A Comparative Overview of Architectural Form and Structural Material in Tall Buildings in Surabaya

Ribka Irena Kartowidjojo[1*], Stephanus Wirawan Dharmatanna[2]
[1*,2]Jurusan Arsitektur, Fakultas Teknik Sipil dan Perencanaan, Universitas Kristen Petra, Indonesia
Email: [1*] ribkairena25@gmail.com, [2] stephanus.dharmatanna@petra.ac.id

Abstrak. *Penelitian ini mengkaji hubungan antara desain kerangka arsitektur dan struktural pada gedung-gedung tinggi yang dibangun di Surabaya dari tahun 1995 hingga 2024. Metode deskriptif dan eksploratif digunakan, dengan meneliti 83 gedung tinggi yang berfokus pada fungsi, gaya arsitektur, elemen struktural, dan material yang digunakan untuk tampilan eksternalnya. Informasi dikelompokkan berdasarkan waktu pembangunan dan fitur utamanya, yang dikumpulkan dari berbagai bahan tertulis dan koleksi informasi daring. Studi ini mengungkapkan bahwa bangunan multifungsi merupakan jenis konstruksi vertikal yang paling umum di Surabaya. Bentuk bangunan yang paling sering ditemui adalah bentuk setback. Beton ditemukan sebagai material utama yang digunakan untuk struktur karena daya tahan dan efektivitasnya, sementara desain eksterior biasanya menggunakan campuran dua atau tiga material, seperti dinding kaca, panel komposit, dan dinding beton, untuk mencapai daya tarik estetika dan kinerja yang baik. Perbandingan visual dilakukan untuk mengidentifikasi pola desain umum dan pengaturan tipikal, tanpa mencoba membuktikan kausalitas langsung atau signifikansi statistik. Melalui temuan penelitian, pemahaman umum tentang berbagai jenis gedung tinggi dan perkembangan teknologi terkini di Surabaya dikembangkan, yang berfungsi sebagai titik awal bagi arsitek, insinyur, dan pihak terkait untuk menciptakan desain gedung tinggi yang efektif dan berkelanjutan yang mengatasi keterbatasan ketersediaan lahan perkotaan.*

Kata Kunci : *bangunan tinggi, sistem struktur, bentuk arsitektur, material fasad, tipologi*

Abstract. This research delves into the connections noticed between the design of architectural and structural frameworks in tall buildings constructed in Surabaya from 1995 to 2024. A descriptive and exploratory method was used, examining 83 tall buildings focusing on their use, architecture style, structural elements, and the materials used for their external appearance. Information was grouped by when they were built and their main features, gathered from different written materials and online collections of information. This study revealed that multifunctional buildings are the most common type of vertical construction in Surabaya. The most frequently encountered building form is the setback form. Concrete was found to be the primary material used for the structure due to its durability and effectiveness, while exterior designs typically utilize a mix of two or three materials, such as glass walls, composite panels, and concrete walls, to achieve aesthetic appeal and good performance. Visual comparisons were conducted to identify common design patterns and typical arrangements, without attempting to prove direct causality or statistical significance. Through the research findings, a general understanding of various types of high-rise buildings and current technological developments in Surabaya is developed, which serves as a starting point for architects, engineers, and related parties to create effective and sustainable high-rise building designs that address the limitations of urban land availability.

Keywords : Architectural Form; Facade Material; High Rise Building; Structural System; Typology

1. Introduction

In the 21st century, the construction of high-rise buildings has become a symbol of economy, technology, and transformation as well as identity for a country (Praditya, 2024). The rapid pace of urbanization has increased the need for residential space, offices, and public facilities in urban areas. As horizontal land is limited, vertical development becomes an efficient and sustainable strategic solution. By 2025, Indonesia ranks 9th in the world and 2nd in Southeast Asia in the number of tall buildings (Maulana, 2024), with hundreds of tall buildings that serve as both landmarks and symbols of the city's growth. Tall buildings not only reflect technological innovation and construction progress, but are also an important part of achieving the Sustainable Development Goals (SDGs), particularly SDG 9 Industry, Innovation and Infrastructure and SDG 11 Sustainable Cities and Settlements (Al-Kodmany, 2022).

Surabaya, as the second largest metropolitan city in Indonesia, is also experiencing a surge in vertical development, fueled by economic growth and increasing space requirements (BPS Surabaya, 2024). Since 1995, various high-rise buildings have sprung up such as Adhiwangsa Tower, reflecting the technological advancements and vertical residential trends in the city (Victor, 2015). However, until now there are not many systematic studies that discuss the evolution of high-rise buildings in Surabaya comprehensively, both in terms of function, structural form and material. This study aims to provide an overview of the development of high rise typologies in Surabaya during the period 1995 - 2025, analyze design trends and construction technology, and classify high rise buildings based on their main characteristics. The results of this study are expected to be a reference for planners, developers and stakeholders in designing efficient, inclusive and sustainable vertical solutions.

