Civil Engineering and Architecture 11(3): 1606-1615, 2023 http://www.hrpub.org
DOI: 10.13189/cea.2023.110339

Review on Supertall Building Forms

Hüseyin Emre Ilgın

School of Architecture, Faculty of Built Environment, Tampere University, P.O. Box 600, FI–33014 Tampere, Finland

Received January 1, 2023; Revised February 13, 2023; Accepted March 12, 2023

Cite This Paper in the Following Citation Styles

(a): *[1] Hüseyin Emre Ilgın , "Review on Supertall Building Forms," Civil Engineering and Architecture, Vol. 11, No. 3, pp. 1606 - 1615, 2023. DOI: 10.13189/cea.2023.110339.*

(b): *Hüseyin Emre Ilgın (2023). Review on Supertall Building Forms. Civil Engineering and Architecture, 11(3), 1606 - 1615. DOI: 10.13189/cea.2023.110339.*

Abstract To date, few studies have provided an understanding of the interrelations between forms and key design parameters in supertall towers (equal to or higher than 300 m). This vital topic was examined through data collected from 140 supertall cases, considering height, location, function, load-bearing system, and material as the main parameters. Key findings of the paper highlighted the following: (i) in 300-399 m high towers, mostly prismatic, setback, tapered, and free forms were used; (ii) tapered forms were generally preferred in Asia, while the prevalence of prismatic and free forms was noted in the Middle East; (iii) while tapered form was preferred most in mixed-use function, office towers were generally built in free form; (iv) prismatic and tapered forms were generally utilized in supertall cases with tube system, whereas tapered and free forms were utilized more in towers with outriggered frame system; (v) while reinforced concrete was commonly used in prismatic and setback towers, tapered and free tower forms were mostly built in composite. This paper is considered to be an initial guideline for key project and construction stakeholders.

Keywords Supertall Building, Form, Height, Location, Building Function, Structural System, Material

1. Introduction

Architectural forms of tall buildings, often conceived as box-shaped commercial spaces in the early 1900s, have undergone significant changes since the 1950s to meet the growing demand for iconic towers [1]. The rising trend of urbanization [2,3], combined with the race to become the tallest tower and symbol of the city, has contributed greatly to the construction of supertall towers that have gained momentum all over the world [4] as in Central Park Tower and The Exchange 106. Moreover, according to the 'Council on Tall Buildings and Urban Habitat' database, there are more than 100 supertall towers currently under construction [5].

Furthermore, especially in the Middle East and the Far East, skyscrapers are becoming an even more indispensable component of urbanization to create a skyline, cultural identity, or reputation [6]. Thus, at the global level, the growing interest in supertall buildings has led to an increase in research focusing on the parameters such as form, load-bearing system, wind load as well as space efficiency (e.g. [7-10]). These inputs are important in the planning and construction of these gigantic investments.

Thanks to the widespread use of computer technologies and digital tools in architectural modeling, as well as advanced structural analysis, new design, and construction methods, today's supertall towers can be built with challenging architectural and structural design solutions and complex forms.

In a supertall building design, the choice of the building form is critical as it affects many other important parameters (e.g., structural efficiency, aerodynamic efficiency, energy efficiency) that make the project viable [12,13]. In supertall buildings, the load-bearing systems cannot be designed independently without taking into account the building form [14]. In addition, some forms, such as tapered forms, show better structural efficiency than others [15]. Tapered forms with this feature are well-known in supertall building design and have been used in many towers around the world [16]. Similarly, lateral displacements due to gravitational forces increase with tilt angle, which is considered a structural disadvantage of tilted forms [17].

In terms of aerodynamic efficiency, twisted and free forms often outperform equivalent prismatic forms as these forms can reduce building sway by disrupting the vortex [18,19]. Regarding sustainability, certain building forms are naturally more effective than other forms, at this point, compact forms come to the fore [20]. Additionally, building forms can be optimized in terms of environmental performance, for example, to reduce solar radiation [21] or to increase energy efficiency [22].

There are few studies in the literature examining the relationship between the building form and the key planning considerations. Among these papers, Vollers [23] focused on non-orthogonal tall buildings and proposed a morphological scheme that allows data on the environmental features of different forms. Elnimeiri and Almusaraf [24] examined the interrelation between structural effectiveness and the architectural form of high-rise towers. Alaghmandan et al. [25] studied structural and architectural evaluations of 73 supertall towers erected by the end of 2012 to forecast the potential trend in form and structural systems. Szolomicki and Golasz-Szolomicka [4] analyzed the architectural and structural approaches for tall buildings in the last ten years, focusing on geometric form, load-bearing systems, mechanical systems, and environmental features. Golasz-Szolomicka and Szolomicki [26] presented the construction features and design characteristics of high-rise towers with twisted forms. They concluded that the advancement of BIM systems, architectural styles, and sustainability were key drivers for evaluating advanced materials and construction methods. Ilgın et al. [27] explored the current advancements in key structural and architectural drivers and various interrelationships through more than 90 supertall cases to assist the designers as an introductory design guide. Ilgın and Gunel [28] examined aerodynamic concerns in architecture as current trends in skyscraper design. They highlighted the concept of ‘aerodynamically adaptive architectural form’ as one of the most efficient ways to realize wind-resistant design. While Ilgın [29] focused on the interrelatedness of structural systems and main planning concerns through more than 100 contemporary supertall towers, Ilgın [30] analyzed the interrelation of aspect ratio and key design parameters in modern skyscrapers.

The interrelations of supertall building forms and important design criteria were explored in this article using 140 supertall case studies. The parameters included tower height, location, function, load-bearing system, and structural material, to make more feasible design decisions for next-generation supertall buildings.

2. Materials and Methods

In this paper, case study method was used to collect and combine data on building cases to scrutinize the interrelations of building form and main planning concerns. These buildings were 140 cases from diverse spots [78 in Asia, 31 in the Middle East, 20 in North America, 7 in Russia, 2 in Australia, 1 in South America, and 1 in Europe].

