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Vertical Housing Design Based on Ecological Architecture for Low-Income Communities in the Batu Ampar Industrial Area

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ABSTRACT

The rapid growth of the industry in Batu Ampar, Batam City, has made this area one of the main economic centers with more than 1,300 active industries employing more than 169,000 workers. However, industrial development has not been matched by the provision of adequate housing for workers, especially in low-income communities (MBR) with an average income of between two and three million rupiah per month. Land scarcity, high land prices, and the presence of a 178-hectare slum area have further exacerbated the housing crisis. This issue urgently requires a solution in the form of efficient, healthy, and affordable vertical housing to accommodate the needs of the population. The design of this apartment complex applied an analytical method with an ecological architecture approach. Analyses were conducted on on-site characteristics, local climate, socio-economic conditions of the community, and required spatial needs. The design was found to optimally respond to the environment through the application of maximum cross-ventilation, adequate natural lighting, provision of green open spaces, an effective rainwater management system, and the use of locally sourced, environmentally friendly, and energy-efficient materials. The design outcome was a four-story apartment building with an effective circulation system and supporting facilities such as vertical gardens, communal spaces, children's playgrounds, and comfortable pedestrian pathways. This concept not only provided housing but also created a healthy, inclusive, and sustainable living environment.

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1. INTRODUCTION

Batu Ampar is an industrial area in Batam City. The industrial sector is also a key driver of a country's economic development. With many factors contributing to rapid progress, the industrial sector's operation also has various impacts on the surrounding environment, ranging from the growth of residential areas and community activities to environmental effects (Setiawan & Bella, 2023). The growth of the Batu Ampar industrial area in Batam City has made a significant contribution to the regional and national economy. According to data from the (Dinas Perumahan permukiman dan Pertamanan Kota Batam, 2021), more than 1,300 active industries employ approximately 169,000 workers. However, rapid industrialization has not been accompanied by adequate housing for low-income communities (MBR) working in this sector. Limited urban land, high land prices, and the presence of 178 hectares of slums further exacerbate the housing gap. This situation demands land-efficient, healthy, affordable, and sustainable housing solutions (Chandra & Ariyanti, 2021).

Limited urban land, rising land prices, and the growth of informal settlements are further worsening the conditions of settlements around industrial areas (Laksmiyanti & Poedjioetami, 2021). The Batam City Medium-Term Development Plan (Rencana Pembangunan Jangka Menengah Daerah Tahun 2021-2026, 2021) reports a housing backlog of over 15,000 units, primarily concentrated in densely populated industrial areas, such as Batu Ampar. This problem demands solutions that address not only quantity but also quality and environmental sustainability.

The development of flats (rusun) is seen as an effective strategy to address the housing crisis in densely populated areas. As a vertical solution, flats can optimize land use, reduce the horizontal expansion of slums, and support infrastructure efficiency (Aprianto et al., 2024). However, for these vertical residences to meet occupant health and comfort standards, a sustainability-oriented design approach is required. Negative effects also impact the physical environment, such as pollution and waste produced by industries, which can affect air quality, water quality, and soil conditions (Pradani et al., 2017).

Flats (rusun) as a solution for urban density offer land efficiency but also challenge aspects of environmental quality and thermal comfort, ventilation, and social relationships between residents. In many urban contexts, traditional flat designs often neglect passive climate strategies (daylighting, cross-ventilation, building mass configuration), green public spaces, and environmentally friendly water/energy management — resulting in increased energy consumption, decreased indoor air quality, and decreased occupant comfort. Empirical studies and reviews highlight the need to integrate ecological architecture principles to address these issues (Al-Kodmany, 2022).

The ecological architecture approach was chosen in this design because it has been proven to reduce building energy consumption through the application of energy efficiency principles, the utilization of natural lighting and ventilation, and the use of environmentally friendly materials. Studies by (Gupta & Deb, 2023) show that the application of ecological concepts to buildings can reduce energy consumption by 30–50% compared to conventional buildings. Furthermore, (Perera et al., 2025) emphasizes that sustainable residential development is crucial in creating cities that are resilient, inclusive, and adaptive to the impacts of climate change.

In addition to environmental aspects, (Tisnawati et al., 2024) highlight the importance of considering social and cultural activities in vertical residential development to create an

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inclusive environment. (Budi et al., 2018) present a green design strategy to optimize natural ventilation in high-rise buildings as an effort to improve thermal comfort in tropical climates.

