



A Climate-Responsive Building for the New Guayaquil: Integrated Environmental Design

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ABSTRACT

The relocation of Guayaquil's international airport has created a unique opportunity for urban regeneration through the development of New Guayaquil, a large-scale masterplan intended to transform the former airport site into a new mixed-use district. Within this context, this thesis explores the design of a climate-responsive mixed-use building that responds to the urban, environmental, and technical conditions of the site.

Guayaquil's hot-humid tropical climate presents significant challenges for contemporary architecture due to high temperatures, persistent humidity, intense solar radiation, and a strong dependence on mechanical cooling systems. The research investigates how passive design strategies can improve thermal comfort and reduce cooling demand while supporting the broader objectives of the masterplan.

The methodology combines urban and site analysis, climate assessment, case study research, architectural design development, environmental simulations, and preliminary structural design. Through an iterative design process, the proposal is evaluated in terms of environmental performance, urban integration, and technical feasibility.

The final project reinterprets selected principles of Guayaquil's vernacular architecture within a contemporary mixed-use building designed for the future development of New Guayaquil. The research demonstrates how integrated design approaches can contribute to more climate-responsive, connected, and resilient urban environments while reducing dependence on mechanical cooling systems.

Climate-Responsive Design; Mixed-Use Building; Urban Regeneration; Tropical Architecture; Passive Design Strategies; Environmental Performance; Integrated Design; New Guayaquil

ABSTRACT

La delocalizzazione dell'aeroporto internazionale di Guayaquil ha creato un'opportunità unica di rigenerazione urbana attraverso lo sviluppo di New Guayaquil, un masterplan su larga scala finalizzato alla trasformazione dell'ex area aeroportuale in un nuovo distretto a uso misto. In questo contesto, la presente tesi esplora la progettazione di un edificio mixed-use climate-responsive in grado di rispondere alle condizioni urbane, ambientali e tecniche del sito.

Il clima tropicale caldo-umido di Guayaquil presenta sfide significative per l'architettura contemporanea a causa delle elevate temperature, dell'umidità persistente, dell'intensa radiazione solare e della forte dipendenza dai sistemi di raffrescamento meccanico. La ricerca indaga come le strategie passive possano migliorare il comfort termico e ridurre il fabbisogno di raffrescamento, contribuendo al contempo agli obiettivi più ampi del masterplan.

La metodologia combina analisi urbana e del sito, studio delle condizioni climatiche, analisi di casi studio, sviluppo del progetto architettonico, simulazioni ambientali e una progettazione strutturale preliminare. Attraverso un processo progettuale iterativo, la proposta viene valutata in termini di prestazioni ambientali, integrazione urbana e fattibilità tecnica.

Il progetto finale reinterpreta alcuni principi dell'architettura vernacolare di Guayaquil all'interno di un edificio contemporaneo a uso misto pensato per il futuro sviluppo di New Guayaquil. La ricerca dimostra come un approccio progettuale integrato possa contribuire alla realizzazione di ambienti urbani più resilienti, connessi e sensibili alle condizioni climatiche, riducendo al contempo la dipendenza dai sistemi di raffrescamento meccanico.

Acknowledgement

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INDEX

ABSTRACT	2
ACKNOWLEDGEMENT	5
CHAPTER 1: INTRODUCTION AND RESEARCH FRAMEWORK	17
1.1 Overview	18
1.2 Problem statement	19
1.3 Goals	20
Specific objectives	20
1.4 Research questions	20
1.5 Scope and limitations	21
1.6 Methodology	22
CHAPTER 2: CONTEXT OF GUAYAQUIL	25
2.1 Introducing guayaquil	26
Geographical context	26
2.2 Overview of the climatic context of guayaquil	27
2.2.1 Temperature	28
2.2.2 Wind patterns	29
2.2.3 Humidity	30
2.2.4 Precipitation	30
2.2.5 Impermeable surfaces and ground conditions	31
2.2.6 Solar radiation	32
2.2.7 Urban heat island effect	33
2.3 Urban morphology and architectural evolution	34
2.3.1 Historical patterns of construction in guayaquil	36
2.3.2 Construction systems and materials today	39
2.4 New guayaquil city masterplan	40
CHAPTER 3: URBAN AND SITE ANALYSIS	45
3.1 Definition of the study area	46
3.1.1 Analysis area extent and planning assumptions	47
3.2 Site analysis	48
3.2.1 Land use	48
3.2.2 Road network and public transportation	49
3.2.3 Local climate and comfort	50
3.2.4 Built up system	51
3.3 Constraints map	52

