



The Impact of Architectural Form on Seismic Performance of Buildings / Original Article

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تأثير البعد الشكلي على الأداء الزلزالي لعمارة الأبنية العالية

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Abstract

Seismic overall performance of buildings is a important issue in each architectural and structural design, especially in regions exposed to seismic dangers. Despite giant improvements in structural engineering technologies, the function of architectural form stays insufficiently incorporated into layout practices geared toward improving seismic resistance. This look at investigates the effect of the formal dimension of architectural design on the seismic performance of buildings by analyzing key shape-related attributes, namely regularity, symmetry, simplicity, continuity, and slenderness. An analytical–descriptive method is followed, based totally on an extensive evaluation of applicable literature and the assessment of architectural configurations with regards to their structural behavior underneath seismic loading. The findings indicate that architectural form performs a fundamental role in organizing mass and stiffness distribution, defining load paths, and influencing the dynamic reaction of homes. Regular, symmetrical, and simple forms contribute to a greater balanced seismic response and reduce torsional results, whereas abnormal and complicated configurations cause multiplied structural vulnerability and unpredictable behavior. Continuity enhances the integrity of load transfer mechanisms, whilst slenderness presents great challenges in excessive-upward thrust buildings due to expanded lateral displacements. The examine concludes that integrating formal design considerations inside the early levels of architectural decision-making is essential for enhancing seismic resilience. It also proposes a conceptual framework linking architectural form with seismic performance, thereby bridging the gap between architectural design and structural behavior, and assisting the improvement of extra green and resilient.

KEYWORDS: Seismic Performance, Architectural Form, Formal Dimension, Load Path

المستخلص

يعد الأداء الزلزالي للأبنية العالية من القضايا الأساسية في التصميم المعماري والإنشائي، لا سيما في المناطق المعرضة للنشاط الزلزالي. وعلى الرغم من التطور الكبير في التقنيات الإنشائية، لا يزال دور الشكل المعماري في تحسين مقاومة الأبنية للزلازل غير مستثمر بالشكل الكافي ضمن الممارسات التصميمية. كما يهدف هذا البحث إلى تحليل تأثير البعد الشكلي على الأداء الزلزالي للأبنية، من خلال دراسة مجموعة من المفردات الشكلية الأساسية، وهي الانتظام، التماثل، البساطة، الاستمرارية، والنحافة. ويعتمد البحث منهجا تحليليا وصفيا، يستند إلى مراجعة الأدبيات العلمية وتحليل النماذج الشكلية المرتبطة بالسلوك المعماري والإنشائي تحت تأثير الأحمال الزلزالية. أظهرت النتائج أن الشكل المعماري يلعب دورا محوريا في تنظيم توزيع الكتلة والصلابة، وتحديد مسارات انتقال القوى، والتأثير على الاستجابة الديناميكية للمبنى. حيث تسهم الأشكال المنتظمة والمتماثلة والبسيطة في تحقيق استجابة زلزالية متوازنة وتقليل التأثيرات الالتوائية، في حين تؤدي الأشكال غير المنتظمة والمعقدة إلى استجابات إنشائية غير مستقرة وزيادة في احتمالية الضرر. كما تبين أن الاستمرارية تعزز تكامل النظام الإنشائي، بينما تمثل النحافة تحديا في الأبنية العالية بسبب زيادة الإزاحات الجانبية. يخلص البحث إلى أن دمج اعتبارات البعد الشكلي ضمن المراحل المبكرة من التصميم المعماري يعد مدخلا فعالا لتعزيز مقاومة الأبنية للزلازل. كما يقدم إطارا مفاهيميا يربط بين الخصائص الشكلية والأداء الزلزالي، مما يساهم في تقليص الفجوة بين التصميم المعماري والتحليل الإنشائي، ويدعم تطوير استراتيجيات تصميمية أكثر كفاءة ومرونة، خاصة في الأبنية السكنية العالية.

الكلمات المفتاحية: الأداء الزلزالي، الشكل المعماري، البعد الشكلي، مسارات انتقال الأحمال.



1. Introduction

Earthquakes are taken into consideration some of the maximum dangerous herbal hazards on the Earth's floor, without delay affecting the built surroundings, as they cause widespread human and fabric losses, particularly in areas with high urban density. With the increasing trend towards vertical expansion and the emergence of high-upward thrust buildings, it has turn out to be important to increase layout techniques and strategies able to improving seismic performance and reducing related dangers. As is not unusual in maximum studies inside the field of seismic engineering, the focal point is primarily located on structural elements, such as improving fabric residences, developing lateral force-resisting systems, and employing isolation and damping techniques. Despite the significance of these efforts, the role of architectural design—specially architectural form—remains insufficiently utilized as an effective means of enhancing homes' resistance to earthquakes.

Architectural shape represents one of the fundamental determinants of a constructing's behavior underneath seismic masses, because it immediately affects the distribution of mass and stiffness, even as also defining load paths and the nature of dynamic response. Numerous research have proven that irregular or complicated paperwork cause unbalanced structural responses, accelerated torsional outcomes, and a better chance of localized damage or partial crumble. In comparison, regular, symmetrical, and easy bureaucracy make a contribution to achieving greater stable and predictable seismic overall performance with the aid of decreasing irregularities in force distribution and enhancing load transfer efficiency. Other parameters, which include continuity and slenderness, additionally play a enormous role in determining constructing behavior, specifically in high-upward push buildings, where lateral displacement results and instability.



2. The Research Theoretical Framework

The research targets to become aware of, examine, and evaluate the effect of the formal dimension on enhancing the seismic overall performance of high-rise buildings. This is done by way of reading the effect of architectural shape elements—together with regularity, symmetry, simplicity, continuity, and slenderness—on the character of seismic reaction to lateral structural masses. In addition, the research seeks to bridge the know-how gap among theoretical standards and sensible application in using these elements within architectural design. This is accomplished through the analysis of nearby case research to decide their compatibility with theoretical principles of seismic overall performance. The studies ultimately develops a layout framework that clarifies the mechanisms for integrating formal design components with structural issues, thereby contributing to decreasing seismic impacts and improving the safety and efficiency of excessive-upward thrust residential homes.

3. The Research Theoretical Framework

The conceptual framework of the research comprises four main axes. The first addresses the concept of architectural form, while the second focuses on the seismic performance of buildings. The third examines the integrative relationship between formal design parameters and seismic response, whereas the fourth axis is concerned with the study of high-rise buildings as the applied case of the research.

3.3 Architectural Form

Architectural Form is described because the geometric and mass configuration of a building, which is shaped thru the association and corporation of its spatial and volumetric factors on one hand, and its structural factors on the opposite, inside a



unified framework that defines its dimensions and ordinary shape, whether or not at the level of the plan, elevation, or volumetric composition. Architectural shape helps mirror a hard and fast of morphological traits along with simplicity or complexity, regularity or irregularity, and symmetry or asymmetry, which result from the layout choices made via the architect throughout the early degrees of the design process[1].