This literatures show that the application of ecological architecture principles to vertical housing not only provides environmental benefits but also improves the overall quality of life of the residents. Therefore, this research is directed at designing flats in the Batu Ampar Industrial Estate as a suitable, healthy, and affordable vertical housing solution for low-income communities (MBR) by integrating ecological architecture principles to create a sustainable, energy-efficient residential environment and support the well-being of its residents.

1.1 Literature Review

The concept of flats is defined in (Undang-Undang Republik Indonesia Nomor 20 Tahun 2011 tentang Rumah Susun, 2011), Flats as a multi-storey building consisting of residential units that can be owned and used separately, and are equipped with shared parts, objects, and land. General criteria explain that high-rise simple housing buildings must meet building plans that consider efficient, affordable, and simple requirements, and also support improvements in the surrounding environmental quality (Sujana et al., 2016).

Literature shows that an ecological architecture approach in apartments contributes to improving environmental quality and occupant comfort. Research by (Wulandari & Pasaribu, 2023) in the Klender Rusunawa (Rice Flats) demonstrated that cross-ventilation and natural lighting can improve the thermal quality of a space and reduce dependence on artificial energy. (Ulima, 2024) highlighted the importance of water management systems and adaptation to flood risks in apartment design in urban areas such as Rawa Buaya, Jakarta.

Another study by (Avesta et al., 2017) in West Jatinegara found that an appropriate window opening design can reduce energy consumption while improving occupant visual comfort. In Pati Regency, (Mandani et al., 2023) designed a sustainable apartment building using the 3R principles, solar panels, and site efficiency. Meanwhile, (Ananditya, 2017) developed a sustainable apartment concept in Surakarta using a participatory approach and the use of local materials.

From these various studies, it can be concluded that the application of ecological architecture principles not only provides environmental benefits but also improves overall residential quality. This research continues this direction by focusing on the context of the industrial area in Batam, which has its own challenges and potential in sustainable vertical housing planning.

2. RESEARCH METHOD

This research uses an analytical-descriptive approach that combines qualitative and quantitative methods to obtain a comprehensive overview of the existing conditions and design needs for vertical housing in the Batu Ampar industrial area. The design phase begins with problem identification, data collection, site analysis, and the formulation of a design concept based on ecological architecture principles.

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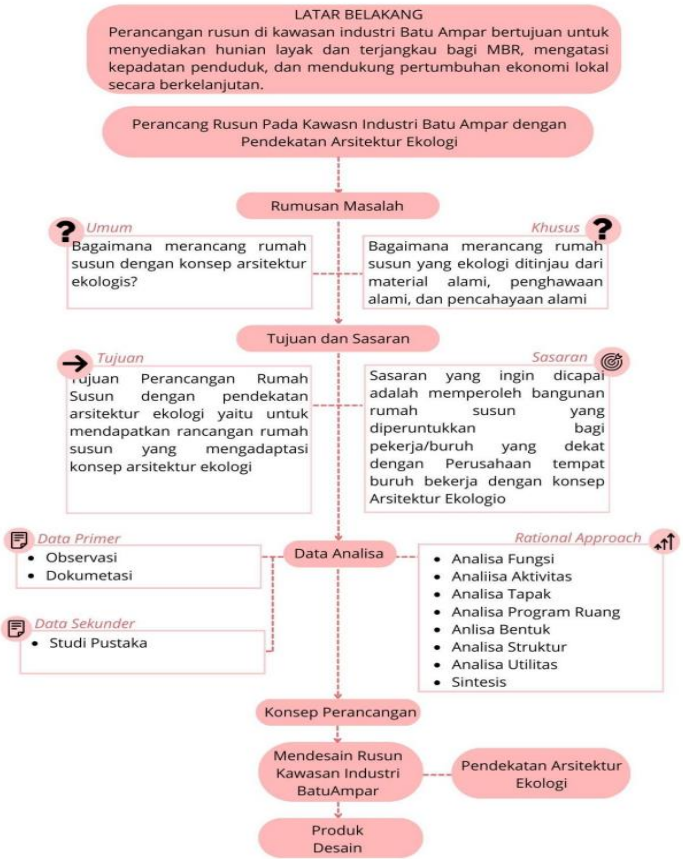

Figure 1. Research Framework
(Source: Analysis, 2025)