In the study, the following considerations, which play a critical role in the design of skyscrapers and are associated with the form, were analyzed: (i) height; (ii) location; (iii) function; (iv) structural system; and (v) material.

Here, hotel, residence, and office were taken as the main functions in the design of skyscrapers, while their combinations were considered mixed-use. Supertall towers can be functionally categorized as single- and mixed-use. In this paper, supertall tower is equal to or taller than 300 m and megatall is a 600 m or taller building [3]. The core, structural system, and structural material classifications made by Ilgın [27] were employed in this paper (Figure 1).

Among the structural systems, it is worth noting that, mega core system consists of a mega core with much greater cross-sections than usual, continuing throughout the building height, mega column system, on the other hand, consist of mega columns or shear walls with much greater cross-sections than usual and continuing throughout the building height. Outriggered frame system consists of at least one-story-high outriggers added to shear-frame system. In tube system, (i) framed-tube consists of closely spaced exterior columns with spandrel beams on the building exterior; (ii) trussed-tube consists of perimeter columns with outer multi-story mega braces, and (iii) bundled-tube consists of a combination of multiple tubes. As an advanced shear wall system, buttressed core system consists of shear walls bracing the central structural core. Moreover, each of the supertall building structural systems can exceed 40-story efficiently and economically [19].

Core	**Structural system**
Central core • central • central split	Shear-frame system • shear trussed frame • shear walled frame
Atrium core • atrium • atrium split	Mega core system Mega column system Outriggered frame system
External core • attached • detached • partial split • full split	Tube system • framed-tube • trussed-tube • bundled-tube Buttressed core system
Peripheral core • partial peripheral • full peripheral • partial split • full split	**Structural material** Steel Reinforced concrete Composite

Figure 1. Core, structural system, and material classifications used in this study

In this study, the tripartite design approach was applied to supertall tower forms. This approach, which emerged at the end of the 19th century, consists of a base, tower/main body, and head/top [31-33]. The adaptation of this concept to today's supertall buildings such as Makkah Royal Clock Tower can be seen in Figure 2. Below are briefly discussed the three primary parts of the supertall tower when viewed vertically.

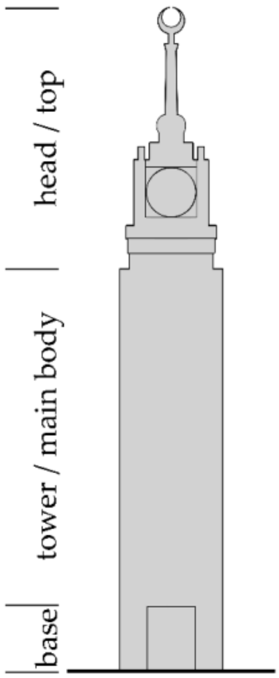


Figure 2. Typical supertall building section

Base: It can reach up to 10-story and mediates the relationship of the building with the urban environment, as it is the most perceived section from the street level. It has little impact on the urban features due to its low height. However, the scale of 'base' has a major impact on the definition of the street, the building's contextual quality, and the humanization of its image.

Tower/main body: It extends from the base of the building to the top. This section plays an important role in the perception of tower scale and the interface between structure and eco-environmental conditions.

Head/top: Created by the stylistic effects of both other building sections and urban silhouettes, this part has little effect on the ecological characteristics of the tower compared to the 'main body' part. However, it has a great impact on the identity of the supertall building. In this paper, building form classification (Figure 3) is based on the 'main body' pattern [34,35].

3. Results: Interrelations of Building Form and Key Design Parameters

Interrelationships of building form and main design concerns associated with it, tower height, location, function, structural system, and material were explored below. As the most prevalent core typology in the case studies was central core, no analysis was performed on it.

3.1. Interrelation of Building Form and Height

As seen in Figure 4, the bars show the total number of towers (right axis) by building form, whereas dots represent the towers' heights in this form (left axis).

As shown in Figure 4, according to the study group, prismatic forms predominantly (>80%) occurred in the height range of 300-399 m, while setback forms were largely used in towers with a height range of 300-399 m and 400-499 m.

Similarly, tapered forms, the most common forms, generally (>55%) occurred in the height range of 300-399 m, and in this group, only Suzhou Zhongnan Center could exceed the megatall height limit.

The two towers built with twisted form, which was the most rarely used building form (only 4 cases), also surpassed the megatall heights. The free form, which was used in the tallest building of the sample group by far, was mostly preferred in towers with a height of 300-399 m.

As a result, it is noteworthy that all building forms push the height limits as shown in Figure 4. Also, considering that Burj Khalifa, the world's tallest building, was built in a setback form, the aerodynamic superiority of this form can be emphasized.

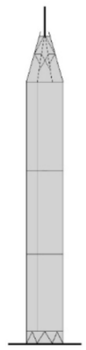
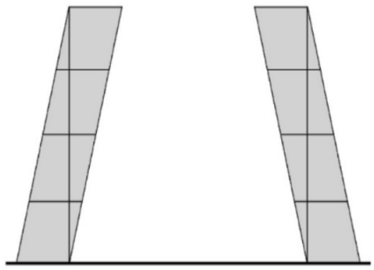
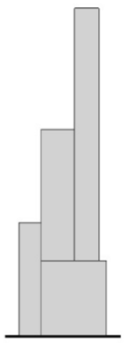
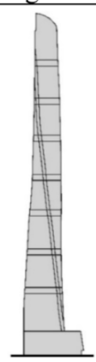
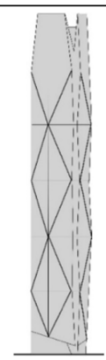
Prismatic	Leaning/tilted	Tapered
buildings whose two ends are similar, equal and parallel in shape, with the same sides and exactly perpendicular axes	buildings with inclined form	buildings with a tapering effect by reduced floor plans and surface areas with a linear or non-linear profile along the height
		