The role of architectural form isn't limited to being merely a visual or aesthetic expression; instead, it is taken into consideration an influential thing within the normal seismic overall performance of a building. It is circuitously associated with the behavior of the structural gadget via its impact on mass distribution, spatial organisation, and cargo transfer paths. From this perspective, **architectural form is regarded as one of the maximum critical criteria and determinants that make a contribution to shaping the initial seismic response of a constructing while subjected to external loads, which includes seismic hundreds[2].**

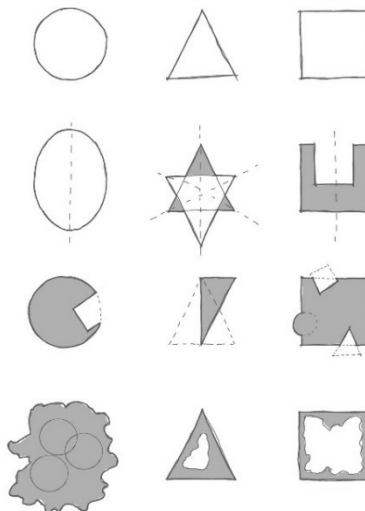


Figure (1) Source: (Author).



In the context of seismic-resistant structure, architectural form acquires specific significance, as its geometric residences impact the degree of constructing regularity and the balance of its additives, that is eventually pondered in the efficiency of its seismic overall performance. Regular and easy bureaucracy regularly permit for a balanced distribution of forces and a reduction in abnormal deformations, while complex or irregular bureaucracy may additionally cause sudden responses, thereby requiring extra architectural and structural layout interventions to make sure the safety of the building [3]. Figure (1) illustrates the types of forms (simple, composite, and complex).

3.4 Seismic Performance

Seismic performance is defined as the ability of buildings to respond to seismic loads in a manner that achieves specified levels of safety and security while minimizing damage and distortion and avoiding total structural collapse. This performance is evaluated based on the behavior of the building under dynamic forces and its ability to absorb and dissipate seismic energy while maintaining its structural and functional stability [4]. Seismic performance is directly related to the characteristics of both the structural system and the architectural configuration. Factors such as mass and stiffness distribution, geometric regularity and type of lateral load-resisting system play an important role in determining the response of a building during an earthquake. Furthermore, geotechnical site conditions play an important role in amplifying or reducing the impact of seismic waves, making seismic performance the result of a complex interaction between building properties and the surroundings [5].

Within the modern framework, the concept of performance-based seismic design (PBSD) has been adopted as an advanced approach that aims to define



different performance levels for buildings, such as immediate use, life safety and collapse prevention. This approach enables the prediction of building behavior under different seismic scenarios and links design decisions to both functional and structural objectives [6]. From an architectural perspective, achieving seismic performance extends beyond structural treatment to include the formal configuration of the building. Architectural form parameters such as regularity, symmetry, simplicity and continuity directly affect the distribution.

3.5 The Relationship between Architectural Form and Seismic Response

The seismic response of buildings is closely related to their formal characteristics, as architectural form is considered one of the most important factors and determinants that control the nature of the dynamic behavior of a building when subjected to seismic loads. This is evident in the influence of architectural form on mass distribution, stiffness distribution and the center-of-mass-center-of-stiffness ratio – factors that are crucial in controlling displacements and deformations induced by seismic events. The more regular the architectural form, whether in plan or vertical, the more balanced the distribution of seismic forces, which reduces stress concentrations and limits irregular deformations. In contrast, irregular shapes give rise to more complex responses due to uneven mass and stiffness distribution, resulting in phenomena such as torsion and localized buckling, which are the primary causes of structural failure [2].

Architectural form also plays an important role in defining load paths within building as illustrated in Simple and continuous shapes provide clear and regular paths for transferring loads to the foundation, while complex or discontinuous shapes disrupt these paths, leading to force concentrations at specific points and

increasing damage potential [4]. Furthermore, symmetry in the formal configuration helps reduce deviations between centers of mass and stiffness, thereby reducing torsional moments, while asymmetry increases seismic responses, especially in tall buildings. Therefore, control of architectural form characteristics represents one of the most important design strategies to improve seismic performance and reduce earthquake-related risks [6].

Figure (2) illustrates the concept of load paths within a building. Simple and non-stop bureaucracy show off clear and regular paths for moving masses from higher stages to the principles, thereby improving seismic overall performance. In evaluation, complex architectural bureaucracy or the ones containing discontinuities or abrupt adjustments in configuration obstruct those paths, ensuing in pressure concentrations at particular factors and growing the chance of structural harm.

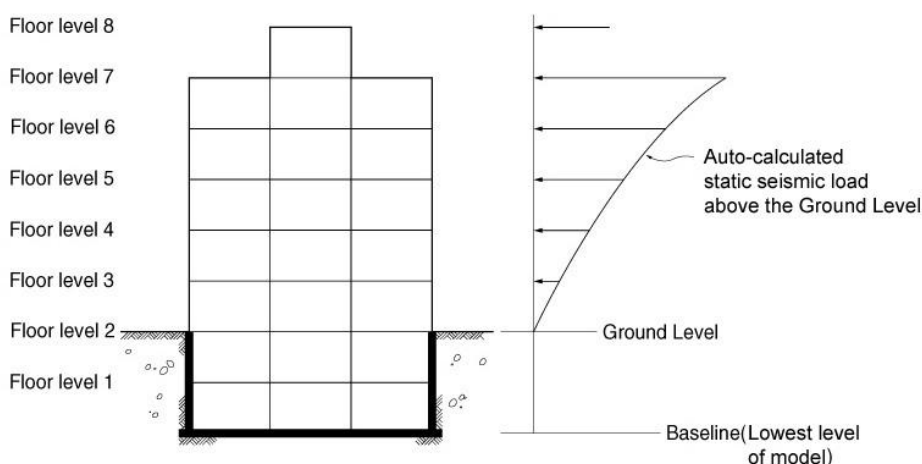


Figure (2) Illustrates the load transfer path within the building.
Source: Prepared by the author.

Figure (3) offers a assessment between a building with a normal architectural form on the proper facet of the picture and an abnormal one on the left. It can be determined that the regular building famous a uniform distribution of seismic forces, resulting in a strong and predictable reaction. In assessment, the abnormal constructing demonstrates complex conduct because of abrupt modifications in shape, mass, or stiffness, leading to stress concentrations and the emergence of vulnerable zones that growth the chance of structural failure.