1. Problem Identification
   The initial stage of the research was conducted by identifying existing problems in the Batu Ampar industrial area. The analysis focused on environmental and social conditions, such as limited land, high population density, and the limited provision of adequate housing for low-income communities (MBR). These factors are important indicators that reinforce the urgency of designing vertical housing based on principles of sustainability and ecological architecture.
2. Data Collection
   In this stage, the researchers used three main methods: literature study, field survey, and interviews. The literature study included a review of scientific journals, planning books, technical standards, and regional policy documents such as the Batam City Medium-Term Development Plan (RPJMD) to provide a theoretical basis for the design. Field surveys were conducted to observe the physical conditions of the site, such as sun orientation, wind direction, vegetation, contours, and accessibility. Informal interviews were conducted with residents and land managers to determine basic housing needs, spatial preferences, and social challenges for low-income communities.
3. Site Analysis
   Data obtained from the field survey were analyzed in depth to understand the characteristics of the site. This analysis includes measuring the land area, topography, potential views, physical obstacles, and connectivity to transportation systems. This stage aims to determine zoning, building orientation, and efficient building mass placement in accordance with ecological architecture principles.

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4. Design Concept Formulation
   Based on the site analysis results, a vertical housing design concept is developed that is responsive to the environment and user needs. The concept focuses on maximizing natural ventilation, natural lighting, utilizing green open spaces, and using environmentally friendly local materials. This concept formulation also considers social and cultural aspects so that the design not only meets technical needs but is also relevant to the local community.
5. Design Development
   The final stage is design development, where the formulated concept is realized in design form. This process includes the preparation of a design schematic, the processing of the building mass, and the depiction of the design in two and three dimensions. Thus, the resulting design provides a comprehensive, sustainable, and appropriate vertical housing solution within the context of the Batu Ampar industrial area.

All collected data was analyzed to formulate a design strategy responsive to the environment and user needs. The design concept focused on maximizing natural ventilation, natural lighting, utilization of green open spaces, and the use of environmentally friendly local materials. The design process was then developed in stages, starting with site analysis, schematic design, building mass processing, and finally, two- and three-dimensional design representations.

3. RESULTS AND DISCUSSION

The design of the apartment complex in the Batu Ampar industrial area was carried out by integrating ecological architecture principles into all aspects of the design. The design process began with an analysis of the site and local environmental conditions, including sun orientation, wind direction, and surrounding residential density. The analysis showed that the area has potential for land-efficient vertical residential development, taking into account the humid tropical climate that dominates Batam City.

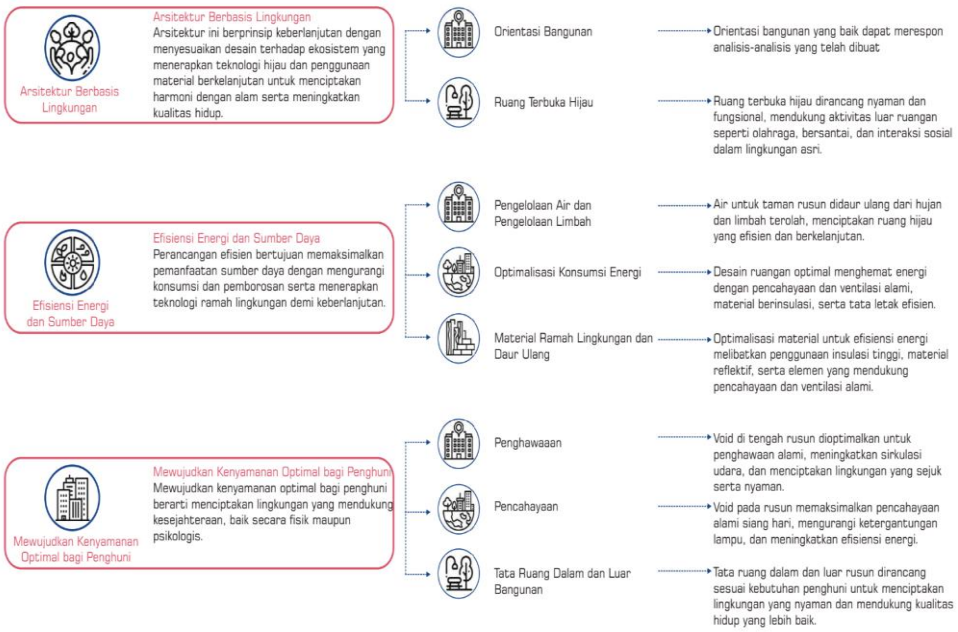

Figure 2. Concept
(Source: Analysis, 2025)

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The application of ecological architecture principles is reflected in several key design aspects. The concept of air circulation is crucial in creating passive thermal comfort. Cross-ventilation is implemented through opposite openings, allowing air to flow naturally and reducing reliance on artificial cooling systems. These results align with a study by (Wulandari & Pasaribu, 2023), which showed improved thermal quality in ecological apartment complexes in Jakarta.