Setback	**Twisted**	**Free**
buildings with recessed horizontal sections along the height	buildings with floors or facades that gradually rotate as they multiply upward along an axis, entering a twist angle	buildings not in the previously mentioned forms
		

Figure 3. Supertall building forms

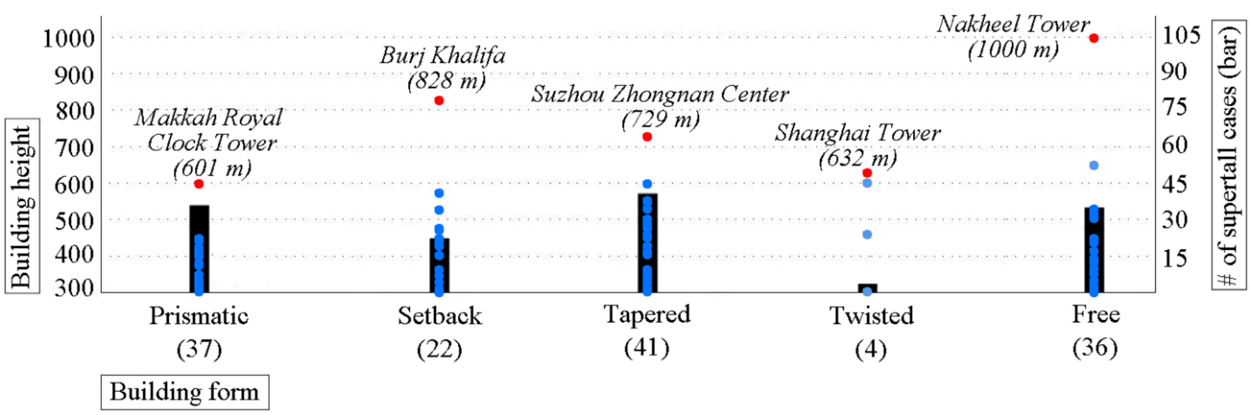
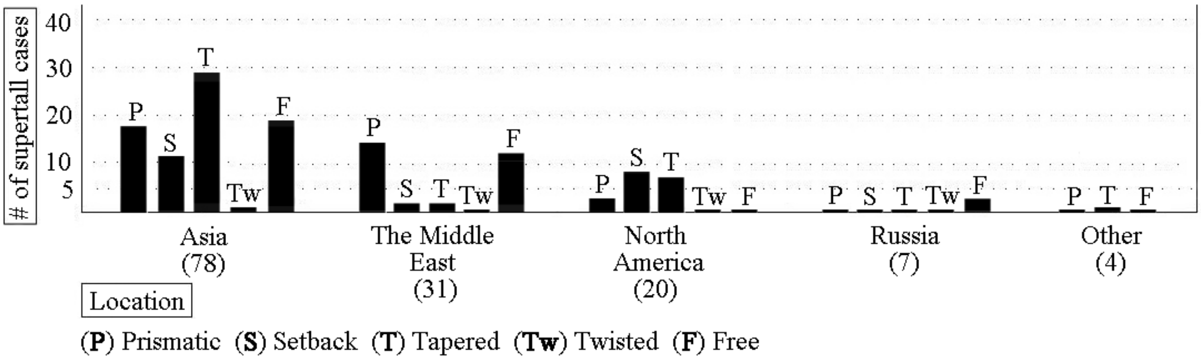


Figure 4. Interrelation of building form and height

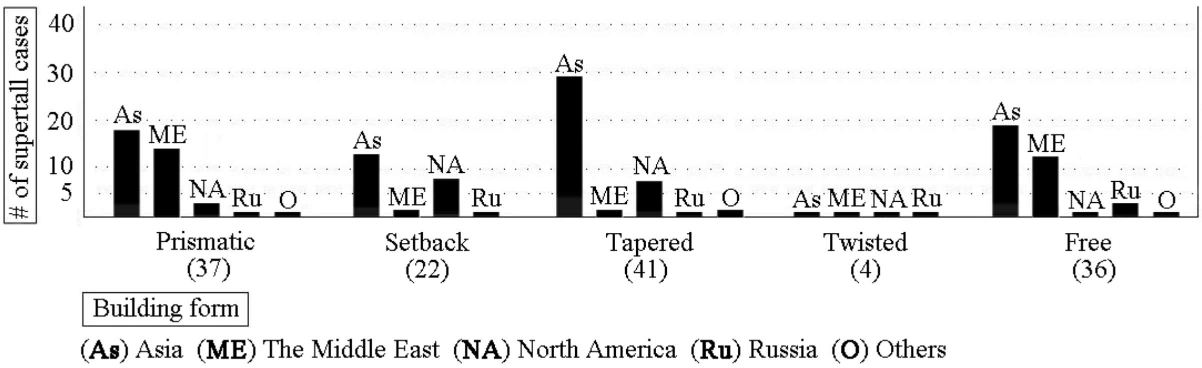
3.2. Interrelation of Building Form and Location

Figures 5a-b show the interrelation of building form and location. Tapered forms were generally used in Asia (37%), followed by free and prismatic forms. While the prevalence of prismatic and free forms was noted in the Middle East, setback and tapered forms were more preferred in supertall towers in North America.

Since the number of buildings in Russia and other countries in the case study sample was very small, it would probably not be appropriate to draw a correlation between the form of these buildings and their location.