3.4 Resource map	53
3.5 Swot	54
3.6 Case studies	56
CHAPTER 4: URBAN DESIGN	61
4.1 Vision	62
4.1.1 Strategies	63
4.2 Concept plan	65
4.3 Masterplan	66
CHAPTER 5: ARCHITECTURAL DESIGN	69
5.1 Local identity	70
5.2 Project strategy	74
5.3 Building parameters	74
5.4 Massing optionering	75
5.5 Case studies	76
5.6 Programme	80
5.7 Strategies	81
5.8 Funtional distribution	82
5.9 Residential typologies	83
5.10 Architectural drawings	89
5.11 Architectural visualizations	101
5.12 Pasive strategies	106
5.13 Active strategies	108
CHAPTER 6: STRUCTURAL DESIGN	111
6.1 Structural design criteria	112
6.2 Structural system description	113
6.3 Geotechnical assumptions and foundation strategy	116
6.4 Representative structural assessment approach	118
6.5 Load analysis	119
6.6 Load combination	120
6.7 Representative structural bay selection	121
6.8 Preliminary structural predimensioning criteria	122
6.9 Representative primary beam verification	122
6.10 Representative column verification	125

CHAPTER 7: ENERGY AND DAYLIGHT	128
7.1 Environmental design workflow	129
7.2 Energy focus and scope of the analysis	130
7.3 Simulation tools and model assumptions	130
7.4 Climate-based design criteria	131
7.5 Building radiation analysis	132
7.6 Selection of two façade case studies	134
7.7 Baseline model	137
7.8 Passive façade optimization scenarios	140
Window to wall ratio	141
Balcony / facade depth	142
Solar shading device	143
Envelope optimization	144
Opaque wall assembly	145
Improved glazing system	146
7.9 Optimized façade configuration	147
7.10 Final performance evaluation	148
7.11 Photovoltaic (pv) active strategy	149
7.12 Final combined energy impact	151
CHAPTER 8: CONCLUSIONS & RECOMMENDATIONS	157
REFERENCES	162

FIGURES TABLE

Chapter 1: Introduction and research framework

Figure 1. Methodology process. (Author, 2026).	22
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Chapter 2: Context of guayaquil

Figure 3. Nighttime panorama of Guayaquil. (Municipality of Guayaquil, 2014).	26
Figure 2. Geographic location of Ecuador within the American continent and its position on the Equator. (Author, 2026)	26
Figure 4. Köppen climate classification (Kottek, Grieser, Beck, Rudolf, & Rubel, 2006) (Wikipedia, Köppen climate classification, 2014)	27
Figure 5. Köppen climate classification (Kottek, Grieser, Beck, Rudolf, & Rubel, 2006) (Wikipedia, Köppen climate classification, 2014)	27
Figure 7. Hourly outdoor thermal comfort distribution throughout the year in Guayaquil. (Weatherspark 2026)	28
Figure 6. Average high and low temperatures in Guayaquil throughout the year. (Weatherspark 2026)	28
Figure 8. Average Wind Speed in Guayaquil. (Weatherspark 2026)	29
Figure 9. Average Wind Direction in Guayaquil. (Weatherspark 2026)	29
Figure 10. Annual outdoor humidity comfort levels in Guayaquil. (Weatherspark 2026)	30
Figure 11. Average Monthly Rainfall in Guayaquil. (Weatherspark 2026)	30
Figure 12. source: Guayaquil municipality	31
Figure 13. Guayaquil solar Radiation. (Wunderground.com 2026)	32
Figure 14. Average Daily Incident Shortwave Solar Energy in Guayaquil. (Weatherspark 2026)	32
Figure 15. source: Enteria, Santamouris and Eicker (2021), *Urban Heat Island (UHI) Mitigation: Hot and Humid Regions*, Springer.	33
Figure 16. Historical and contemporary views of Guayaquil's waterfront, illustrating the city's urban transformation over time. (Adapted from Archivo Histórico del Guayas and municipal photographic archives.)	34
Figure 17. Crecimiento y asentamiento de las invasiones a lo largo del tiempo en la ciudad de guayaquil. (El universo, 2012)	35
Figure 20. 1925. Palacio de la Gobernación del Guayas.	36
Figure 19. 1896. Guayaquil after the fire.	36
Figure 18. Vernacular architecture in the early guayaquil	36
Figure 23. 1943. Luis Vernaza hospital	37
Figure 21. 1925. Palacio de la Gobernación del Guayas.	37
Figure 22. 1925. Mercado Sur, Guayaquil	37