The implementation of natural lighting, or daylighting, is also a focus in the design. Each unit is designed with windows proportionally sized to the room area, allowing optimal sunlight to enter throughout the day. This strategy aims to reduce electricity use during the day and create good visual comfort for residents. A study by (Avesta et al., 2017), emphasized that appropriate opening design can significantly reduce energy consumption and improve the quality of life for low-cost apartment residents.

Green open areas are integrated into the site plan through communal gardens, multi-functional fields, and infiltration vegetation areas that function as ecological balancing elements. These open spaces not only provide social spaces for residents but also improve air quality, mitigate the heat island effect, and act as flood control by increasing groundwater absorption. This concept draws on (Ulima, 2024) idea regarding the importance of green space as a multi-functional element in sustainable low-cost apartments.

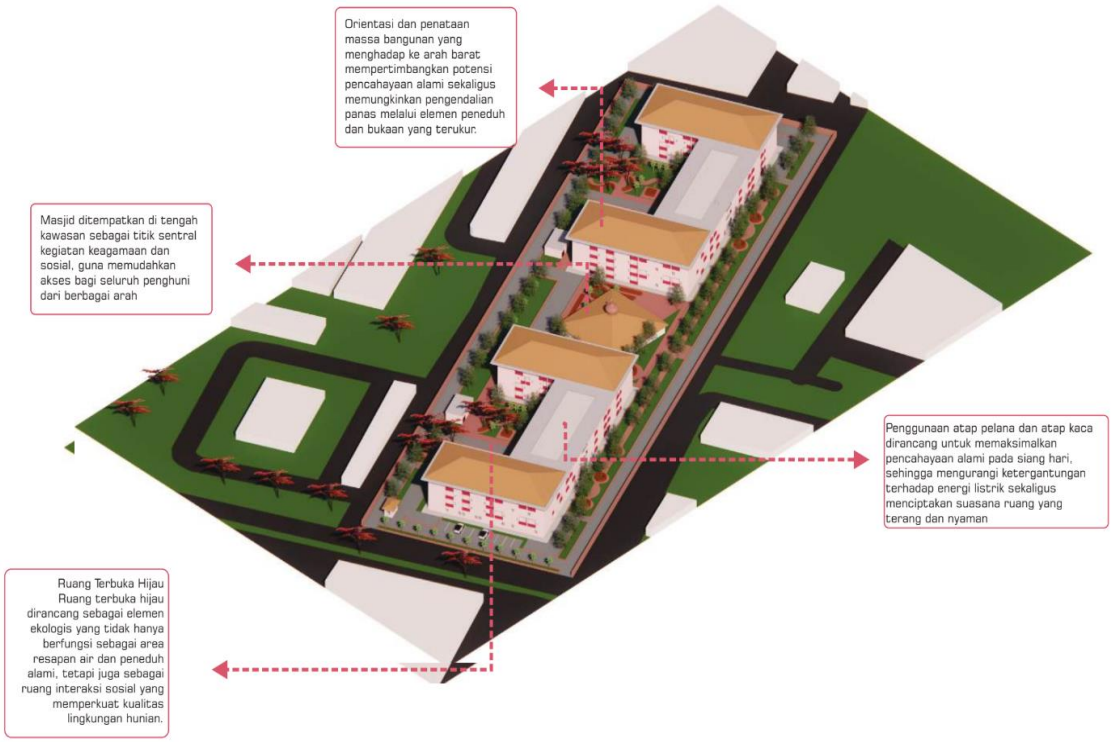

Figure 3. Design Strategy
(Source: Analysis, 2025)

In terms of the building's form and mass composition, the massing is designed to form a "U" pattern that opens in the optimal direction for light and wind. This strategy aims to optimize airflow across the building and natural lighting throughout the units. This design also encourages social interaction by creating a central courtyard that serves as a meeting point for residents. This approach reinforces the ideas of (Mandani et al., 2023), who emphasize the importance of managing mass form in achieving energy efficiency and social integration.