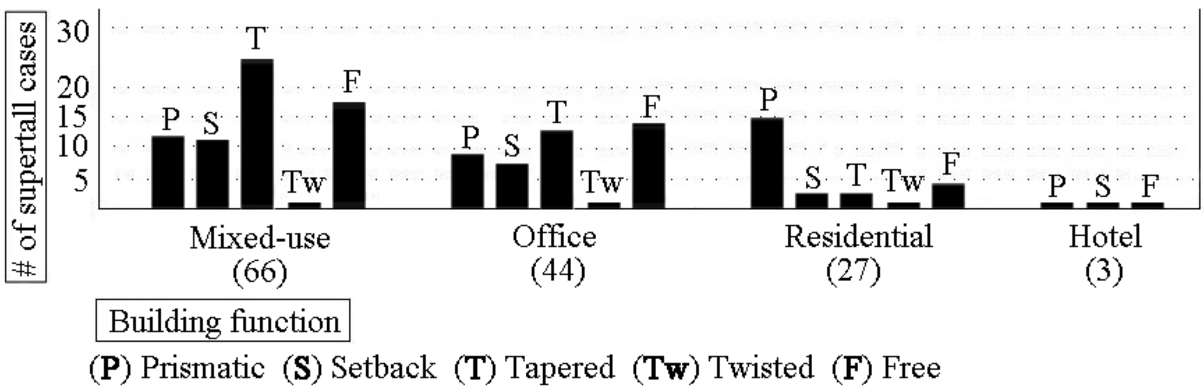


(a)

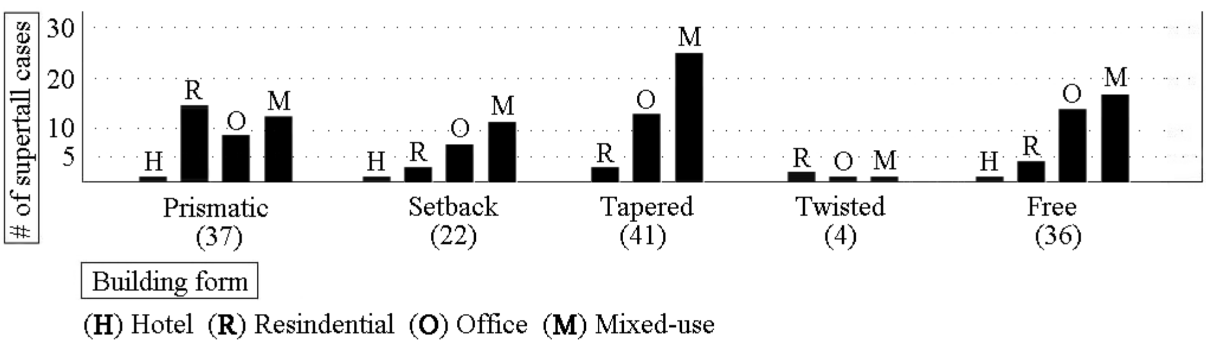


(b)

Figure 5. Interrelation of building form and location



(a)



(b)

Figure 6. Interrelation of building form and function

3.3. Interrelation of Building Form and Function

The usage of different tower forms for a particular function is compared in Figure 6a. Tapered form (38%) was the most preferred in mixed-use function, followed by free form with 26%. While office towers are generally built in free form (32%), more than half of the residential buildings in the sample group are in prismatic form. The reason why prismatic forms are widely used in residential areas may be the ease of workmanship, practicality, and efficient use of interior space compared to more complicated forms [36,37].

Figure 6b compares the use of other functions for a given form. While residential and mixed-use development occurred mostly in prismatic forms, mixed-use mainly came to the fore in tapered forms (61%). The fact that tapered form naturally can allow different lease spans may have made it more preferred for mixed-use supertall buildings. This can also be considered for setback forms, where mixed-use was the most common function (50%), followed by office use. Among free forms, mixed-use and office functions were most common at 47% and 39% respectively.

As the number of cases with twisted form and hotel function was very few, it would probably be inaccurate to form a correlation between the form and function of these towers.

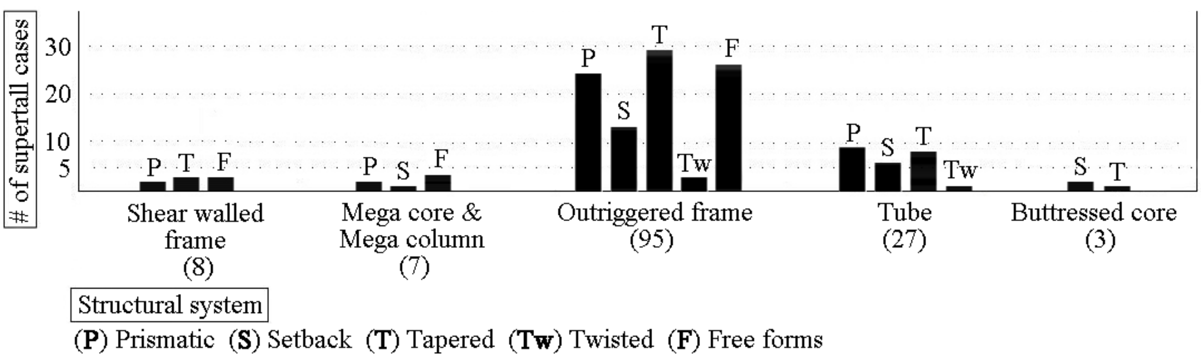
3.4. Interrelation of Building Form and Structural System

The usage of different building forms for a particular structural system is compared in Figure 7a. in the sample group, prismatic and tapered forms were mostly used in supertall towers built with tube systems, whereas tapered and free forms were utilized in buildings with outriggered frame systems.