Figure 26. 2012. The point Building	38
Figure 25. 1995. La previsora	38
Figure 24. 1979. Policentro Comercial center	38
Figure 27. Image of the new Guayaquil's Masterplan. (Eastman, 2018)	40
Figure 28. Districs of the masterplan (Eastman, 2018)	41
Figure 29. Masterplan. (Eastman, 2018)	42
Figure 30. Districs of the masterplan (Eastman, 2018)	42
Figure 31. Districs of the masterplan (Eastman, 2018)	43

Chapter 3: Urban and site analysis

Figure 32. Map of Guayaquil. (Author, 2026).	46
Figure 33. Project site location within the urban context. (Author, 2026).	47
Figure 34. Land use map. (Author, 2026).	48
Figure 35. Road network and public transportation map. (Author, 2026).	49
Figure 36. Key transportation hubs located near the project site. (Author compilation, 2026).	49
Figure 37. Local climate and comfort map. (Author, 2026)	50
Figure 38. Project site within its immediate urban context. (Author, 2026).	51
Figure 39. Constraints map.(Author, 2026)	52
Figure 40. Resource map.(Author, 2026)	53
Figure 42. Existing mono-functional residential fabric and underperforming public realm.(Google Maps Street View, 2026)	56
Figure 41. Urban context and functional zoning of Barrio del Aeropuerto, illustrating its isolation between airport infrastructure, industrial estates, and major transport corridors. (Adapted from C40 Reinventing Cities, 2026.)	56
Figure 43. Proposed masterplan illustrating the urban restructuring strategy and spatial reorganization of Barrio del Aeropuerto. (C40 Reinventing Cities, 2026.)	57
Figure 44. Key urban regeneration strategies derived from the Barrio del Aeropuerto case study. (Author)	57
Figure 46. Masterplan of Roma Tuscolana 1379 illustrating the proposed urban restructuring strategy. (AFK Studios, 2024.)	58
Figure 45. Existing rail corridor and urban context of the Roma Tuscolana 1379 site. (C40 Reinventing Cities, 2026.)	58
Figure 48. Conceptual transition from a transport-oriented area to an active urban destination through increasing levels of permanence and urban activity. (Author, 2026).	59
Figure 47. Strategies diagram. (Source: AFK Studios, 2024.)	59

Chapter 4: Urban design

Figure 49. Project vision, objectives, and design strategies developed for the intervention. (Author, 2026).	62
Figure 50. Urban mobility strategies integrating multimodal accessibility, active transportation networks, and traffic reorganization within the masterplan. (Author, 2026).	63
Figure 51. Blue-green infrastructure strategies connecting the urban fabric with the riverfront through public spaces, ecological corridors, and climate-responsive landscape design. (Author, 2026).	63
Figure 52. Architectural development strategies supporting urban activation, mixed-use growth, and climate-responsive building performance. (Author, 2026).	64
Figure 53. Key spatial components of the masterplan. (Author, 2026).	64
Figure 54. Concept plan (Author, 2026)	65
Figure 55. Masterplan proposal (Author, 2026)	66
Figure 56. Masterplan systems and spatial organization. (Author, 2026).	67
Figure 57. Traditional residential architecture in Guayaquil.	68