High-rise buildings are defined by various criteria, such as a minimum height of 50 m or 20 floors equipped with a vertical circulation system that supports movement between floors (Craighead, 2009). Tall buildings also focus on verticality, standing out from the built environment and pushing the boundaries of functional and spatial efficiency (Swenson & Chang, 2024). While the Council on Tall Building and Urban Habitat or better known as CTBUH classifies tall buildings into 3, namely tall buildings which are tall buildings of more than 50 meters, which require technological assistance in their implementation system and are not too conspicuous like skyscrapers, supertall buildings are buildings with a height of more than 300 meters which have always been an architectural icon for big cities, and megatall buildings which have a height of more than 600 meters and are often considered as extraordinary skyscrapers.

Tall buildings began in Chicago with the Home Insurance Building in 1885 which used steel frames as the main structure, to address the need for space efficiency due to urbanization and industrialization (Heba & et al., 2023). The concept of verticality at that time was used to support office space and reflect technological advances, in contrast to previous tall structures, such as pyramids that only served as monuments (Bates & Sergison, 2014). The development of tall buildings also began in Indonesia, in 1960 with Hotel Indonesia and Wisma Nusantara in 1972 in Jakarta, and now the tallest building in Jakarta is BNI 46 with a height of 262m and 51 floors (Aini, 2021). This growth was also followed by other cities such as Surabaya due to the need for space and the development of construction technology (Victor, 2015).

In some countries, high-rise buildings have a variety of shapes and characteristics, with a minimum height of 50 m with 20 floors, with a floor area of 750 m² to 1500 m² (Szolomicki & Szolomicka, 2019). Several studies have shown that tall buildings are designed to overcome land limitations with vertical structures that are stable against wind and earthquakes, supported by aerodynamic systems (Al-Kodmany, 2015). Building designs generally tend to be typical, with structures that go straight up, and variations in shape according to needs (Eticon, 2021). In construction, it is generally costly especially to ensure safety through fire-resistant materials, optimal evacuation routes and detailed design analysis to meet safety standards (Craighead, 2009). Tall buildings are designed with distinctive characteristics that reflect the need for land efficiency or

stability, as well as showing the development of architecture, so that a development can be created with a typology based on certain characteristics. Thus, typology goes beyond merely grouping buildings; it also functions as a means to analyze how basic building elements have evolved, especially in architectural studies (Dharmatanna, 2024).

While previous studies on tall buildings have largely focused on structural performance, iconic skyscrapers, or case based analyses in global cities, there is a lack of descriptive and comparative studies that map the observable integration between architectural form, structure material, and facade materials in Indonesian secondary metropolitan cities such as Surabaya. This study addresses this gap by providing a baseline typological overview based on multiple parameters across a broad sample of buildings. Surabaya was selected as a case study due to its position as Indonesia's second largest metropolitan city, its rapid vertical development since the mid 1990s, and its role as a regional economic and urban growth center outside Jakarta.

2. Methodology

The study is a continuation of a previous study that explored the relationship between building height dan function, classification based on the relationship between high and shape, height and structural material, as well as height and exterior facade material (Kartowidjojo & Dharmatanna, 2025). Based on the information acquired, the current research uses a descriptive quantitative method. It collects data from 83 tall structures located in Surabaya, analyzing the architectural traits that are accessible. The emphasis is placed on comparatively mapping the noticeable architectural aspects of tall buildings in Surabaya. The main data was sourced from journals, books, publications, theses, and other online sources. This was done to add to data absent from the CTBUH website (https://www.ctbuh.org/), which generally only has information such as location, height, usage, and structural materials (Effendi et al., 2021). Structures that lacked sufficient information were not included in subsequent analyses, and the compiled data was arranged into a categorization chart, incorporating frequently observed characteristics such as the building's vertical dimension, quantity of stories, intended use, composition of the structural framework, and external surface elements.