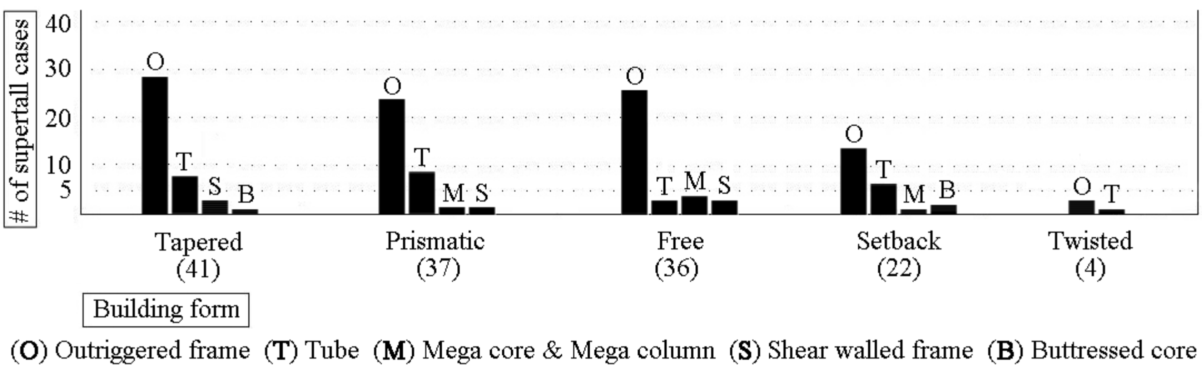
As the number of cases with shear walled frame, mega column & mega core, buttressed core systems as well as the twisted form was quite low, it seems unlikely to form a scientific correlation between the form of these towers and their structural system.

The dominance of outriggered frame systems, that is less preference for other structural systems, may be due to the advantages of outriggered frame systems such as minimizing the hindrance by large exterior structural components, and flexibility in the building envelope [27]. Additionally, the small occurrence of twisted forms can be caused by concerns about twisted structural system problems or construction difficulties [38].

The usage of different load-bearing systems for a particular form is compared in Figure 7b. Although the most popular structural system in all building forms was outriggered frame system, followed by the tube system excluding free form, the dominance of this system became more evident with a ratio of over 70%, particularly in tapered and free forms.

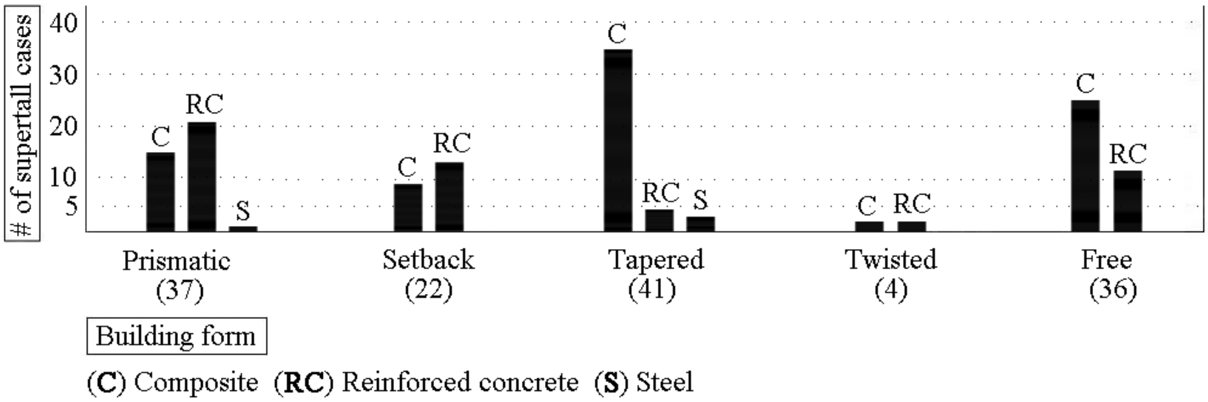


(a)

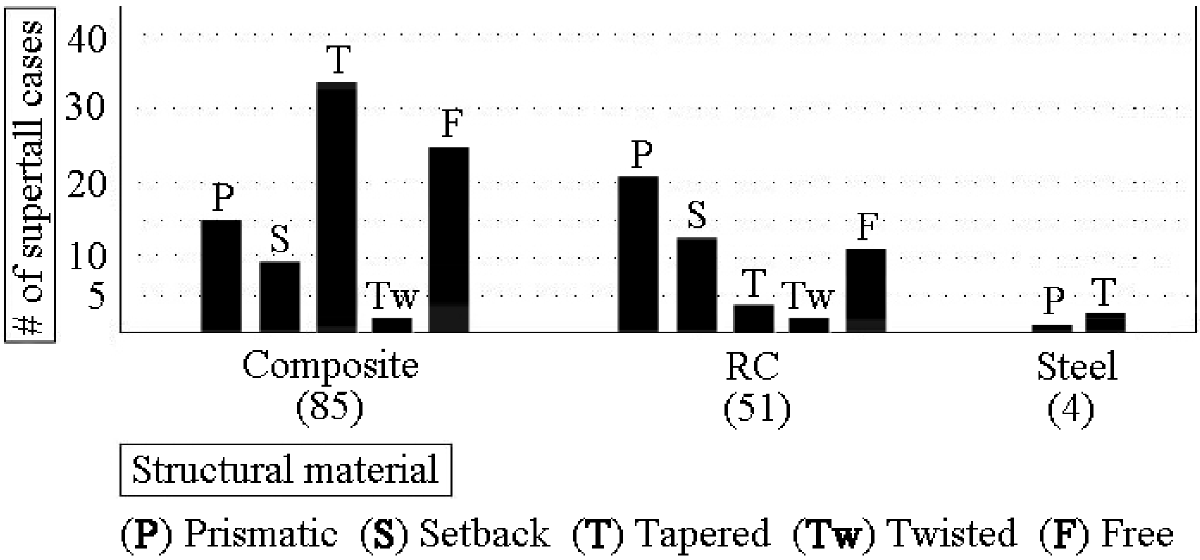


(b)

Figure 7. Interrelation of building form and structural system



(a)



(b)

Figure 8. Interrelation of building form and structural material

3.5. Interrelation of Building Form and Structural Material

Figures 8a-b show the interrelation of form and structural material. While the preference for concrete stood out in prismatic (57%) and setback (59%) towers, tapered (83%) and free (69%) forms were mostly built as composites (Figure 8a). Similar findings were obtained in Figure 8b.