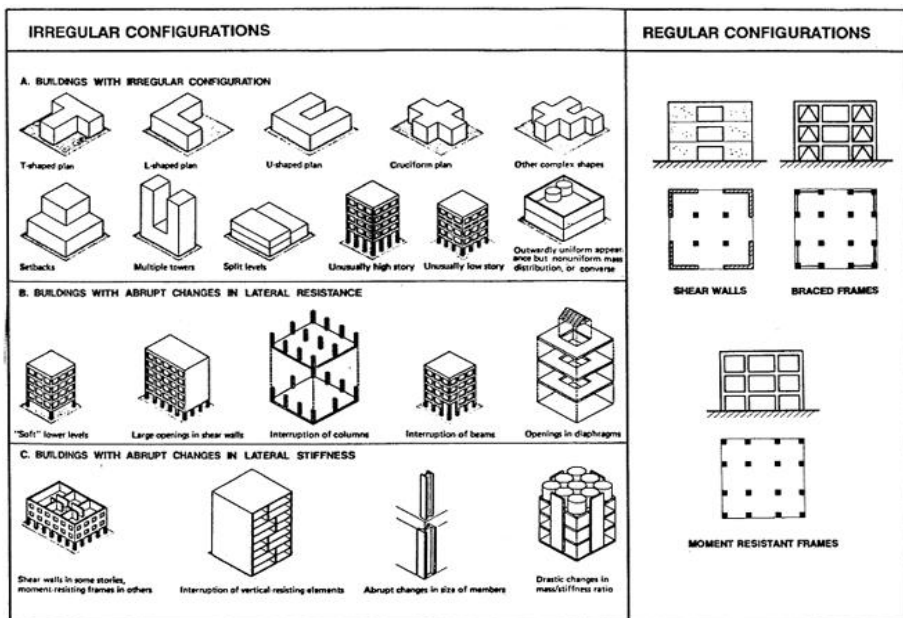


Figure (3) Illustrates the difference between regular and irregular distribution[3].

In end, architectural shape plays a important position in figuring out the kind and nature of a constructing's seismic response via without delay influencing mass and stiffness distribution and organizing load switch paths in the structure. Form characteristics, which include regularity, symmetry, simplicity, and others, make a contribution to attaining more stable and predictable structural behavior. In



contrast, irregularity and complexity extend seismic responses and growth the probability of failure, probably leading to constructing disintegrate.

4. The Theoretical Framework of the Research

The theoretical framework for this research is based on the review and analysis of a set of previous studies that investigated the relationship between architectural form and seismic performance with the aim of extracting key formal aspects that influence building behavior under seismic loads. This approach is based on the premise that formal design decisions in architecture represent the primary determinant of structural response rather than merely acting as an aesthetic element separate from performance.

In this context, a comparative study on regular and irregular architectural configurations in the design of earthquake-resistant buildings (2020) showed that regular buildings are characterized by simplicity, symmetry and balanced load distribution, which contributes to better seismic response and more predictable behavior. In contrast, irregular buildings face problems related to uneven force distribution and the emergence of torsional effects, resulting in complex and unstable structural behavior that requires additional structural solutions to overcome these imbalances. Furthermore, the study identified a set of key indicators that influence seismic performance, including simplicity versus complexity, symmetry versus asymmetry, regularity versus irregularity, as well as dimensional relationships between architectural mass in both horizontal and vertical directions. The study concluded that simple and symmetrical shapes promote uniform load distribution and reduce stress concentrations, thus having a positive impact on the building's structural performance. Similarly, Arnold and Reitherman (2002) presented a comprehensive framework for the influence of formal configuration in seismic design, emphasizing that the shape of a building is the primary factor in determining its seismicity.



Through the evaluation of preceding studies Table (1), it will become glaring that the impact of architectural shape on seismic overall performance can be categorized into a set of measurable and analyzable design variables, which function key indicators for comparing the efficiency of the formal configuration. Accordingly, those variables may be organized into an analytical desk that gives every variable, its architectural and structural indicators, and its role in mitigating seismic results, in education for his or her use as an analytical device inside the studies.

Table (1) Illustrates the formal vocabulary, architectural indicators, and their seismic impact derived from previous studies. Source: Researcher

The role in reducing seismic impact	Architectural – structural index	The formal dimension	the study
It reduces response irregularity and limits force concentration.	Uniformity of mass and rigidity horizontally and vertically	Regularity	Comparative study between regular and irregular morphological formation(2020)
It reduces torsion and improves building stability.	Symmetry of the plan around the principal axes	Symmetry	
It facilitates force transfer and reduces structural complexity.	Simple geometric shapes (square, rectangle)	Simplicity	
It increases the probability of localized failure.	Sudden change in shape or mass	Irregularity	
Reduces secondary forces and improves overall performance	The building's overall shape is uniform.	Formal regularity	Arnold & Reitherman study (2002)
Reduces torsional moments	The mass is symmetrical around the center.	Symmetry	
Leads to weak structural bonding	The mass is divided into unrelated parts.	Segmentation	
Increases the efficiency of analysis and design	The geometric system is clear.	Formal simplicity	



The role in reducing seismic impact	Architectural – structural index	The formal dimension	the study
Ensures uniform force transfer	Continuity of construction paths	Continuity	Bachmann's study (2012)
Prevents load concentration and poor performance	Interruptions in form or height	Sudden change	
Reduces dynamic shocks	Gradual transition in mass or layout	Gradualism	
Facilitates architectural and structural integration	Clarity of design concept	Conceptual simplicity	
Increases sensitivity to lateral loads	High height versus low width	Slenderness	A study of high-rise buildings and their environmental impact (2018)
Affects vibration duration	Number of floors and total height	Height (building height)	
Improves overall stability	Reducing wind resistance	Flowable shape	
Affects center of mass and response	Distribution of building masses	Mass composition	

Based on the desk above and the evaluate of preceding research, it's miles obtrusive that architectural shape isn't merely a cultured detail, but as a substitute a fundamental determinant of a building's performance in responding to seismic masses. Studies have proven that there may be a hard and fast of formal variables that continually appear as the most influential in improving seismic performance, major amongst them being symmetry and ease. These variables contribute to attaining a balanced distribution of mass and stiffness, reducing torsional outcomes, and making sure the everyday transfer of forces inside the structural device. Additional variables, along with continuity and slenderness, each play a particular function in influencing pressure distribution, organizing load paths, and minimizing deformations due to seismic masses. Accordingly, the subsequent sections will cope



with those variables in element by way of analyzing their traits, architectural and structural signs, and their function in enhancing the seismic performance of homes, as follows:

4.1 Symmetry

Symmetry is one of the fundamental formal traits that contributes to improving the seismic performance of buildings. It refers to reaching a balanced distribution of mass and stiffness around unique axes within the constructing, whether or not these axes are horizontal or vertical. Symmetry can be found out while a constructing famous a similar configuration on both facets of one or greater axes, ensuing in an equitable distribution of architectural and structural elements.

Symmetry is without delay related to the constructing's conduct all through earthquakes Figure (4), because it helps reduce discrepancies among the center of mass and the middle of stiffness, thereby limiting torsional consequences Figure (5), which can be some of the maximum critical phenomena affecting building reaction. The higher the level of symmetry, the greater balanced the switch of seismic forces, and the decrease the likelihood of irregular deformations or pressure concentrations. Conversely, the absence of symmetry (asymmetry) results in an uneven distribution of mass and stiffness, producing variations within the response of different constructing elements. This results in torsional rotations around the vertical axis, which make bigger displacements in a few regions as compared to others. Consequently, this situation poses more risk in excessive-upward thrust or complexly configured buildings, wherein dynamic responses grow to be greater touchy to geometric imbalances[8].