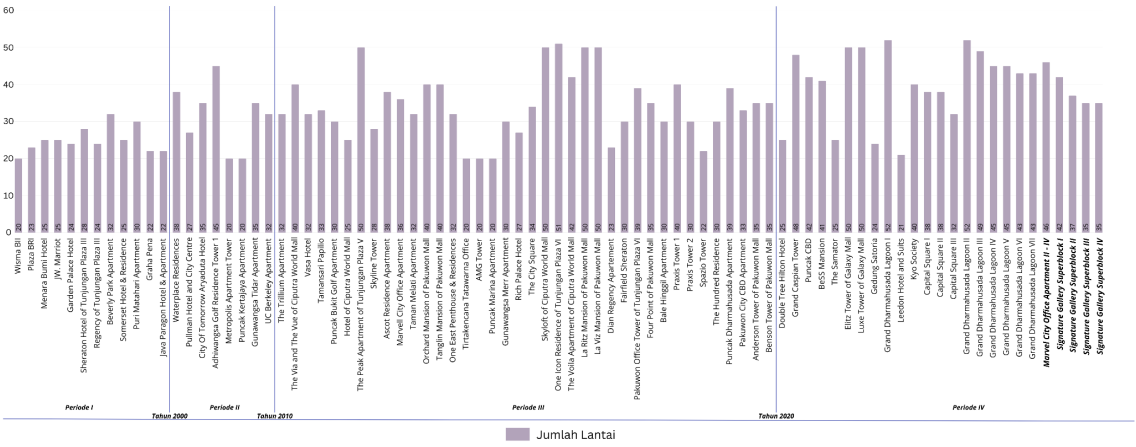


Figure 1. High-rise Building Development Result Chart by Number of Storeys
Source: Author, 2024

To delve deeper into the interconnectedness of design elements, comparisons were conducted and presented visually as bar graphs, examining relationships like purpose against shape, purpose against structural composition, purpose against external surface, shape against structural composition, shape against external surface, and structural composition against external surface. This analytical methodology is geared toward creating initial recommendations for designers and construction professionals, while also determining the degree to which vertical development in

Surabaya can optimize land utilization. The vertical reach of the subject structures spans from 70 to 300 meters, encompassing anywhere from 20 to 55 stories. The distribution of building numbers based on height is as follows: 18 structures ranging from 75 to 100 meters, 36 structures ranging from 101 to 150 meters, 16 structures ranging from 151 to 200 meters, 7 structures ranging from 201 to 250 meters, and 6 structures ranging from 251 to 300 meters. A graphical depiction illustrating the height distribution alongside the story count is provided in Figure 1. As the study relies on secondary data sources, limitations related to data completeness and potential bias in building representations may occur. Buildings with insufficient publicly available information were excluded, which may affect the comprehensiveness of certain categories.

3. Results & Discussion

3.1 Analysis of High Rise Architecture Development in Surabaya Based on Relationship Between Building Functions and Building Forms

The Figure 2 illustrates that high rises in Surabaya are dominantly mixed use with 44.7% in tied across height form, 29.8% in setback form, 19.1% in combination form, 4.3% in discrete clustered form and 2.1% in prismatic form. Another function that is also quite common in Surabaya is residential apartment or condominium with a dominant 45% setback form, 35% prismatic form, 10% tied across height form, 5% discrete clustered form, and 5% combination form.

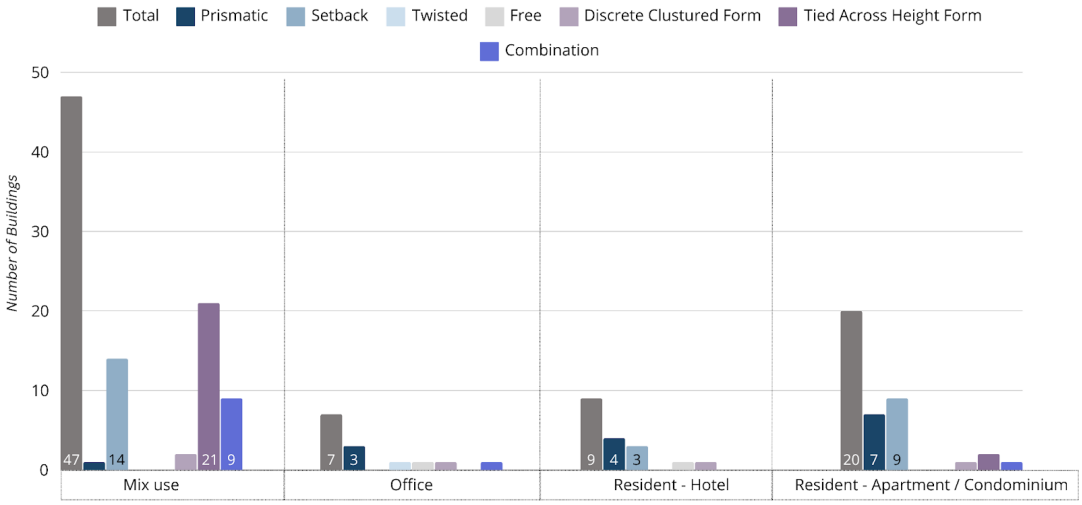


Figure 2. Diagram of the Relationship between Function and Building Form
Source: Author, 2024