Because the number of steel and twisted towers in the study group was very few, it would probably be incorrect to establish a relationship between the forms of these towers and their construction materials.

4. Discussion and Conclusions

Owing to the lack of literature, it was not likely to carry out a broad discussion that would present information about the similarities and dissimilarities between this study from other studies. Though, some findings in the article, such as the relationship between form and location, form and function, were supported by other studies on tall buildings in the literature, for example [16,39]. The 500 m limit was exceeded in both composite and reinforced concrete freeform towers. Also, due to the insufficient number of some supertall tower clusters (such as hotel buildings), it was hardly possible to form a scientific interrelationship between the planning considerations for building height.

On the interrelationships of the building forms and the major planning parameters associated with them, the paper examined tower height, location, function, structural system, and structural material.

Prismatic, setback, tapered, and free forms were mostly utilized in towers 300-399 m high. In addition, it was observed that all building forms exceeded the megatall threshold by forcing the height limits. It was remarkable that both towers, built with the twisted form, which is the least used building form, exceeded 600 meters. While tapered forms were generally preferred in Asia, the prevalence of prismatic and free forms was noted in the Middle East, and setback and tapered forms were more common in North America.

The finding regarding the prevalence of tapering form use in Asian countries might be associated with the result in Ho’s article [40]. Ho highlighted that many Asian towers, for example, TAIPEI 101 (Figure 9a), have a slightly tapered building shape, especially on their upper floors, because tapering has a considerable impact on the aerodynamic and structural behavior of the building. Similarly, Moon's article [41] on the technological responses and contextual effects of supertall buildings in Asia mentioned towers using tapered forms, such as the Lotte World Tower.

In the mixed-use function, the most preferred building form in the case study example was the tapered form. Moon [16] confirmed this result by stating that the tapered form is preferred for mixed-use architecturally, as in the examples of Tianjin CTF Finance Centre (Figure 9b) and Shanghai World Financial Center (Figure 9c). In this context, for residential use in supertall towers, it is essential to create living spaces as close as possible to the natural outdoor environment, including daylight, to increase occupant comfort.

For office use, however, this issue is less critical, and often deeper leasable areas are more in demand. For this reason, tapered forms with office functions on the lower stories and residential functions on the upper stories are very successful in terms of architecture. In the study sample, while office towers were generally built in free form, residential buildings were mostly in prismatic form.

Similarly, Riad [39] emphasized the usefulness of rectangular floor plans in supertall buildings to create functional and efficient spaces, which may explain why the preference for prismatic form is dominant in residential towers. The choice of the free form may be a reflection of the enthusiasm of the architects to design iconic office buildings such as CITIC Tower, TAIPEI 101 (Figure 9a), and Al Hamra Tower (Figure 9d).

While prismatic and tapered forms were generally utilized in supertall towers built with tube systems, tapered and free forms were used more in towers with outriggered frame systems. In this sense, prismatic forms are particularly suitable for the configuration of closely spaced outer columns and deep spandrel beams, which are essential components of framed-tube solutions as in 432 Park Avenue (see Figure 9e). Reinforced concrete was often used in prismatic and setback towers, while tapered and free forms were mostly built in composites.

As the number of cases shear walled frame, mega column & mega core, and buttressed core systems was very low, it seemed unlikely to develop a correlation between the form of these structures and their load-bearing systems. Similarly, the number of towers built in Russia and other countries was not sufficient for scientific analysis. The same was valid for the steel and twisted buildings and hotel-function towers in the study group.

In this paper, using 140 supertall buildings, the interrelationships of building form and key planning parameters including height, location, function, structural system, and material were scrutinized. Overall, the findings in this study are expected to generate an initial guideline for key project and construction stakeholders.