Chapter 5: Architectural design

Figure 58. Visual interpretation of Guayaquil's historic local identity through its traditional domestic architecture: wooden façades, shaded porticos, galleries, balconies, shutters, central patios, tropical vegetation, color, and the commercial street life of the port city. (Author, 2026)	70
Figure 60. Sectional perspective of a traditional Guayaquil house, highlighting the portico, commercial ground floor, gallery, and central patio. (Author, 2026)	71
Figure 59. Typical layout of a traditional urban house in Guayaquil. (Peralta González, 2014).	71
Figure 61. Architectural and cultural references from Guayaquil. (Author compilation, 2026).	72
Figure 62. Translation of vernacular elements into contemporary design strategies. (Author, 2026).	73
Figure 64. Building parameters and regulatory framework for the proposed development. (Author, 2026).	74
Figure 63. Mixed-use programme strategy. (Author, 2026).	74
Figure 65. Massing optioneering study evaluating the influence of building shape, height, and orientation on cooling demand intensity (kWh/m ² ·yr) under Guayaquil climatic conditions. (Author, 2026)	75
Figure 66. Exterior view of the School of Design and Environment 4. (Serie Architects, 2019.)	76
Figure 67. Sectional diagram illustrating SDE4's integrated passive and active environmental strategies. National University of Singapore, 2019)	77

Figure 68. SDE4 hybrid environmental cooling strategy. (National University of Singapore, 2019.)	77
Figure 69. Exterior view of Kampung Admiralty, highlighting its mixed-use vertical organization and integrated greenery. (WOHA Architects, 2018.)	78
Figure 70. Climatic strategy diagrams of Kampung Admiralty showing passive cooling, shading, and integrated vegetation systems. (Source: WOHA Architects, 2018.)	78
Figure 71. Programmatic sectional diagram of Kampung Admiralty showing its vertical mixed-use layering and integrated communal landscape. (Source: WOHA Architects, 2018.)	79
Figure 72. Architectural program organization of the proposed mixed-use building. (Author, 2026)	80
Figure 73. Architectural development strategies of the project. (Author, 2026).	81
Figure 74. Programme evolution of the project. (Author, 2026).	81
Figure 75. Functional distribution of the proposed mixed-use programme. (Author, 2026).	82
Figure 76. Apartment typology A.1. (Author, 2026).	83
Figure 77. Apartment typology A.2. (Author, 2026).	84
Figure 78. Apartment typology B. (Author, 2026).	85
Figure 79. Apartment typology C. (Author, 2026).	86
Figure 80. Apartment typology D. (Author, 2026).	87
Figure 81. Apartment typology E. (Author, 2026).	88
Figure 82. Underground plan. (Author, 2026).	89
Figure 83. Grounfloor plan. (Author, 2026).	90
Figure 84. First floor plan. (Author, 2026).	91
Figure 85. Second floor plan. (Author, 2026).	92
Figure 86. Residencial typical floor plan. (Author, 2026).	93
Figure 87. Roof floor plan. (Author, 2026).	94
Figure 88. Section A.A. (Author, 2026).	95
Figure 89. Section B.B. (Author, 2026).	96
Figure 90. Section C.C. (Author, 2026).	97
Figure 91. Section D.D. (Author, 2026).	98
Figure 93. South-west elevation. (Author, 2026).	99
Figure 92. South-east elevation. (Author, 2026).	99
Figure 95. North elevation. (Author, 2026).	100
Figure 94. East elevation. (Author, 2026).	100
Figure 96. Waterfront view of the proposed mixed-use development. (Author, 2026).	101
Figure 97. Aerial view of the project within the masterplan context. (Author, 2026).	101
Figure 98. Riverfront public promenade and building frontage. (Author, 2026).	102
Figure 99. Nighttime view of the project along the Guayas River waterfront. (Author, 2026).	102
Figure 100. Central courtyard as the social and environmental core of the building. (Author, 2026).	103