3.2 Analysis of the Development of High Rise Architecture in Surabaya Based on the Relationship between Building Functions and Building Structural Materials

Figure 3 illustrates that high rises in Surabaya predominantly function as mixed use with structural materials generally using concrete at 87.2% and some using composites at 12.8%. Other functions such as apartments also use 90% concrete and the remaining 10% use composites. As for the office and hotel functions, it can be said that they are still fairly average with not too many buildings.

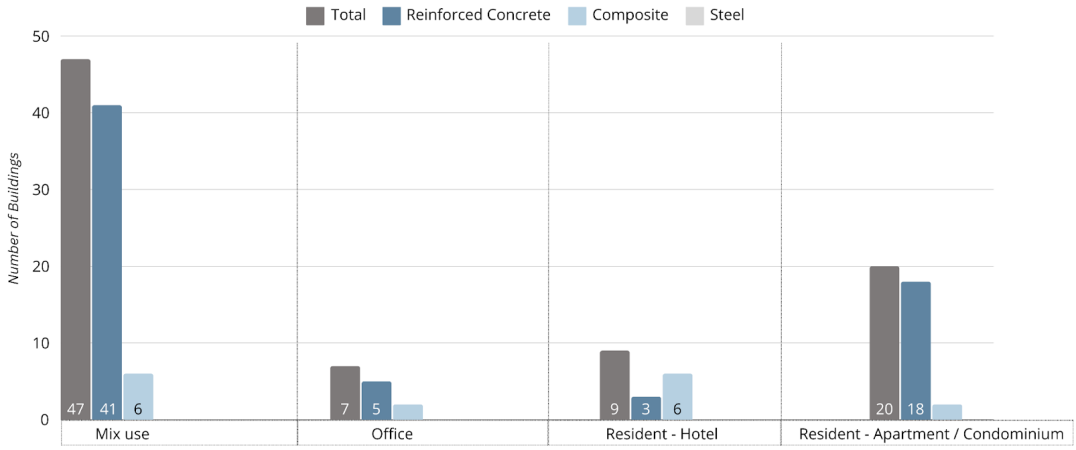


Figure 3. Diagram of Relationship Results Between Function and Building Structure Materials
Source: Author, 2024

3.3 Analysis of High Rise Architecture Development in Surabaya Based on Relationship Between Building Functions and Building Outer Facade Material

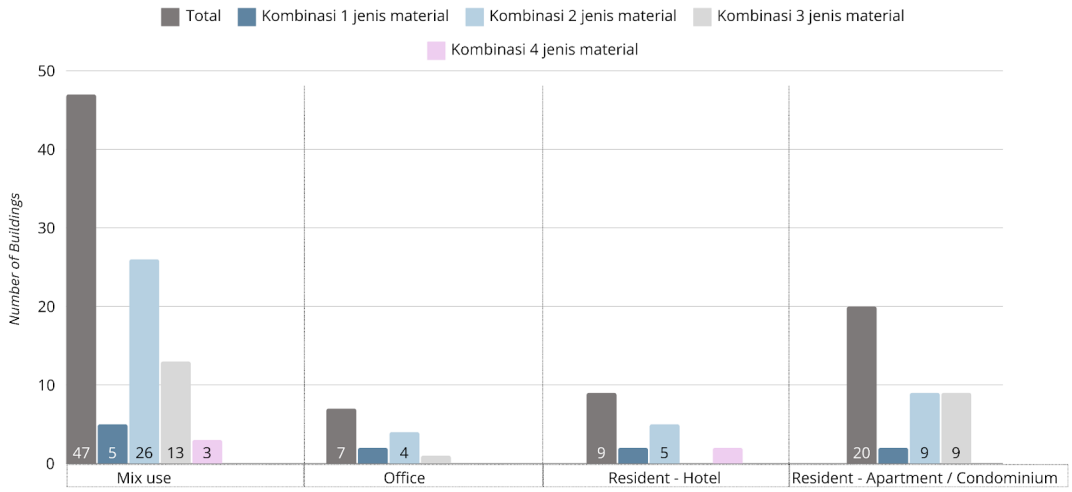


Figure 4. Diagram of Relationship Results Between Functions and Materials of the Building's Outer Facade
Source: Author, 2024