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Figure 4. Air Circulation Concept
(Source: Analysis, 2025)

Other ecological elements are also adopted, such as a rainwater harvesting system, the use of grey water for garden irrigation, and the potential use of solar panels as an alternative energy source, if possible in further development. These overall strategies demonstrate that the design not only addresses housing issues in a densely populated area but also contributes to climate crisis mitigation and sustainable development in urban environments.

Figure 5. Light Circulation
(Source: Analysis, 2025)

Figure 6. Green Open Areas and Indoor Courts
(Source: Analysis, 2025)

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Figure 7. Mass Composition
(Source: Analysis, 2025)

In 2016, the KOTAKU Team updated Batam City's slum data through a field survey. Slum reduction efforts continued until 2020, as outlined in the 2021-2026 Regional Medium-Term Development Plan (RPJMD).

Table 1. Slum Areas in Batam City

No	Lokasi	SK 2019	Luasan Kumuh 2021	Capaian Pengurangan Luasan Kumuh (Ha)				
				2016	2017	2018	2019	2020
1	Batam Kota	33,28	21,61	0	0,00	0,00	166,22	11,67
2	Batu Aji	113,00	69,20	0	0,00	0,00	25,50	43,8
3	Batu Ampar	97,51	88,20	0	3,35	2,75	45,94	9,31
4	Belakang Padang	312,79	312,79	0	0,00	0,00	0,00	0
5	Bengkong	98,24	49,90	0	7,06	9,59	125,58	48,34
6	Bulang	223,61	223,61	0	0,00	0,00	0,00	0
7	Galang	317,37	317,37	0	0,00	0,00	0,00	0
8	Lubuk Baja	32,20	10,50	0	0,00	0,00	45,21	21,7
9	Nongsa	186,30	171,01	0	14,37	13,72	10,44	15,29
10	Sagulung	90,70	75,14	0	40,47	19,56	77,81	15,56
11	Sei Beduk	29,18	12,59	0	24,84	24,03	8,56	16,59
12	Sekupang	93,21	78,54	0	2,28	8,23	39,20	14,67
	Jumlah	**1.627,39**	**1.430,46**	**0**	**92,37**	**77,88**	**544,46**	**196,93**

Sumber : Rencana Pembangunan Jangka Menengah Daerah (RPJMD) 2021-2026

The 2016 slum area data collected by the KOTAKU Team serves as a crucial basis for planning slum management in Batam City. Until 2020, the slum reduction program was implemented using a sustainable architectural approach that integrates environmental design and effective spatial planning, in line with the targets of the 2021-2026 RPJMD (Regional Medium-Term Development Plan), to provide decent housing and improve community well-being.

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4. CONCLUSION

The design of an apartment building in Batam City using an ecological architecture approach demonstrates how integrating functional design with sustainability principles can produce decent, comfortable, and environmentally friendly housing. This sustainability concept is realized through energy efficiency by maximizing natural lighting and ventilation, the use of sustainable local materials, and the provision of green open spaces that function as shading and carbon sequestration.

The building layout is designed to follow the sun's orientation and dominant wind direction to enhance thermal comfort for residents. Furthermore, an environmentally conscious drainage system and pedestrian-friendly paths support a balanced ecosystem and ease of mobility within the residential area. Overall, this design not only addresses the housing needs of low-income communities but also makes a positive contribution to environmental sustainability and improves the quality of life in the Batu Ampar industrial area.

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REFERENCE

Al-Kodmany, K. (2022). Sustainable High-Rise Buildings: Toward Resilient Built Environment. *Frontiers in Sustainable Cities*, *4*(April), 1–13. https://doi.org/10.3389/frsc.2022.782007

Ananditya, K. (2017). Implementasi Arsitektur Berkelanjutan pada Strategi Perancangan Rusunawa di Surakarta. *Arsitektura*, *15*(2), 455. https://doi.org/10.20961/arst.v15i2.12840

Aprianto, F. I., Laksmiyanti, D. P. E., Poedjioetami, E., & Laksono, S. H. (2024). Tatanan Lahan Rumah Susun untuk Masyarakat Berpenghasilan Rendah Melalui Pendekatan Sustainable Architecture. *Tekstur (Jurnal Arsitektur)*, *5*(1), 11–24. https://doi.org/10.31284/j.tekstur.2024.v5i1.5035