Figure 101. Ground-floor public space and courtyard interface. (Author, 2026).	103
Figure 102. Open gallery circulation overlooking the central courtyard. (Author, 2026).	104
Figure 103. Perspective view from the Guayas River waterfront. (Author, 2026).	104
Figure 104. Main urban frontage and pedestrian-oriented public realm. (Author, 2026).	105
Figure 105. Passive design strategies implemented during daytime operation. (Author, 2026).	106
Figure 106. Nighttime passive strategies supporting thermal comfort and natural ventilation. (Author, 2026).	106
Figure 107. Active systems integrated to improve building energy performance. (Author, 2026).	108
Figure 108. Nighttime active strategies for energy efficiency and building operation. (Author, 2026).	108

Chapter 6: Structural design

Figure 109. Ecuadorian seismic hazard zoning. (Adapted by the author from NEC-SE-DS (2015).)	112
Figure 110. Structural zoning and separation of the building into independent structural blocks. (Author, 2026).	113
Figure 111. Commercial floor typical structural plan. (Author, 2026).	114
Figure 112. Residential floor typical structural plan. (Author, 2026).	115
Figure 113. Conceptual foundation strategy illustrating the proposed piled raft system	116
Figure 114. Structural layout of the underground level. (Author, 2026).	117
Figure 115. Representative structural sector selected for preliminary structural evaluation. (Author, 2026).	118
Figure 116. Table of permanent loads	119
Figure 117. Live loads. (Author, 2026).	120
Figure 118. Representative structural bay selected for preliminary beam and column verification. (Author, 2026).	121
Figure 120. Materials assumptions. (Author, 2026).	122
Figure 119. Preliminary structural predimensioning criteria. (Author, 2026).	122
Figure 121. Representative beam selected for preliminary structural verification and sizing. (Author, 2026).	123
Figure 122. Representative column selected for preliminary structural verification and sizing. (Author, 2026).	125
Figure 123. Load calculation process for the representative column. (Author, 2026).	126

Chapter 7: Energy and daylight

Figure 124. Energy and daylight assessment workflow. (Author, 2026).	129
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Figure 125. Climate-based design criteria guiding the environmental response of the project. (Author, 2026).	131
Figure 126. Monthly solar exposure distribution. (Author, 2026).	132
Figure 127. Simplified building model used for whole-building solar radiation analysis. (Author, 2026).	132
Figure 128. Orientation-based façade classification used for solar exposure assessment. (Author, 2026).	132
Figure 129. Annual solar radiation analysis of the East façade. (Author, 2026).	133
Figure 130. Annual solar radiation analysis of the South-East façade. (Author, 2026).	133
Figure 131. Annual solar radiation analysis of the South-West façade. (Author, 2026).	133
Figure 132. Annual solar radiation analysis of the North façade. (Author, 2026).	133
Figure 133. Solar incidence pattern during the summer solstice. (Author, 2026).	134
Figure 134. Solar incidence pattern during the winter solstice. (Author, 2026).	134
Figure 135. Solar incidence pattern during the equinox. (Author, 2026).	134
Figure 136. Selection of representative apartment units for the comparison of façade orientations and solar exposure conditions. (Author, 2026).	135
Figure 137. Simplified apartment models used as representative façade case studies. (Author, 2026).	136
Figure 138. Main parameters and modelling decisions for the representative apartment unit case studies. (Author, 2026).	136
Figure 139. Baseline configuration and internal load assumptions used for the representative residential simulation model. (Author, 2026).	137
Figure 140. Baseline external wall assembly. (Author, 2026).	138
Figure 141. Baseline internal wall assembly. (Author, 2026).	138
Figure 142. Baseline floor slab assembly. (Author, 2026).	139
Figure 143. Baseline single clear glazing system. (Author, 2026).	139
Figure 144. Comparison of annual cooling demand, window solar gains, and total energy use intensity (EUI) for the baseline apartment model under east- and north-facing orientations. (Author, 2026).	140
Figure 145. Window-to-wall ratio (WWR) scenarios evaluated during the façade optimization process. (Author, 2026).	141
Figure 146. Comparative thermal performance of WWR scenarios under baseline conditions. (Author, 2026).	141
Figure 147. Comparative daylight performance of the three WWR scenarios under identical simulation conditions. (Author, 2026).	142
Figure 148. Balcony depth scenarios evaluated as integrated shading strategies for the residential façade. (Author, 2026).	142
Figure 150. Solar shading device scenarios evaluated as integrated shading strategies for the residential façade. (Author, 2026).	143
Figure 149. Comparative thermal performance of balconies scenarios under	