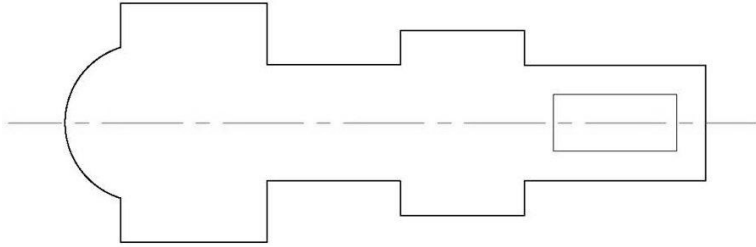


Figure (4) Illustrates a schematic of a hypothetical constructing this is symmetric about a unmarried axis, displaying a balanced distribution of mass and structural elements. This symmetry outcomes in a uniform seismic response and reduces displacement differences among various elements of the building. Source: Prepared through the author.

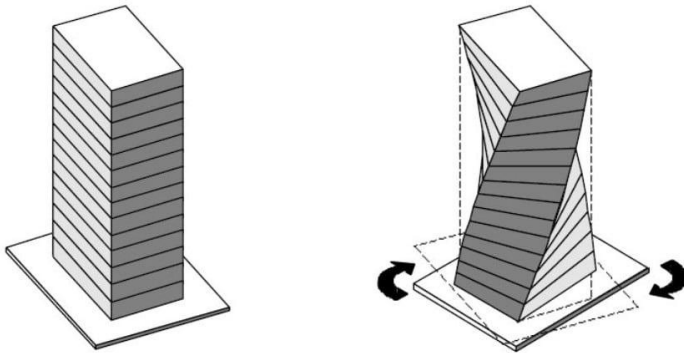


Figure (5) Illustrates the phenomenon of torsional rotation attributable to asymmetry, wherein the constructing rotates around its vertical axis because of unbalanced forces, increasing the chance of harm on the extremities. Source[8].

From the analysis of the above figures, it is able to be concluded that symmetry performs a fundamental function in attaining a balanced distribution of mass and stiffness within a constructing, thereby decreasing discrepancies between the center of mass and the center of stiffness and mitigating torsional results during earthquakes. Symmetry helps unify the response of various constructing elements and minimizes abnormal deformations, which complements structural stability and



makes the dynamic behavior more predictable. Accordingly, symmetry is taken into consideration one of the key design ideas for lowering seismic risks and enhancing the overall efficiency of constructing overall performance.

4.2 Simplicity

Simplicity is one of the essential design standards that at once influences the seismic overall performance of high-upward push homes. It refers to adopting clean and straightforward formal configurations characterised by way of geometric regularity and the avoidance of unnecessary complexity or overlapping paperwork. Simplicity is frequently embodied in ordinary shapes together with rectangles and squares, which allow for a balanced distribution of mass and stiffness[2].

The significance of simplicity lies in its contribution to attaining clearer and greater predictable structural conduct in the course of earthquakes, as it facilitates the transfer of seismic hundreds thru ordinary and direct load paths, decreasing the likelihood of stress concentrations or localized deformations. Simple bureaucracy Figure (6), additionally lessen analytical complexities in dynamic modeling and permit extra efficient structural detail layout. In contrast, complicated architectural forms—which includes damaged or irregular plans (L-, U-, or T-formed)— Figure (7), bring about heterogeneous seismic behavior, causing interruptions in load paths and producing susceptible zones due to uneven distribution of mass and stiffness, which increases the probability of cracking or partial crumble. Furthermore, formal complexity is regularly related to torsional effects and abnormal deformations, specially when the form isn't like minded with the structural device [11].

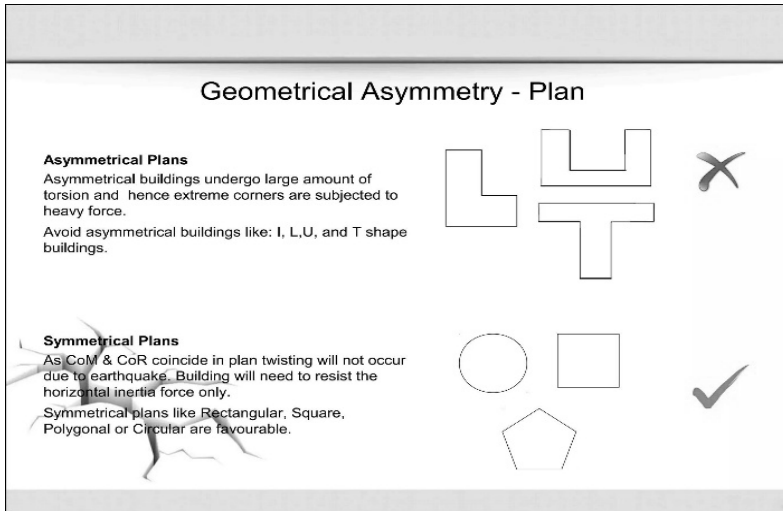


Figure (6) Gives a schematic illustrating the distinction between simple bureaucracy (square or square) and complex or composite paperwork (L-, T-, U-shaped), which result in heterogeneous seismic conduct. Source[9].

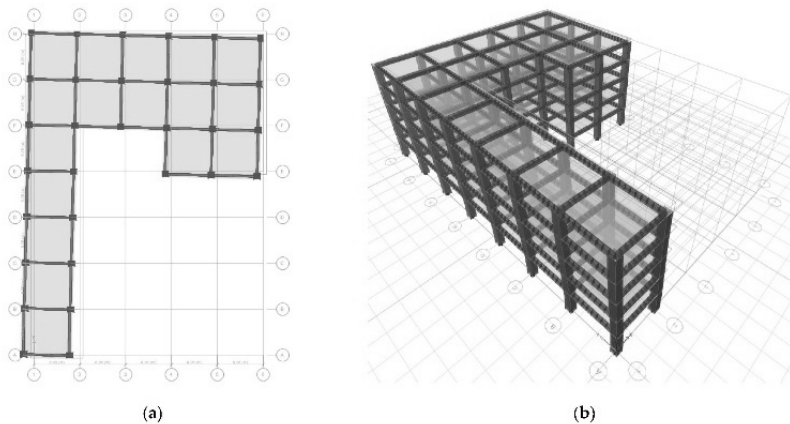


Figure (7) Illustrates a building with a complex and abnormal form, where corners and offsets disrupt the burden paths, leading to stress concentrations and an expanded probability of harm. Source[2].

Analysis of the above figures suggests that simplicity in architectural configuration without delay contributes to improving seismic performance by imparting clarity and regularity in load paths and decreasing formal complexities that may reason interruptions or stress concentrations. Simple and compact forms assist distribute hundreds evenly and reduce the likelihood of localized deformations or partial collapses. Therefore, adopting simplicity as a design technique is an vital factor in improving building stability and increasing its performance in resisting seismic loads.

4.3 Continuity

Continuity is one of the fundamental elements in reaching seismic performance in excessive-upward thrust homes, as it is immediately related to the structural gadget's capacity to switch seismic loads in a continuous and regular way through its various additives Figure (8). Continuity refers to making sure the mixing and connectivity of vertical and horizontal factors inside a unified structural device, forming clear load paths that begin from the points of load application at the pinnacle of the constructing and extend down to the foundations without interruption or unexpected changes in path[12].