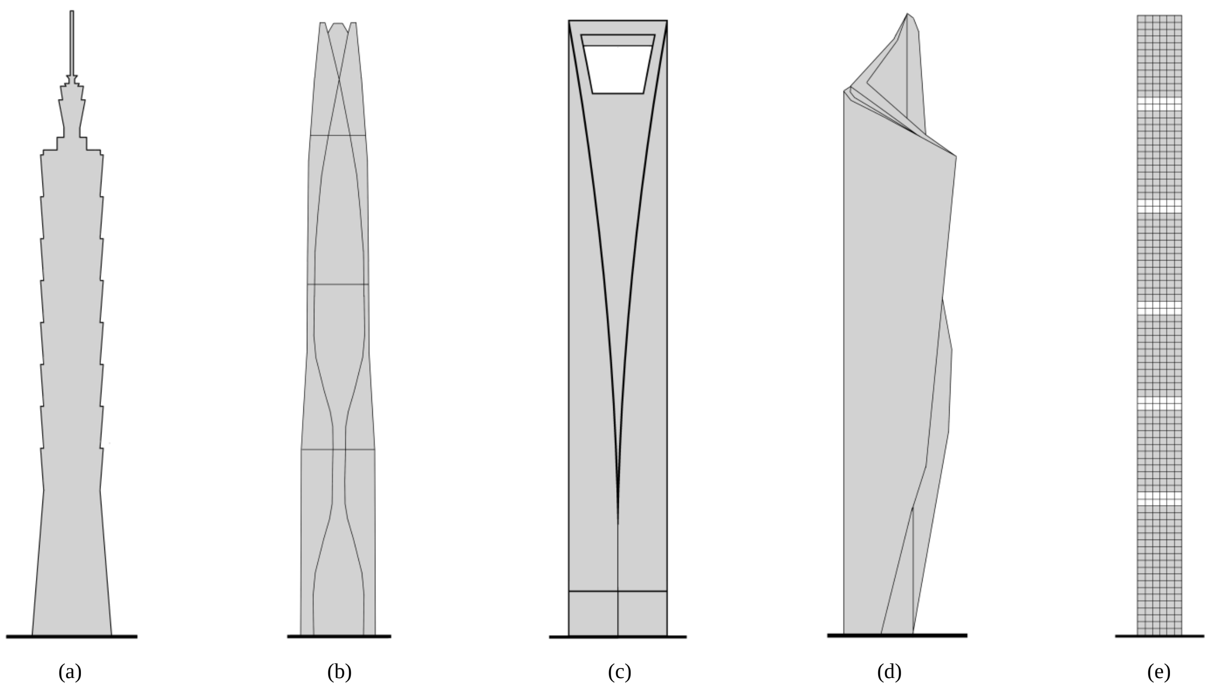


Figure 9. (a) TAIPEI 101; (b) Tianjin CTF Finance Centre; (c) Shanghai World Financial Center (d) Al Hamra Tower; (e) 432 Park Avenue

The data presented in the article is limited to supertall structures. In particular, for buildings that are underrepresented in the sample group, for example, twisted buildings if the results are biased, explanations were made, where necessary, emphasizing their numerical inadequacies. However, considering the increasing demand for supertall buildings, especially in the world's metropolises, it can be predicted that scientifically sufficient numbers will be reached for all building groups in the near future. Moreover, non-supertall buildings can be added to the sample study group to reach a sufficient number of sub-categories.

REFERENCES

[1] Ilgın, H.E. “Potentials and limitations of supertall building structural systems: guiding for architects”, PhD Dissertation, Department of Architecture, Middle East Technical University, Ankara, Turkey, 2018.

[2] Tulonen, L., Karjalainen, M., Ilgın, H.E. “Tall Wooden Residential Buildings in Finland: What Are the Key Factors for Design and Implementation?”, Engineered Wood Products for Construction, 1st ed, IntechOpen, 2021.

[3] Ilgın, H.E., Karjalainen, M. “Tallest Timber Buildings: Main Architectural and Structural Design Considerations”, Wood Industry - Past, Present and Future Outlook, 1st ed, IntechOpen, 2022.

[4] Szolomicki, J., Golasz-Szolomicka, H. “Technological advances and trends in modern high rise buildings”, Buildings, Vol. 9, No. 9, pp. 193-, 2019. DOI: 10.3390/buildings9090193

[5] CTBUH, Council on Tall Buildings and Urban Habitat; Illinois Institute of Technology, S.R. Crown Hall: 3360 South State Street, Chicago, IL, USA, https://www.ctbuh.org (accessed February 10, 2023).

[6] Ilgın, H.E. “A search for a new tall building typology: structural hybrids”, LIVENARCH VII Livable Environments and Architecture 7th International Congress OTHER ARCHITECT/URE(S), September 28-30, Trabzon, Turkey, 2021, pp. 95-107.

[7] Sev, A., Özgen.A “Space efficiency in high-rise office buildings.” METU Journal of Faculty of Architecture, Vol. 26 No. 2, pp. 69-89, 2009. DOI: 10.4305 /METU.JFA.2009.2.4.

[8] Ilgın, H.E. “Space efficiency in contemporary supertall residential buildings”, Architecture, Vol 1, No. 1, pp. 25-37, 2021. DOI: 10.3390/architecture1010004

[9] Maing, M. “Superblock transformation in Seoul Megacity: Effects of block densification on urban ventilation patterns”, Landscape and Urban Planning, Vol. 222, 2022. DOI: 10.1016/j.landurbplan.2022.104401.

[10] Al-Kodmany, K., Xue, Q., Sun, C. “Reconfiguring Vertical Urbanism: The Example of Tall Buildings and Transit-Oriented Development (TB-TOD) in Hong Kong”, Buildings, Vol. 12, No.2, pp. 197-, 2022. DOI: 10.3390/buildings12020197.

[11] Yang, B., Pan, L., Zhu, H., Sun, S., Zhang, Q. “Spatiotemporal correlation analysis of the dynamic response of supertall buildings under ambient wind conditions”, The Structural Design of Tall and Special Buildings, Vol. 31, No. 4, 2022. DOI: 10.1002/tal.1914.

[12] Kazemi, P., Ghisi, A., Mariani, S. “Learning the Link between Architectural Form and Structural Efficiency: A Supervised Machine Learning Approach”, Computer Sciences & Mathematics Forum, Vol. 2, No. 1, pp. 18-, 2021. DOI: 10.3390/IOCA2021-10891.

[13] Yang, Y., Wang, P. “Effects of Building Physics Form on Energy Consumption for Buildings”. Journal of Physics. Conference Series, Vol. 2186, No. 1, pp. 012008-, 2022. DOI: 10.1088/1742-6596/2186/1/012008.

[14] Ali, M.M., Moon, K.S. “Advances in Structural Systems for Tall Buildings: Emerging Developments for Contemporary Urban Giants”, Buildings Vol. 8, pp. 104-, 2018. DOI: 10.3390/buildings8080104

[15] Ilgın, H.E., Günel, M.H. “The role of aerodynamic modifications in the form of tall buildings against wind excitation”, METU Journal of the Faculty of Architecture, Vol. 24, No. 2, pp. 17-25, 2007.

[16] Moon, K.S. “Comparative Evaluation of Structural Systems for Tapered Tall Buildings”, Buildings, Vol. 8, No. 8, pp. 108-, 2018. DOI: 10.3390/buildings8080108.

[17] Moon, K.S. “Comparative Evaluation of Structural Systems for Tilted Tall Buildings”, International Journal of High-Rise Buildings, Vol. 3, No. 2, pp. 89-98, 2014.

[18] Günel, M.H., Ilgın, H.E. “Yüksek Bina: Taşıyıcı Sistem ve Aerodinamik Form”, METU Faculty of Architecture Press, Ankara, Turkey, 2014. (in Turkish).