Figure 4 shows the dominant function of mix use with 55.3% using a combination of 2 types of materials ranging between curtain walls and composite panels, 27.7% using a combination of 3 types of materials, 10.6% using 1 type of material generally only in the form of concrete walls, and 6.4% using a combination of 4 types of materials. As for the apartment function, 45% use a combination of 2 types of materials, 45% a combination of 3 types of materials and the remaining 10% still use 1 type of material. For the hotel function, 55.6% chose to use a combination of 2 types of materials and the remaining 44.4% used a combination of 1 type of material or a combination of 4 types of materials. Similarly, 57.1% of offices choose to use a combination of 2 types of materials, 28.6% use 1 type of material, generally a full curtain wall as additional natural lighting, and the remaining 14.3% use a combination of 3 types of materials.

3.4 Analysis of the Development of High Rise Architecture in Surabaya Based on the Relationship Between Building Form and Building Structure Material

Figure 5 illustrates that the two most widely applied forms in Surabaya City are setback form with 76.9% using concrete and 23.1% using composite structures, and tied across height form with 96.7% using concrete and 4.3% using composite materials. Two other building forms that are also commonly found are prismatic form with 80% using concrete, 20% composite, and combination form with 72.7% also using concrete, the remaining 27.3% using composite materials.

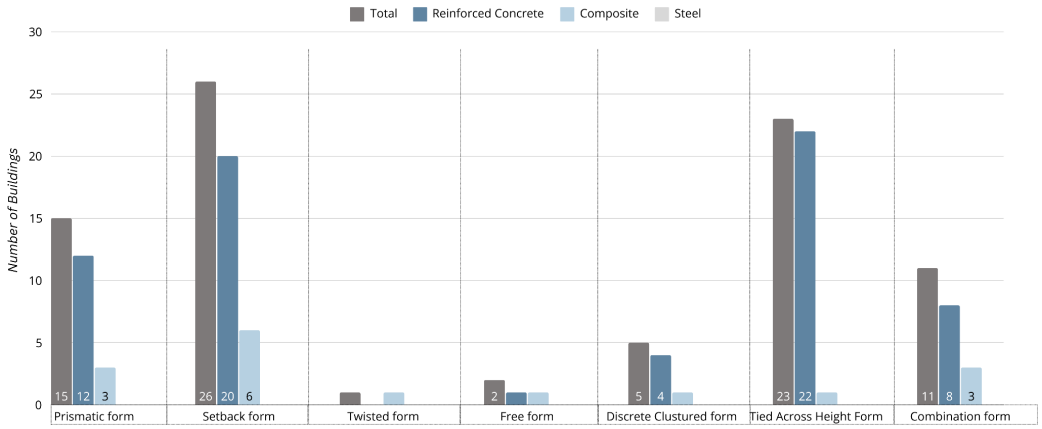


Figure 5. Diagram of the Relationship between Form and Materials of Building Structures
Source: Author, 2024

3.5 Analysis of the Development of High Rise Architecture in Surabaya Based on the Relationship Between Building Forms and Building Outer Facade Materials

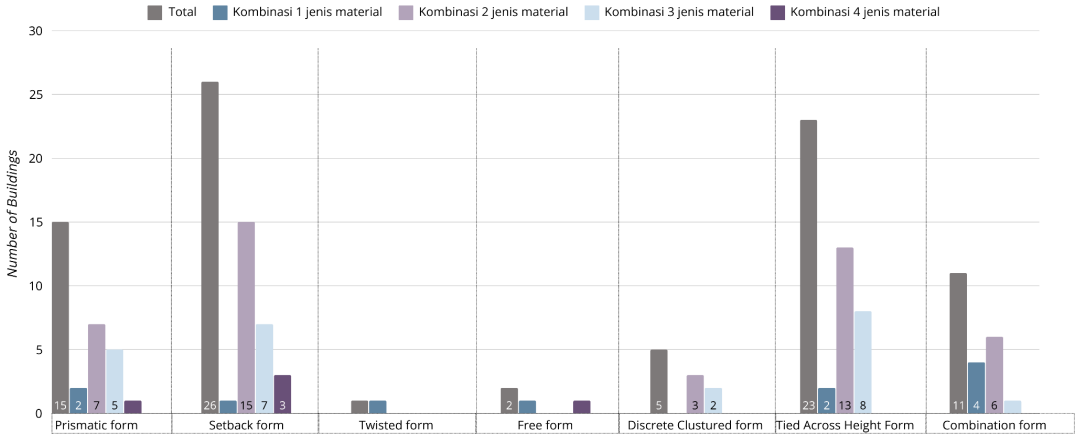


Figure 6. Diagram of the Relationship between Form and Material of the Building's Outer Facade
Source: Author, 2024

Figure 6 illustrates that the two most applied forms in Surabaya City are the setback form which is dominant at 57.7% using a combination of 2 types of materials, and the tied across height form with 56.5% also using a combination of 2 types of materials. In some other forms, the use of a combination of 2 types of materials is still very dominant with 46.7% in the prismatic form and 54.5% in the combination form.