The importance of continuity lies in its potential to reduce complexities inside the building's dynamic conduct throughout earthquakes. Systems with excessive continuity show off a extra uniform reaction, with evenly allotted forces and displacements, minimizing the chance of vulnerable zones or stress concentrations. Continuity additionally enhances the included overall performance of various structural factors, which includes columns, shear walls, and frames, permitting them to act as a unmarried unit to face up to lateral hundreds. In contrast, discontinuities disrupt load paths, representing one of the maximum crucial reasons

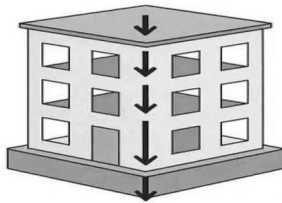
of seismic failure. Such discontinuities may additionally rise up from gentle testimonies, abrupt changes in element dimensions, architectural setbacks, or loss of continuity in shear partitions alongside the constructing height Figure (9). These interruptions make bigger interstory drifts and pay attention deformations in unique regions, growing the chance of partial or total fall apart[8].

Therefore, reaching continuity isn't always restrained to the structural element alone however calls for near integration with architectural choices within the early design stages to make sure compatibility among the architectural form and the structural machine, thereby ach

What is a Load Path?

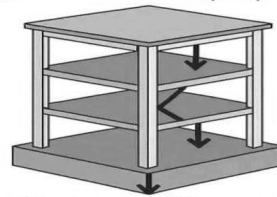
A load path is the route that structural loads (weight) follow as they move from the top of the building down to the foundation and into the ground.

Vertical Load Path



Roof & Floor Loads
Slabs & Beams
Columns & Walls
Foundation
Soil/Ground

Lateral Load Path (for wind & earthquake)



Diaphragms (floor slabs or roof slabs) transfer to vertical elements
Shear walls / Bracing / Frames
Foundation system

Why is it important?

- Ensures safety & stability, avoid unexpected failure, helps design efficient structural systems

Figure (8) Illustrates the distinction between seismic load transfer thru a non-stop path from the pinnacle of the building to the principles, where forces are progressively disbursed across structural elements—representing the ideal case of continuity—and the case of misplaced continuity, wherein one story is much less stiff than the others, causing localized deformation and growing the chance of disintegrate. This is among the most commonplace reasons of seismic failure[8].

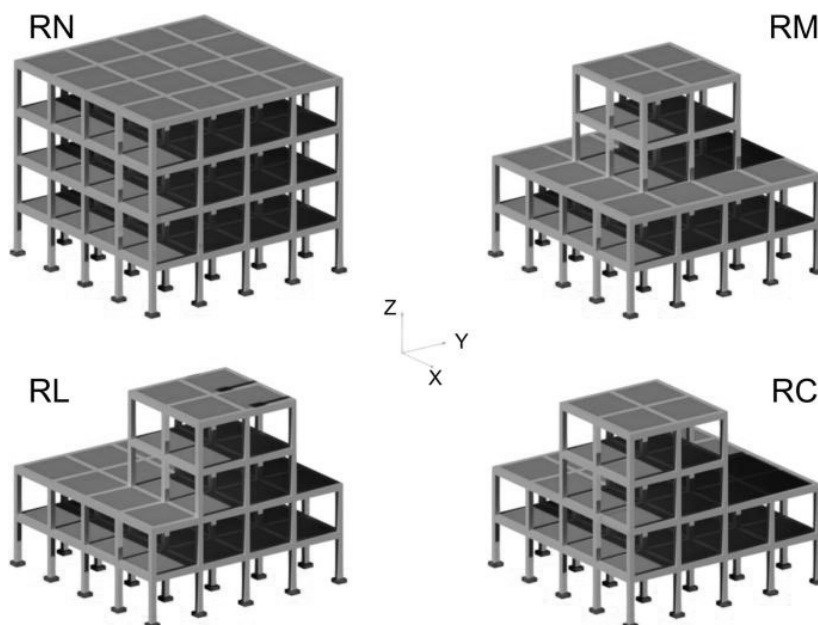


Figure (9) Illustrates the effect of geometric discontinuities in a constructing, wherein surprising adjustments in form regulate the burden paths and concentrate stresses in particular regions, thereby compromising seismic resistance performance[10].

In end, continuity represents a critical issue in reaching balanced seismic performance, because it ensures ordinary load transfer and minimizes localized deformations. Conversely, its absence disrupts structural response and increases the chance of failure, underscoring the necessity of integrating continuity with architectural layout choices from the early stages.

4.4 Slenderness

Slenderness is one of the fundamental geometric characteristics that without delay have an effect on the dynamic conduct of homes, specially excessive-upward push residential structures. It expresses the ratio among the constructing's height and its horizontal dimensions; as this ratio increases, the



effect of lateral forces, which include seismic loads, at the building's reaction additionally will increase.

The importance of slenderness lies in its control over the constructing's flexibility and vibration susceptibility. Slender homes have a tendency to show off longer natural periods, which amplifies lateral displacements and interstory drifts. While this pliability might also help dissipate some seismic strength, it can concurrently result in immoderate deformations, affecting the integrity of non-structural factors and person comfort. Moreover, expanded slenderness amplifies $P-\Delta$ effects, as inner forces due to lateral displacements grow, doubtlessly causing slow instability in the structural machine. Slender buildings also are extra touchy to irregularities or asymmetry, complicating their seismic response. Conversely, decreasing slenderness with the aid of growing the building's width or using efficient structural structures (together with shear walls or tube structures) complements lateral stiffness, minimizes displacements, and achieves a higher balance among stiffness and flexibility. Therefore, controlling the slenderness ratio is a critical layout selection that requires specific coordination between architectural and structural factors to make sure secure and powerful seismic performance[2]. Figure (10) illustrates the overall behavior of a slender building during earthquakes and how lateral drift is distributed among the floors. Lateral displacements increase noticeably due to the high height-to-width ratio of the building, reflecting greater flexibility and sensitivity to lateral loads, as well as a longer natural vibration period, which may lead to deformations in non-structural elements[8].