[19] Günel, M.H., Ilgin, H.E. “Tall Buildings: Structural Systems and Aerodynamic Form”, Routledge, London; New York, NY, 2014.

[20] D’Amico, B., Pomponi, F. “A compactness measure of sustainable building forms”, Royal Society Open Science, Vol. 6, No. 6, pp. 181265-181265, 2019. DOI: 10.1098/rsos.181265.

[21] Taleb, S., Yeretzian, A., Jabr, R.A., Hajj, H. “Optimization of building form to reduce incident solar radiation”, Journal of Building Engineering, Vol. 28, pp. 101025-, 2020. DOI: 10.1016/j.jobe.2019.101025.

[22] Okeil, A. “A holistic approach to energy efficient building forms”, Energy and Buildings, Vol. 42, No. 9, pp. 1437-1444, 2010. DOI: 10.1016/j.enbuild.2010.03.013.

[23] Vollers, K. “The CAD-tool 2.0 morphological scheme of non-orthogonal high-rises”, CTBUH Journal, Vol. 3, pp. 38-49, 2009.

[24] Elnimeiri, M., Almusharaf, A. “The interaction between sustainable structures and architectural form of tall buildings”, International Journal of Sustainable Building Technology and Urban Development, Vol. 1, No. 1, pp. 35-41, 2010. DOI: 10.5390/SUSB.2010.1.1.035.

[25] Alaghmandan, M., Bahrami, P., Elnimeiri, M. “The Future Trend of Architectural Form and Structural System in High-Rise Buildings”, Architecture Research, Vol. 4, No. 3,

pp. 55-62, 2014.

[26] Golasz-Szolomicka, H., Szolomicki, J. "Architectural and Structural Analysis of Selected Twisted Tall Buildings", IOP Conference Series, Materials Science and Engineering, Vol. 471, No. 5, pp. 52050-, 2019. DOI: 10.1088/1757-899X/471/5/052050

[27] Ilgın, H.E., Ay, B.Ö., Gunel, M.H. "A study on main architectural and structural design considerations of contemporary supertall buildings", Architectural Science Review, Vol. 64, No. 3, pp. 212-224, 2021. DOI: 10.1080/00038628.2020.1753010

[28] Ilgın, H.E., Günel, M.H. "Contemporary trends in supertall building form: aerodynamic design considerations", Livenarch VII Livable Environments and Architecture 7th International Congress Other Architect/Ure(S), September 28-30, Trabzon, Turkey, 2021, pp. 61-81.

[29] Ilgın, H.E. "A study on interrelations of structural systems and main planning considerations in contemporary supertall buildings", International Journal of Building Pathology and Adaptation, Vol. ahead-of-print, No. ahead-of-print, 2022. DOI: 10.1108/IJBPA-12-2021-0172

[30] Ilgın, H.E. "Interrelations of slenderness ratio and main design criteria in supertall buildings", International Journal of Building Pathology and Adaptation, Vol. ahead-of-print, No. ahead-of-print, 2022. DOI: 10.1108/IJBPA-07-2022-0102

[31] Ali, M.M., Armstrong, P. "Architecture of Tall Buildings", Council on Tall Buildings and Urban Habitat Committee (CTBUH), New York: McGraw-Hill Book Company, 1995.

[32] Ilgın, H.E. "Use of aerodynamically favorable tapered form in contemporary supertall buildings", Journal of Design for Resilience in Architecture and Planning, Vol. 3, No. 2, pp. 183–196, 2022. DOI: 10.47818/DRArch.2022.v3i2052

[33] Al-Kodmany, K., Ali, M.M. "An overview of structural and aesthetic developments in tall buildings using exterior bracing and diagrid systems", International Journal of High-Rise Buildings, Vol. 5 No. 4, pp. 271-291, 2016. DOI: 10.21022/IJHRB.2016.5.4.271.

[34] Ilgın, H.E. "Space efficiency in contemporary supertall office buildings", Journal of Architectural Engineering, Vol. 27, No. 3, pp. 4021024-, 2021. DOI: 10.1061/(ASCE)AE.1943-5568.0000486

[35] Ilgın, H.E. Karjalainen, M. "Freeform Supertall Buildings," Civil Engineering and Architecture, Vol. 11, No. 2, pp. 999 - 1009, 2023. DOI: 10.13189/cea.2023.110233.

[36] Karjalainen, M., Ilgın, H.E., Tulonen, L. "Main Design Considerations and Prospects of Contemporary Tall Timber Apartment Buildings: Views of Key Professionals from Finland", Sustainability, Vol. 13, No. 12, pp. 6593, 2021. DOI: 10.3390/su13126593

[37] Ilgın, H.E., Karjalainen, M., Pelsmakers, S. "Contemporary Tall Timber Residential Buildings: What are the Main Architectural and Structural Design Considerations?", International Journal of Building Pathology and Adaptation, Vol. ahead-of-print, No. ahead-of-print, 2022. DOI: 10.1108/IJBPA-10-2021-0142

[38] Baker, W.F., Brown, C., Young, B. Zachrison, E. Infinity Tower. Dubai, UAE, Structures Congress 2010, 2010, pp. 3078–3087.

[39] Riad, J. "Conceptual High-Rise Design A design tool combining stakeholders and demands with design", MSc thesis, Structural Engineering and Building Technology, Department of Applied Mechanics, Chalmers University of Technology Gothenburg, Sweden, 2016.

[40] Ho, P.H.K. "Economics Planning of Super Tall Buildings in Asia Pacific Cities", Strategic Integration of Surveying Services, FIG Working Week 2007, Hong Kong SAR, China, 13-17 May 2007.

[41] Moon, K.S. "Supertall Asia/Middle East: Technological Responses and Contextual Impacts", Buildings, Vol. 5, No. 3, pp. 814-833, 2015. DOI: 10.3390/buildings5030814