments

On this occasion, I would like to first of all thank my family who supported me during this work, my wife and my children. Of course, I would like to thank my mentors who gave me clear guidelines for the preparation of this scientific paper. And I would also like to thank the WMCCAU Team who extended the deadline for the submission of scientific papers.

References

1. K. Jani and V. P. Paresh, "Analysis and design of diagrid structural system for high rise steel buildings," *Procedia Engineering,* vol. 51, pp. 92-100, 1 Januar 2013.
2. Moon K, "Dynamic Interrelationship between Technology and Architecture in Tall Buildings," 2005.
3. Gunel, H. M and E. I. H, "A proposal for the classification of structural systems of tall buildings," *Building and environment,* vol. 1, pp. 2667-2675, July 2007.
4. M. A. Mir and A.-K. Kheir, "Structural Systems for Tall Buildings," *Encyclopedia,* vol. 2, pp. 1260-1286, 5 July 2022.
5. R. A, A. AM and M. MR, "Drift analysis due to earthquake load on tall structures," *Journal of civil engineering and Construction Technology,* pp. 154-158, 2012.
6. I. Kovačević and S. Džidić, High-Rise Buildings-Structures and Materials, Vols. ISBN 978-9958-834-59-2, Sarajevo: Internacionalni BURCH Univerzitet Sarajevo, Bosna i Hercegovina, 2018, p. 181.
7. H. Hrvatović, "Identifikacija i procjena geoloških hazarda zemljotresa," Ministarstvo sigurnosti Bosne i Hercegovine, Sarajevo, Bosna i Herzegovina, Sarajevo, 2006.
8. F. Avdić, S. Džidić, E. Hodžić and A. Čaušević, "Seismic Actions on Buildings According to the National Regulations and Eurocode 8 for Bosnia and Herzegovina," *Springer, Cham. https://doi.org/10.1007/978-3-031-66271-3_6,* Vols. New Technologies, Development and Application VII. NT 2024., no. vol 1070, pp. 606-619, 2024.
9. P. b. 1.-1. o. 1.-0.-0. Službeni list SFRJ, br. 70/91. JUS U.C7.110 1991., "OPTEREĆENJE VJETROM, Osnovni principi i osrednjeni aerodinamički pritisak vetra," *JUGOSLAVENSKI STANDARD, Osnove proračuna Građevinskih konstrukcija,* p. 24, 08 July 1991.
10. E. Hodžić, "OPTEREĆENJE VJETROM U BIH PREMA ZAHTJEVIMA EN 1991-1-4," Novi Sad, 2018.
11. CTBUH, "CTBUH Height Criteria for Measuring & Defining Tall Buildings," 6 June 2020. [Online]. Available: https://www.ctbuh.org/resource/height.
12. European Committee for Standardization, "Part 1: General rules, seismic actions and rules for buildings," in *EN 1998-1 (2004), Eurocode 8, Design of structures for earthquake resistance*, Brussels, CEN, 2004, p. 231.
13. A. Carpinteri, G. Lacidogna and S. Cammarano, "Structural analysis of high-rise buildings under horizontal loads: A study on the Intesa Sanpaolo Tower in Turin," *The Open Construction & Building Technology Journal,* vol. 1, p. 1362–1371, 31 May 2019.
14. P. Harry G, "The Design of High-Rise Building Foundations," *Geotech Hanoi,* pp. 978-604, October 2011.
15. R. Anupam and P. P. Guha, "ANALYSIS OF WIND & EARTHQUAKE LOAD FOR DIFFERENT SHAPES OF HIGH RISE BUILDING," *International Journal of Civil Engineering and Technology,* pp. 38-45, Februar 2015.
16. I. S. B. i. H. Institut za standardizaciju Bosne i Hercegovine, "BAS EN 1991-1-4/NA, 2018," *Eurokod 1: Djelovanja na konstrukcije - Dio 1-4: Opća djelovanja - Djelovanja vjetra - Nacionalni dodatak,* 2018.
17. V. C. RIST and S. SVENSSON, "METHODOLOGY FOR PRELIMINARY DESIGN OF HIGH-RISE BUILDINGS," Sweden, 2016.
18. European Committee for Standardization, "Part 1-1: General actions - Densities, self-weight, imposed loads for buildings," in *EN.1991.1.1.2002, Eurocode 1: Actions on structures*, Brussels, CEN, April, 2002, p. 47.
19. European Committee for Standardization, "Part 1-4: General actions - Wind actions," in *EN 1991-1-4:2005, Eurocode 1: Actions on structures*, Brussels, CEN, 2010, p. 149.
20. B. I. S. B. B. E. 1.-1. National Annex, "Eurocode 8: Design of structures for earthquake resistance," in *Part 1: General rules, seismic actions and rules for buildings - National annex*, Sarajevo, 2018.
21. S. Džidić, F. Avdić, A. El Sayed and A. Čaušević, "Contribution to Reasons for the Seismic Risk Re-evaluation for Structural Design of High-Rise Buildings in Bosnia and Herzegovina," *Springer Cham https://doi.org/10.1007/978-3-031-34721-4,* Vols. New Technologies, Development and Application VI, Volume 2, no. ISSN 2367-3370 ISSN 2367-3389, pp. 270-283, 2023.
22. A. Sev and M. E. Çırpı, "Innovative Technologies and Future Trends in Tall Building Design and Construction," *ISITES,* p. 1114–1123, 2014.