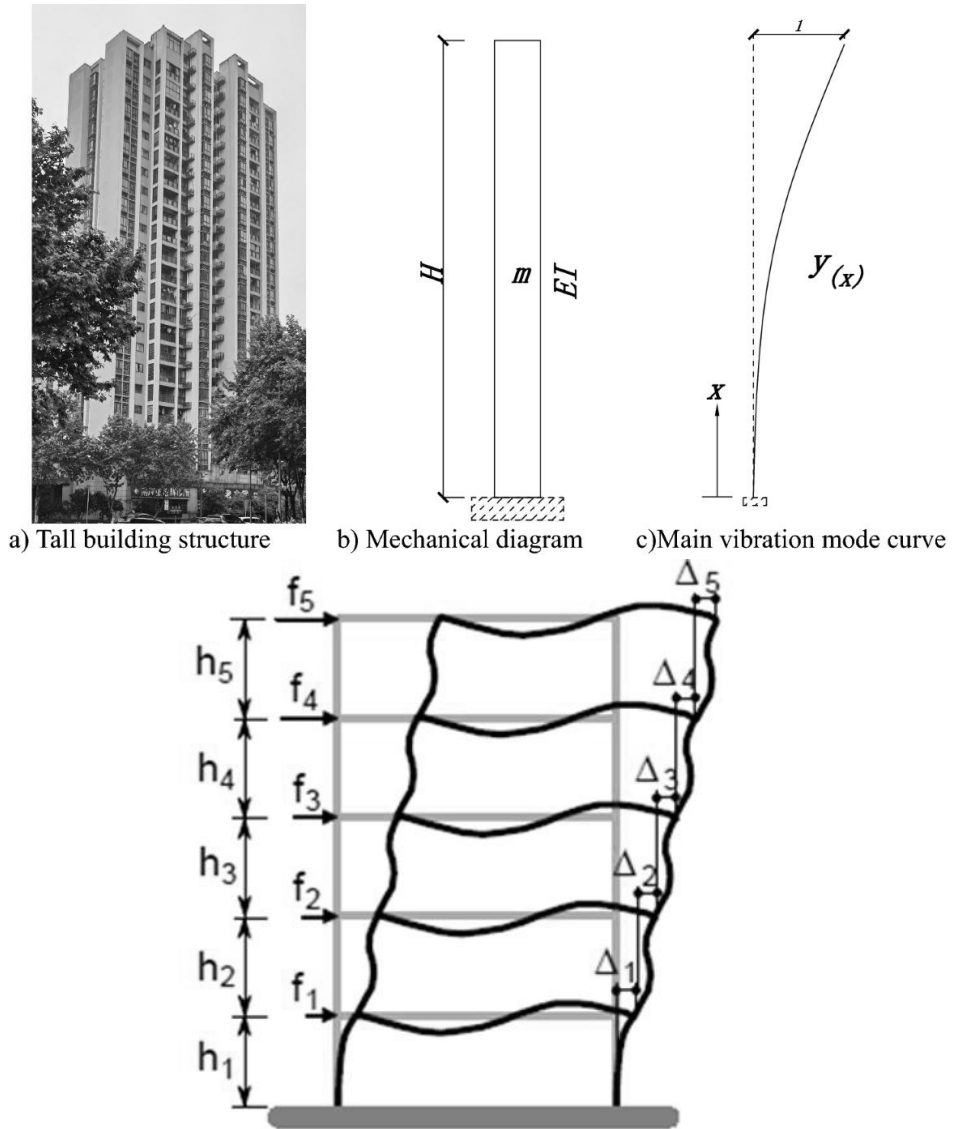


Figure (10) Shows the behavior of a slender building during earthquakes. Source: Researcher.

It is clear that slenderness is a noticeably influential thing in figuring out the seismic reaction of buildings. An increase in slenderness amplifies lateral displacements and deformations, as well as magnifies instability consequences, necessitating cautious



architectural and structural design interventions. Therefore, achieving a properly-taken into consideration balance within the slenderness ratio is essential to make certain secure seismic overall performance, especially in high-upward thrust homes.

5. The Applied Framework of the Research

This section goals to assess the performance of the architectural form of decided on excessive-upward push residential buildings in Baghdad, particularly (the Garden City Residential Towers, the Al-Fakher Residential Towers, and the Downtown Towers), by way of making use of the formal layout factors and linking them to the predicted seismic overall performance signs. An analytical technique become followed, specializing in deciphering the connection among architectural characteristics and structural conduct below lateral masses.

The applied framework is primarily based at the hypothesis that systematically using formal design factors complements the building's seismic response and reduces the damaging outcomes of lateral forces. Accordingly, 5 key layout elements representing the middle of the formal components were adopted: Regularity, Symmetry, Simplicity, Continuity, and Slenderness. Each element could be analyzed inside its realistic context inside the decided on models, as follows:

First: Garden City Towers

The Garden City Towers are located in Baghdad's Al-Alawi place inside a cutting-edge residential complicated Figure (11). They characteristic a present day layout primarily based on notably repetitive vertical blocks, with contemporary architectural treatment of the facades.

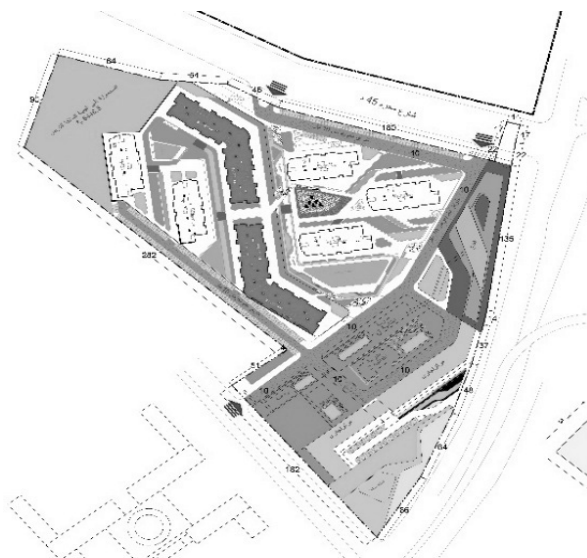


Figure (11) Illustrates the site plan of the Garden City Towers [13].

Analysis of the architectural shape of the Garden City Towers indicates that the structural system relies on easy geometric configurations with a rather regular distribution of mass and stiffness, contributing to a reduction in dynamic reaction irregularities. The horizontal and vertical regularity on this model enables limit differential go with the flow and enhances the efficiency of seismic load transfer thru the structural factors.

However, symmetry is not completely performed, as a few facades showcase partial versions in architectural treatment, which may additionally generate torsional moments due to misalignment among the middle of mass and the middle of stiffness. Continuity in the structural load direction is moderate, given the presence of certain interruptions within the façade format, which can have an effect on the performance of load switch.

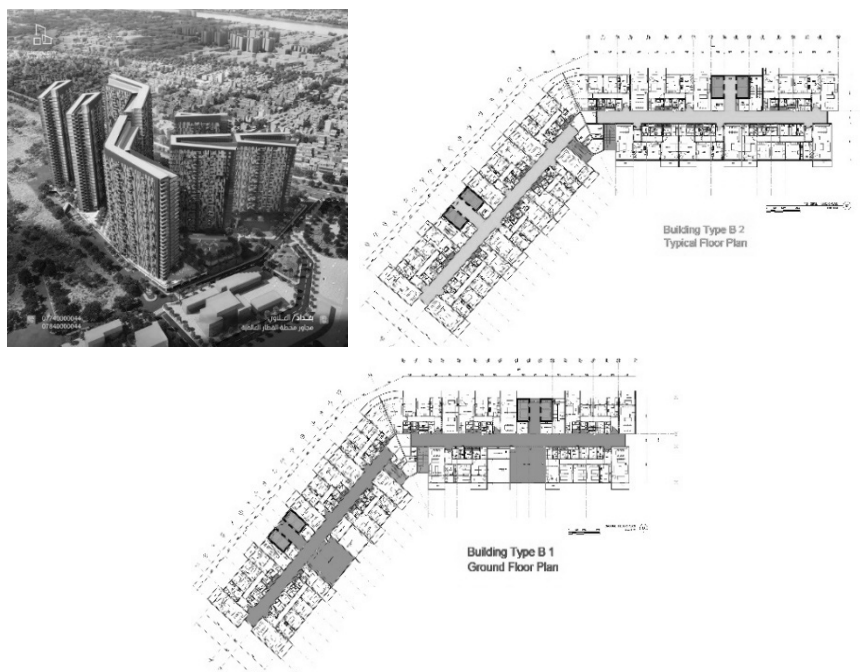


Figure (12) Illustrates the ground floor and typical floor plans of one of the Garden City Towers, along with the exterior view of the residential complex [13].