3.6 Analysis of the Development of High Rise Architecture in Surabaya Based on the Relationship Between Building Structure Material and Building Outer Facade Material

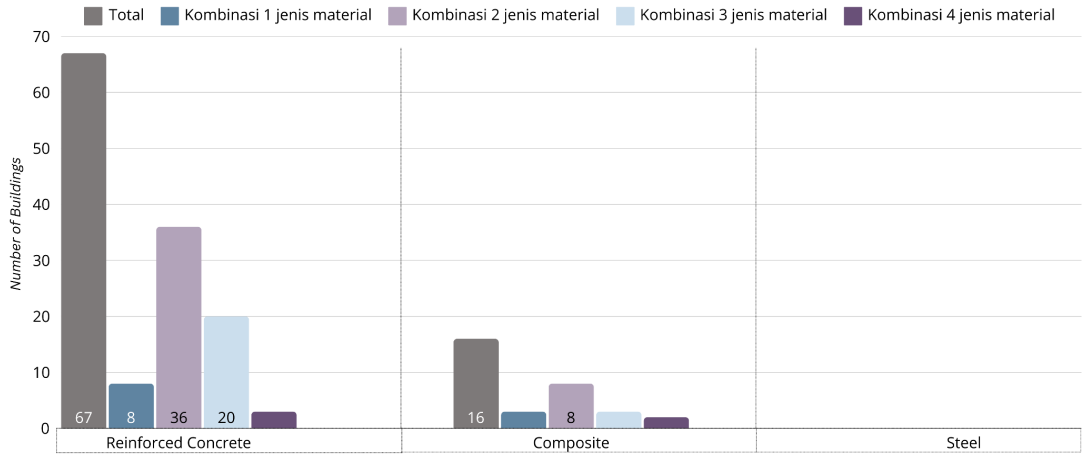


Figure 7. Diagram of Relationship Results Between Structural Materials and Building Outer Facade Materials
Source: Author, 2024

Figure 7 illustrates that the two most commonly used materials for structures are concrete and composite materials. As shown in the diagram above, 53.7% combine concrete structural materials with facade materials using a combination of 2 types of materials, 29.9% with a combination of 3 types of materials, 11.9% with a combination of 1 type of material and 4.5% with a combination of 4 types of materials. As for materials with composite structures, 50% use a combination of 2 types of materials, 18.8% use a combination of 3 types of materials, 18.8% use a combination of 1 type of material and the remaining 12.5% with a combination of 4 types of materials.

The observed dominance of mixed use typologies and compact vertical forms aligns with SDG 11 (Sustainable Cities and Communities) by promoting land use efficiency and functional integration in dense urban contexts. Additionally, the prevalence of concrete structural system and modular facade combinations reflects ongoing efforts related to SDG 9 (Industry, Innovation, and Infrastructure), particularly in terms of construction efficiency and technological standardization. However, as this study focuses on observable design characteristics, further research is required to assess environmental performance and sustainability outcomes in greater depth.

4. Conclusion

The results indicate that high rise development in Surabaya is predominantly characterized by mixed use functions, with setback and tied across height forms emerging as the most frequently observed architectural typologies. Concrete remains the primary structural material due to its capacity to resist vertical and lateral loads efficiently. In terms of facade design, the prevalent use of combined material systems particularly curtain walls and composite panels suggest an emphasis on balancing aesthetic expression and building performance. Rather than establishing causal relationships, this study highlights recurring tendencies and consistent configurations across architectural form, function, structural systems and facade material. As a descriptive and exploratory overview, the findings contribute to an improved understanding of the evolving typologies and technological tendencies of tall buildings in Surabaya. This research may serve as a baseline reference for architects and engineers and provide a foundation for future, more in depth analytical or performance based studies on high rise development in Indonesian urban context.