baseline conditions. (Author, 2026).	143
Figure 151. Comparative thermal performance of external shading device scenarios under baseline conditions. (Author, 2026).	144
Figure 152. Opaque wall assemblies evaluated during the envelope optimization process. (Author, 2026).	145
Figure 153. Impact of wall insulation thickness on cooling demand and annual energy use intensity (EUI). (Author, 2026).	145
Figure 155. Comparative performance of the baseline and improved façade configurations. (Author, 2026).	146
Figure 154. Improved double-glazing system selected for the optimized façade configuration. (Author, 2026).	146
Figure 156. Summary of the baseline and optimized façade configurations. (Author, 2026).	147
Figure 157. Comparative thermal performance of the baseline and final optimized façade configurations. (Author, 2026).	147
Figure 159. Simplified whole-building energy models used for the baseline and improved performance assessment. (Author, 2026).	148
Figure 158. Overall reduction in cooling demand and annual EUI achieved through the optimized façade design. (Author, 2026).	148
Figure 160. Comparison of total annual energy use and cooling energy demand for the baseline and improved building models. (Author, 2026).	149
Figure 162. Summary of whole-building performance improvements achieved through passive optimization and photovoltaic integration. (Author, 2026).	149
Figure 161. Annual Energy Use Intensity (EUI) comparison between the baseline and improved building scenarios. (Author, 2026).	149
Figure 165. PVGIS simulation interface used to assess solar resource availability and photovoltaic generation potential for the project site in Guayaquil. (Source: PVGIS, 2026).	150
Figure 163. Rooftop surfaces considered for photovoltaic integration. (Author, 2026).	150
Figure 164. Monthly PV electricity generation estimated through PVGIS for the proposed rooftop system. (European Commission PVGIS / Author elaboration). (Author, 2026).	150
Figure 166. Photovoltaic contribution to operational demand. (Author, 2026).	151
Figure 167. Annual electricity demand comparison between the baseline, passive optimization, and final net-demand scenarios after photovoltaic integration. (Author, 2026).	151
Figure 168. Representative façade section and material composition of the final optimized building envelope. (Author, 2026).	153
Figure 169. Representative façade render. (Author, 2026).	153
Figure 170. DT01 – Residential Roof detail. (Author, 2026).	154
Figure 171. DT02 – Commercial façade detail. (Author, 2026).	155
Figure 172. DT03 - Ground-floor detail. (Author, 2026).	156

Chapter 1:

Introduction and research framework

1.1 OVERVIEW

Cities are constantly evolving in response to social, economic, and environmental transformations. As urban areas expand, new districts emerge, creating opportunities to rethink the relationship between mobility, public space, buildings, and community life. These transformations require architectural responses that not only accommodate future growth but also contribute to the creation of functional, comfortable, and resilient urban environments.

In Guayaquil, the development of the Nes Guayaquil Masterplan represents one of the most significant urban interventions currently proposed for the city. Located in the former airport site and connected to major transportation infrastructure, the masterplan is expected to become an important urban node that combines residential, commercial, and public functions. This new condition presents both opportunities and challenges, particularly regarding the integration of urban activity, environmental performance, and quality of life.

At the same time, the climatic conditions of Guayaquil strongly influence the way buildings are designed and operated. High temperatures, elevated humidity levels, and intense solar exposure often increase the dependence on mechanical cooling systems, making energy consumption an important consideration in the design process. Consequently, architectural strategies that improve thermal comfort and reduce cooling demand become essential components of sustainable urban development.