Based on the above images and plans in Figure (12), the formal layout factors of this pattern will be evaluated to evaluate the effectiveness of its seismic performance, as follows:

Table (2) Shows the evaluation of the formal dimension items for the First sample.

Source: Researcher

Se.	Element	Evaluation	Interpretation
1	Regularity	middle	Some variations in mass are present.
2	Simplicity	weak	The form and interfaces are complex.
3	Continuity	middle	Partial continuity in elements is lacking.
4	Slenderness	High	There is a significant height compared to the width.
5	Symmetry	weak	A clear asymmetry in the composition is evident.

From the Table (2), the seismic performance of this sample may be categorised as exceptionally exact, as the simplicity and partial symmetry make amends for the weaknesses resulting from the shortage of complete symmetry.

Secondly: Al-Fakher Residential Towers

Al-Fakher Residential Towers are placed within the Al-Qadisiyah location of Baghdad and represent one of the city's distinguished excessive-upward thrust residential tasks Figure (13), comprising several towers exceeding fifty flooring. The fairly open web site with river perspectives topics the towers to high lateral hundreds, whether or not from wind or seismic forces, making the architectural configuration a important issue in figuring out structural performance performance.

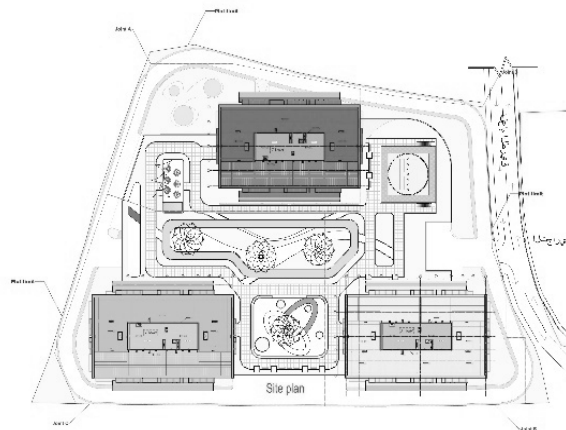


Figure (13) Illustrates the site plan of Al-Fakher Towers [14].

The morphological evaluation suggests that the challenge is based on a multi-block system, wherein the towers encompass slim vertical blocks repeated ground by means of floor, with outstanding variant in the façade treatment via projections, recesses, and special arrangements of balconies and openings.

Symmetry isn't fully done within the towers, inflicting a deviation between the center of mass and the center of stiffness, which generates torsional moments adversely affecting seismic response. Furthermore, the configuration famous a high degree of complexity, lowering the clarity of load paths and growing the likelihood of stress awareness. Regarding continuity, it is only partly realized due to interruptions inside the façade layout. As for slenderness, the high-rise towers' top-to-width ratio increases the constructing's sensitivity to lateral loads and amplifies lateral displacements, mainly in the absence of a regular geometric configuration.

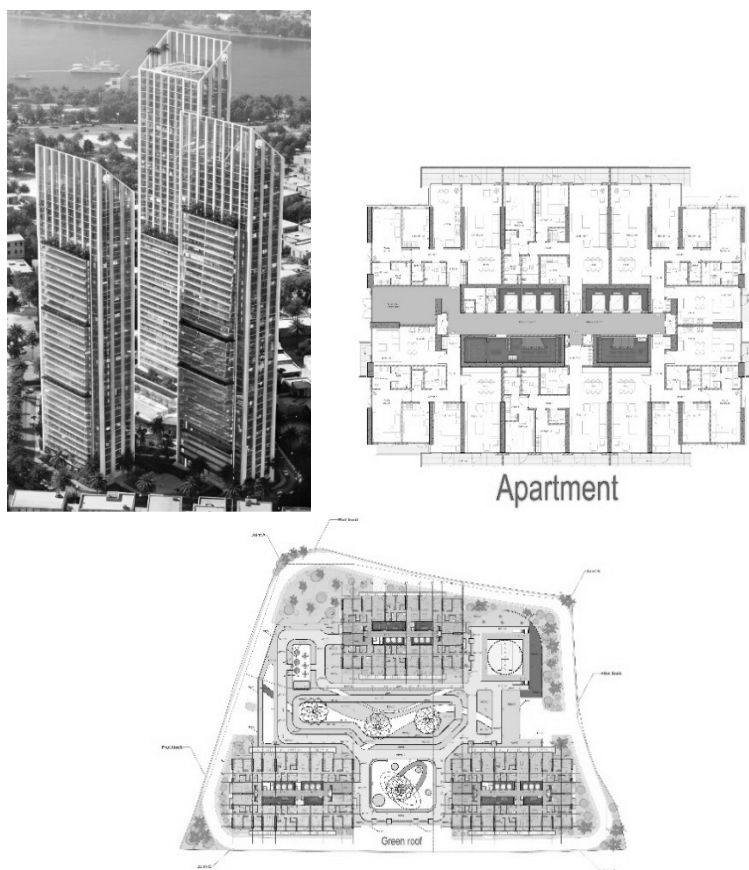


Figure (14) illustrates the ground floor and typical floor plans of one of the Al-Fakher Residential Towers, along with the exterior view of the residential complex [14].

Based on the above photographs and plans in Figure (14), the formal layout elements of this sample may be evaluated to decide the effectiveness of its seismic overall performance, as follows:

Table (3) shows the evaluation of the formal dimension items for the Secondly sample.
Source: Researcher

Se.	Element	Evaluation	Interpretation
1	Regularity	High	Uniform distribution of mass and height
2	Simplicity	middle	Some variation without excessive complexity
3	Continuity	High	Clear continuity in elements
4	Slenderness	middle	Balanced proportions
5	Symmetry	High	Clear symmetry around the axes

From the Table3)), concluded that the predicted seismic performance of those towers levels from slight to enormously susceptible from a morphological perspective. This suggests that counting on complicated architectural remedies with out systematically controlling formal design elements ends in increased structural needs and decreased seismic performance. This case also highlights the importance of early integration among architectural and structural layout to achieve a stability between formal expression and structural overall performance in excessive-rise residential buildings.

Third: Downtown Towers

Downtown Towers are placed in Baghdad within a enormously modern urban context (Figure 15). The task includes a collection of residential towers with similar heights, characterised by means of highly everyday geometric configurations, predominantly square in shape, with clean repetition of floor layouts meditated in the regularity of the façades.