Reference

Ali, M. M., & Al-Kodmany, K. (2012). Tall Buildings and Urban Habitat of the 21st Century: A Global Perspective. *Buildings*, *2*(4), Article 4. https://doi.org/10.3390/buildings2040384

Al-Kodmany, K. (2022). Sustainable High-Rise Buildings: Toward Resilient Built Environment. *Frontiers in Sustainable Cities*, *4*. https://doi.org/10.3389/frsc.2022.782007

Al-Kodmany, K., Xue, Q. (Charlie), & Sun, C. (2022). Reconfiguring Vertical Urbanism: The Example of Tall Buildings and Transit-Oriented Development (TB-TOD) in Hong Kong. *Buildings*, *12*(2), Article 2. https://doi.org/10.3390/buildings12020197

Anderson, A. (2021, February 17). *Groundscrapers: Exploring the logic behind long, low buildings*. Harvard Graduate School of Design. https://www.gsd.harvard.edu/2021/02/groundscrapers-exploring-the-logic-behind-long-low-buildings/

Bates, S., & Sergison, J. (2014, November 4). *High-Rise, High-Density by Harvard GSD - Issuu*. https://issuu.com/gsdharvard/docs/sergisonbates_highrisehighdensity

BPS Surabaya, B. P. S. K. (2024). *Ekonomi Kota Surabaya Tahun 2023 Tumbuh 5,70 Persen*. https://surabayakota.bps.go.id/id/pressrelease/2024/02/28/332/ekonomi-kota-surabaya-tahun-2023-tumbuh-5-70-persen.html

Cintya, N. (2016). *Vitruvius | PDF*. https://id.scribd.com/document/332019839/Vitruvius

Craighead, G. (2009). High-Rise Building Definition, Development, and Use. In *High-Rise Building Definition, Development, and Use* (Vol. 01). https://booksite.elsevier.com/samplechapters/9781856175555/02~Chapter_1.pdf

Dharmatanna, S. W. (2024). Facade Morphology with Kinetic System in Tall Buildings. *Tekstur (Jurnal Arsitektur)*, *5*(2), 149–160. https://doi.org/10.31284/j.tekstur.2024.v5i2.4917

Dzuri, V., & Zakariya, A. (2024). *IDENTIFIKASI PERAN TIPOLOGI BANGUNAN PADA MUSEUM CAKRANINGRAT DI KABUPATEN BANGKALAN*. *21 No 1*. http://journals.ums.ac.id/index.php/sinektika

Effendi, M. F., Ridzqo, I. F., & Dharmatanna, S. W. (2021). An Overview of High-Rise Buildings in Jakarta since 1967 to 2020. *IOP Conference Series: Earth and Environmental Science*, *933*(1), 012001. https://doi.org/10.1088/1755-1315/933/1/012001

Eticon. (2021, August 20). High Rise Building: Mengenal Pengertian serta Karakteristiknya. *PT Eticon Rekayasa Teknik*. https://eticon.co.id/high-rise-building/

Grover, R., Emmitt, S., & Copping, A. (2019). The language of typology. *Architectural Research Quarterly*, *23*(2), 149–156. https://doi.org/10.1017/S1359135519000198

Heba, K. & et al. (2023). *High Rise Buildings: Assessment Approach*. https://www.researchgate.net/publication/368898557_High_Rise_Buildings_Assessment_Approach

Ilgın, H., & Aslantamer, O. (2024). *Investigating Space Utilization in Skyscrapers Designed with Prismatic Form*. https://www.mdpi.com/2075-5309/14/5/1295

Ilgın, H. E., Karjalainen, M., & Pelsmakers, S. (2023). Contemporary tall residential timber buildings: What are the main architectural and structural design considerations? *International Journal of Building Pathology and Adaptation*, *41*(6), 26–46. https://doi.org/10.1108/IJBPA-10-2021-0142

Irawan, A. C. (2024). *Negara Pemilik Gedung Pencakar Langit Terbanyak, Ada Indonesia—Suara Merdeka Surabaya—Halaman 2*. Negara Pemilik Gedung Pencakar Langit Terbanyak, Ada Indonesia - Suara Merdeka Surabaya - Halaman 2. https://surabaya.suaramerdeka.com/gaya-hidup/106113620269/negara-pemilik-gedung-pencakar-langit-terbanyak-ada-indonesia?page=2

iStock. (2023, July 29). *9 Karakteristik High Rise Building yang Penting untuk Diketahui*.

https://www.99.co/id/panduan/high-rise-building/

Kathe, V. (2022, March 30). *Theory in Architecture: Vitruvian module*. RTF | Rethinking The Future. https://www.re-thinkingthefuture.com/architectural-styles/a6544-theory-in-architecture-vitruvian-module/

Kartowidjojo, R. I., & Dharmatanna, S. W. (2025). OVERVIEW OF HIGH RISE DEVELOPMENT IN SURABAYA CITY IN SEVERAL PERIODS OF YEARS. *ALUR : Jurnal Arsitektur*, *8*(1), Article 1.