Avesta, R., Putri, A. D., Hanifah, R. A., Hidayat, N. A., & Dunggio, M. D. (2017). Strategi Desain Bukaan terhadap Pencahayaan Alami untuk Menunjang Konsep Bangunan Hemat Energi pada Rusunawa Jatinegara Barat. *Jurnal Rekayasa Hijau*, *1*(2), 124–135. https://doi.org/10.26760/jrh.v1i2.1633

Budi, J. B. S., Fifthariski, K., Yuliani, S., & Setyaningsih, W. (2018). Strategy of Green Design Implementation for Optimizing of the Natural Ventilation At High-Rise Building. *Arsitektura*, *16*(2), 155. https://doi.org/10.20961/arst.v16i2.20780

Chandra, Z. A. P., & Ariyanti, M. (2021). Strategi Pemasaran Pada Rumah Susun BP Batam. *Jurnal Ecodemica Jurnal Ekonomi Manajemen Dan Bisnis*, *5*(2), 123–130. https://doi.org/10.31294/eco.v5i2.10186

Dinas Perumahan permukiman dan Pertamanan Kota Batam. (2021). *Rencana Strategis Dinas Perumahan Rakyat, Permukiman dan Pertamanan Kota Batam Tahun 2021-2026*. 1–95.

Gupta, V., & Deb, C. (2023). Envelope design for low-energy buildings in the tropics: A review. *Renewable and Sustainable Energy Reviews*, *186*(November 2022), 113650. https://doi.org/10.1016/j.rser.2023.113650

Laksmiyanti, D. P. E., & Poedjioetami, E. (2021). Application of Ecological Architecture Concepts to Industrial Villages in Surabaya (Case Study: Gundih Village). *Opsi*, *14*(1), 59. https://doi.org/10.31315/opsi.v14i1.3958

Mandani, S., Mustaqimah, U., & Marlina, A. (2023). Penerapan Prinsip Arsitektur Hijau Pada Desain Rusunawa Di Kabupaten Pati. *Juli*, *6*(2), 739–750. https://jurnal.ft.uns.ac.id/index.php/senthong/index

Perera, U. S., Weerasuriya, A. U., Zhang, X., Ruparathna, R., Tharaka, M. G. I., & Lewangamage, C. S. (2025). Selecting suitable passive design strategies for residential high-rise buildings in tropical climates to minimize building energy demand. *Building and Environment*, *267*(PB), 112177. https://doi.org/10.1016/j.buildenv.2024.112177

Pradani, D. P., Rahayu, M. J., & Putri, R. A. (2017). Klasifikasi Karakteristik Dampak Industri Pada Kawasan Permukiman Terdampak Industri Di Cemani Kabupaten Sukoharjo. *Arsitektura*, *15*(1), 215. https://doi.org/10.20961/arst.v15i1.12166

Rencana Pembangunan Jangka Menengah Kota Batam Tahun 2021-2026, 231 (2021).

Setiawan, N., & Bella, P. A. (2023). Studi Dampak Operasional Zona Industri Ke Hunian Sekitar (Objek Studi Koridor Jl. Daan Mogot, Tangerang). *Jurnal Sains, Teknologi, Urban, Perancangan, Arsitektur (Stupa)*, *4*(2), 2991–3002. https://doi.org/10.24912/stupa.v4i2.22460

Sujana, A., Prasetia, T., Primadi, I., Alkhairi, L., & Dian, D. (2016). Standar Ukuran dan Fungsi Ruang Bersama Pada Rusunawa Cimindi. *Reka Karsa*, *XX*(Xx), 1–11.

Tisnawati, E., Suparno, S., & Ulya Nur Rahmah Ellyanando, A. (2024). Sustainable Vertical Housing Based on Social and Cultural Activities. *International Journal of Engineering Technology and Natural Sciences*, *6*(1), 75–83. https://doi.org/10.46923/ijets.v6i1.348

Ulima, Y. A. (2024). Perancangan Rusunawa dengan Pendekatan Arsitektur Berkelanjutan di Rawa Buaya, Cengkareng, Jakarta Barat. *Jurnal Arsitektur Wastu Padma*, *2*(2), 089–097. https://doi.org/10.62024/jawp.v2i2.39

Undang-Undang Republik Indonesia Nomor 20 Tahun 2011 Tentang Rumah Susun (2011).

Wulandari, A., & Pasaribu, R. (2023). *Local Engineering Journal of Local Architecture and Civil Engineering-NC-SA 4.0 DEED) license*. *1*(1). https://doi.org/10.59810/localengineering

DOI: http://doi.org/10.17509/jaz.v8i3.88432
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