Figure (15) illustrates the site plan of the Downtown Towers [15].

Morphological analysis suggests that the towers attain a excessive diploma of regularity, both horizontally and vertically, as mass and stiffness are distributed continually the building top, with out a abrupt modifications in dimensions or spatial configuration. This regularity without delay contributes to a greater balanced seismic reaction. In phrases of symmetry, the towers showcase relative symmetry alongside their essential axes, which helps reduce discrepancies among the center of mass and the center of stiffness. Consequently, torsional moments induced by lateral loads are minimized, that is a key fantastic aspect in enhancing seismic overall performance.



Figure (16) Shows the exterior view of the Downtown Towers [15].



Regarding simplicity, the overall configuration demonstrates a great level of readability, with façade treatments constrained to minor and non-abrupt variations, inclusive of moderate projections or diffused differences in beginning preparations, with out reaching a high stage of formal complexity. This simplicity contributes to clearer load paths within the structural system and decreases irregular deformations for the duration of dynamic response. As for continuity, it is honestly performed, with vertical factors extending always from the base to the pinnacle without primary interruptions, and the repetition of floors retaining the integrity of the structural gadget. Based on the exterior images of the complex Figure (16), the formal design elements of this sample will be evaluated to determine the effectiveness of its seismic performance, as follows:

Table (4) shows the evaluation of the formal dimension items for the third sample.
Source: Researcher

Se.	Element	Evaluation	Interpretation
1	Regularity	middle	Some variations in mass are present.
2	Simplicity	middle	Some variation without significant complexity is observed.
3	Continuity	High	Clear continuity in elements is evident.
4	Slenderness	High	A considerable height compared to width is present.
5	Symmetry	weak	Clear asymmetry in composition is apparent.

From the Table (4), it could be concluded that the architectural configuration of the Downtown Towers has a tendency closer to regularity and readability in place of complicated architectural expression, which undoubtedly reflects on seismic overall performance. The combination of regularity, relative symmetry, simplicity, and continuity reduces terrible outcomes including torsion, irregular displacements, and pressure concentrations. Accordingly, the predicted seismic performance of these towers may be categorised as top to excellent from a morphological perspective.



6. Conclusions - Results

6.1 Theoretical Findings and Conclusions

- The formal measurement represents one of the most essential pillars in improving the seismic overall performance of excessive-upward thrust buildings, because the traits of architectural shape immediately influence the nature of structural reaction.
- Studies have proven that regularity in architectural configuration, horizontally or vertically, contributes to achieving a balanced distribution of seismic forces and decreases pressure concentrations, main to a more solid response. In contrast, irregularity amplifies dynamic reaction and will increase the chance of localized damage.
- The literature indicates that symmetry performs a key function in reducing torsional moments by minimizing the space between the center of mass and the center of stiffness, whereas asymmetry leads to unbalanced responses that growth the risk of structural failure.
- Studies highlight the importance of simplicity in improving the clarity of load paths inside the structural system, as simple forms are related to greater predictable structural behavior, unlike complex configurations which growth uncertainty in overall performance.
- The literature confirms that continuity in vertical and horizontal elements is critical for ensuring efficient load switch, at the same time as surprising discontinuities create vital zones. Slenderness, alternatively, has been identified as a main thing in increasing lateral displacements and amplifying dynamic response, particularly in excessive-upward push buildings, therefore requiring careful design treatment.



6.2 Applied Findings and Conclusions

- The analysis showed that towers with clean formal regularity (consisting of Downtown Towers) attain higher performance due to the balanced distribution of mass and stiffness, whereas towers with abnormal configurations (inclusive of a few instances of Al-Fakher Towers) exhibit extra complex responses.
- Asymmetry in a few fashions brought about the generation of torsional moments, negatively affecting performance performance, whilst relative symmetry in other models contributed to a more strong response.
- The applied outcomes verified that towers characterized via formal simplicity and clear architectural configuration provide extra everyday load paths, undoubtedly influencing structural conduct. In evaluation, formal complexity elevated the chance of strain concentration. Continuity in vertical elements and universal configuration became discovered to beautify load switch efficiency, while interruptions and sudden الشكل modifications weakened performance.
- Slenderness truly emerged as an influential component, as more narrow towers have been related to accelerated lateral displacements, necessitating supportive design answers.



References

- [1] Ching, F. D. K. (2014). *Architecture: Form, Space, and Order* (4th ed.). Hoboken, NJ: John Wiley & Sons.
- [2] Taranath, B. S. (2016). *Structural Analysis and Design of Tall Buildings: Steel and Composite Construction* (2nd ed.). Boca Raton, FL: CRC Press.
<https://www.routledge.com/Structural-Analysis-and-Design-of-Tall-Buildings-Steel-and-Composite/Taranath/p/book/9781439804803>
- [3] Charleson, A. W. (2008). *Seismic Design for Architects: Outwitting the Quake*. Oxford, UK: Architectural Press (Elsevier).
<https://www.elsevier.com/books/seismic-design-for-architects/charleson/978-0-7506-8558-7>
- [4] Krawinkler, H., & Miranda, E. (2018). Performance-Based Earthquake Engineering. In: Bozorgnia, Y., & Bertero, V. V. (Eds.), *Earthquake Engineering: From Engineering Seismology to Performance-Based Engineering*. Boca Raton, FL: CRC Press.
- [5] Kramer, S. L. (2019). *Geotechnical Earthquake Engineering*. Upper Saddle River, NJ: Pearson Education.
- [6] Mahdaveinejad, M., Nikghadam, H., & Pour Rahimian, F. (2013). Architectural Design Strategies for Earthquake-Resistant Buildings. *International Journal of Architecture and Urban Development*, 3(3), 29–36.
- [7] ASCE (2016). *Minimum Design Loads and Associated Criteria for Buildings and Other Structures* (ASCE/SEI 7-16). Reston, VA: American Society of Civil Engineers.
<https://ascelibrary.org/doi/book/10.1061/9780784414248>
- [8] Chopra, A. K. (2017). *Dynamics of Structures: Theory and Applications to Earthquake Engineering*, 5th Edition.
- [9] FEMA 450 (2013). *NEHRP Recommended Provisions for Seismic Regulations for New Buildings and Other Structures*.
- [10] Paulay, T., & Priestley, M. J. N. (2015). *Seismic Design of Reinforced Concrete and Masonry Buildings* (2nd ed.).
- [11] Alecci, V., & De Stefano, M. (2018). Building irregularity issues and architectural design in seismic areas. *Fracture and Structural Integrity*, 13(47), 161–168.
<https://www.fracturae.com/index.php/fis/article/view/2176>
- [12] Tirado-Gutiérrez, R. J., *et al.* (2025). The importance of structural configuration in seismic performance. *Infrastructures*, 10(12), 325.
- [13] Garden City Residential Complex Management. info.gcb@halabjagroup.com
- [14] Al-Fakher Residential Complex Management. <https://alfakhertowers.com/ar.html>
- [15] Downtown Residential Complex Management. <https://homele.com/ar/projects/downtown-baghdad-382>