Lefas, P. (2010). On the fundamental terms of Vitruvius's architectural theory. *Bulletin of the Institute of Classical Studies*, *44*, 179–197. https://doi.org/10.1111/j.2041-5370.2000.tb00603.x

Maulana, R. (2024). *Inilah 5 Kota dengan Jumlah Gedung Terbanyak di Indonesia, Bangunannya Tinggi dan Mewah—Timenews*. Inilah 5 Kota dengan Jumlah Gedung Terbanyak di Indonesia, Bangunannya Tinggi dan Mewah - Timenews. https://www.timenews.co.id/nasional/99513066821/inilah-5-kota-dengan-jumlah-gedung-terbanyak-di-indonesia-bangunannya-tinggi-dan-mewah

Moon, K. (2016). *Outrigger Systems For Structural Design of Complex Shaped Tall Buildings*. https://global.ctbuh.org/resources/papers/download/2735-outrigger-systems-for-structural-design-of-complex-shaped-tall-buildings.pdf

Naili, B. (2023). *Façade typology development in high-rise office building envelope in: Pollack Periodica Volume 18 Issue 2 (2023)*. https://akjournals.com/view/journals/606/18/2/article-p151.xml

Ozsahin, B. (2022). An Assessment of the Relation between Architectural and Structural Systems in the Design of Tall Buildings in Turkey. *Buildings*, *12*, 1649. https://doi.org/10.3390/buildings12101649

Pfeifer, G., & Brauneck, P. (2007). Typology. In *Courtyard Houses: A Housing Typology* (pp. 8–17). Birkhäuser. https://doi.org/10.1007/978-3-7643-7924-7_1

Praditya, I. (2024). *10 Negara dengan Gedung Pencakar Langit Terbanyak di Dunia, Indonesia Masuk Daftar—Page 3—Bisnis Liputan6.com*. https://www.liputan6.com/bisnis/read/5519719/10-negara-dengan-gedung-pencakar-langit-terbanyak-di-dunia-indonesia-masuk-daftar?page=3

Prayanka, L. (2019). *VITRUVIUS | PDF*. Scribd. https://id.scribd.com/document/426568882/VITRUVIUS

Santi, T. (2023). *Bab I Tipologi Dalam Arsitektur: 1.1 Pengertian Type | PDF*. Scribd. https://id.scribd.com/document/636407411/Untitled

Santoso, J. (2013). *TIPOLOGI MEMBUKA RUANG BAGI FUNGSI DAN BENTUK*. *9 No 2*. https://journal.untar.ac.id/index.php/teknologi/article/view/255/207

Shakir, I., Jasim, M. A., & Weli, S. S. (2021). High Rise Buildings: Design, Analysis, and Safety: An Overview. *International Journal of Architectural Engineering Technology*, *8*, 1–13. https://doi.org/10.15377/2409-9821.2021.08.1

Sir, M. M., Wunas, S., Parung, H., & Patandu, J. (2015). MODEL TEKTONIKA ARSITEKTUR TONGKONAN TORAJA. *Prosiding Sains Nasional Dan Teknologi*, *1*(1), Article 1. https://doi.org/10.36499/psnst.v1i1.1155

Swenson, A., & Chang, P. (2024). *Construction—Skyscrapers, Design, Engineering | Britannica*. https://www.britannica.com/technology/construction/High-rise-buildings

Szolomicki, J., & Szolomicka, H. (2019). *Technological Advances and Trends in Modern High-Rise Buildings*. https://www.mdpi.com/2075-5309/9/9/193

United Nations. (2019). *World Urbanization Prospects*. https://population.un.org/wup/Publications/Files/WUP2018-Highlights.pdf

Unity, E. O. (2024, May 22). Decoding Vitruvius: Understanding the Principles of Architectural Perfection. *Operations Research*. https://medium.com/operations-research-gig/decoding-vitruvius-understanding-the-principles-of-architectural-perfection-467f1b44fbba

Victor, T. (2015, August 17). Sejarah Bangunan Tinggi Di Indonesia. *Karya Tulis Ilmiah*. https://karyatulisilmiah.com/sejarah-bangunan-tinggi-di-indonesia/

Yulistya, Y., & Roosandriantini, J. (2022). *Kajian Elemen Arsitektur Modern berdasarkan teori Vitruvius*. https://jurnal.ukdc.ac.id/index.php/LKR/article/download/253/261