Within this context, this thesis explores the design of a mixed-use building for the new Guayaquil's development. The research investigates how urban, architectural, environmental, and structural considerations can be integrated into a single proposal that responds to both the characteristics of the site and the needs of future users. The project seeks to balance spatial quality, urban integration, environmental responsiveness, and technical feasibility.

The research combines urban analysis, architectural design, environmental evaluation, and preliminary structural development to propose a building that contributes to the ongoing transformation of the district. Through this approach, the project aims to demonstrate how architecture can support the creation of more livable and climate-responsive urban environments while reducing dependence on mechanical cooling through passive design strategies adapted to the local context.

1.2 PROBLEM STATEMENT

The transformation of the former airport area into New Guayaquil creates an important opportunity for the city, but it also raises several design challenges. The site is expected to become a new urban district with residential, commercial, public, and recreational functions; however, its future success depends on more than the redistribution of land uses. A project of this scale must also address how buildings relate to public space, how people move through the district, and how the built environment responds to the local climate.

In Guayaquil, these issues are particularly relevant because urban growth has often produced fragmented public spaces, car-oriented areas, and buildings that depend heavily on mechanical cooling. The hot and humid climate, combined with high solar exposure and urban heat accumulation, makes thermal comfort one of the main challenges for both indoor and outdoor spaces. As a result, many contemporary buildings tend to rely on air-conditioning as the primary response to environmental discomfort, instead of integrating passive strategies from the beginning of the design process.

At the same time, the development of the masterplan requires an architectural response that is not only environmentally efficient, but also functional, structurally coherent, and connected to its urban context. The challenge is therefore not limited to reducing energy consumption, but to designing a building where urban integration, spatial quality, climatic performance, and technical feasibility work together.

This thesis addresses this problem through the design of a climate-responsive mixed-use building for guayaquil's development. The project explores how architectural form, program, passive strategies, environmental evaluation can be integrated into a single proposal. In this way, the building is understood as part of the broader transformation of the district, contributing to a more livable urban environment while reducing dependence on mechanical cooling.

1.3 GOALS

The main goal of this thesis is to develop a climate-responsive mixed-use building for the “New Guayaquil” that integrates urban, architectural, environmental, and structural considerations into a coherent design proposal adapted to the local context, while serving as a reference and source of inspiration for future developments in the district.

Specific objectives

1. To analyze the urban, environmental, and climatic conditions of New Guayaquil in order to identify the opportunities and constraints that influence the design process.
2. To investigate architectural precedents, local construction practices, and climate-responsive design strategies relevant to the tropical context of Guayaquil.
3. To develop a mixed-use architectural proposal that integrates residential, commercial, and shared functions while responding to the characteristics of the site and its surrounding urban context.
4. To incorporate passive design strategies that improve thermal comfort and reduce dependence on mechanical cooling systems in the hot-humid climate of Guayaquil.
5. To evaluate the proposal through environmental simulations and preliminary structural development to ensure its technical feasibility and environmental performance.

1.4 RESEARCH QUESTIONS

How can a climate-responsive building contribute to the development of the New Guayaquil while responding to the urban, environmental, and technical conditions of the site?

1.5 SCOPE AND LIMITATIONS

This research focuses on the design of a climate-responsive mixed-use building within the New Guayaquil Masterplan. The study integrates urban analysis, climatic assessment, architectural design, environmental evaluation, and preliminary structural development in order to propose a building adapted to the specific conditions of the site and its future urban context.

The scope of the research includes the analysis of the surrounding urban environment, the development of the architectural proposal, the incorporation of passive environmental strategies, and the evaluation of their impact on building performance through environmental simulations. In addition, a preliminary structural strategy is developed to verify the technical feasibility of the proposed design and ensure consistency between architectural and structural requirements.

However, the research does not include detailed structural calculations, complete mechanical, electrical, and plumbing (MEP) design, cost analysis, construction planning, or the development of a full-scale urban masterplan. Similarly, although environmental performance is evaluated, the project is not intended to achieve or certify a specific building standard. Instead, the environmental analysis is used as a design tool to support architectural decision-making and reduce dependence on mechanical cooling systems within the tropical climate of Guayaquil.

1.6 METHODOLOGY

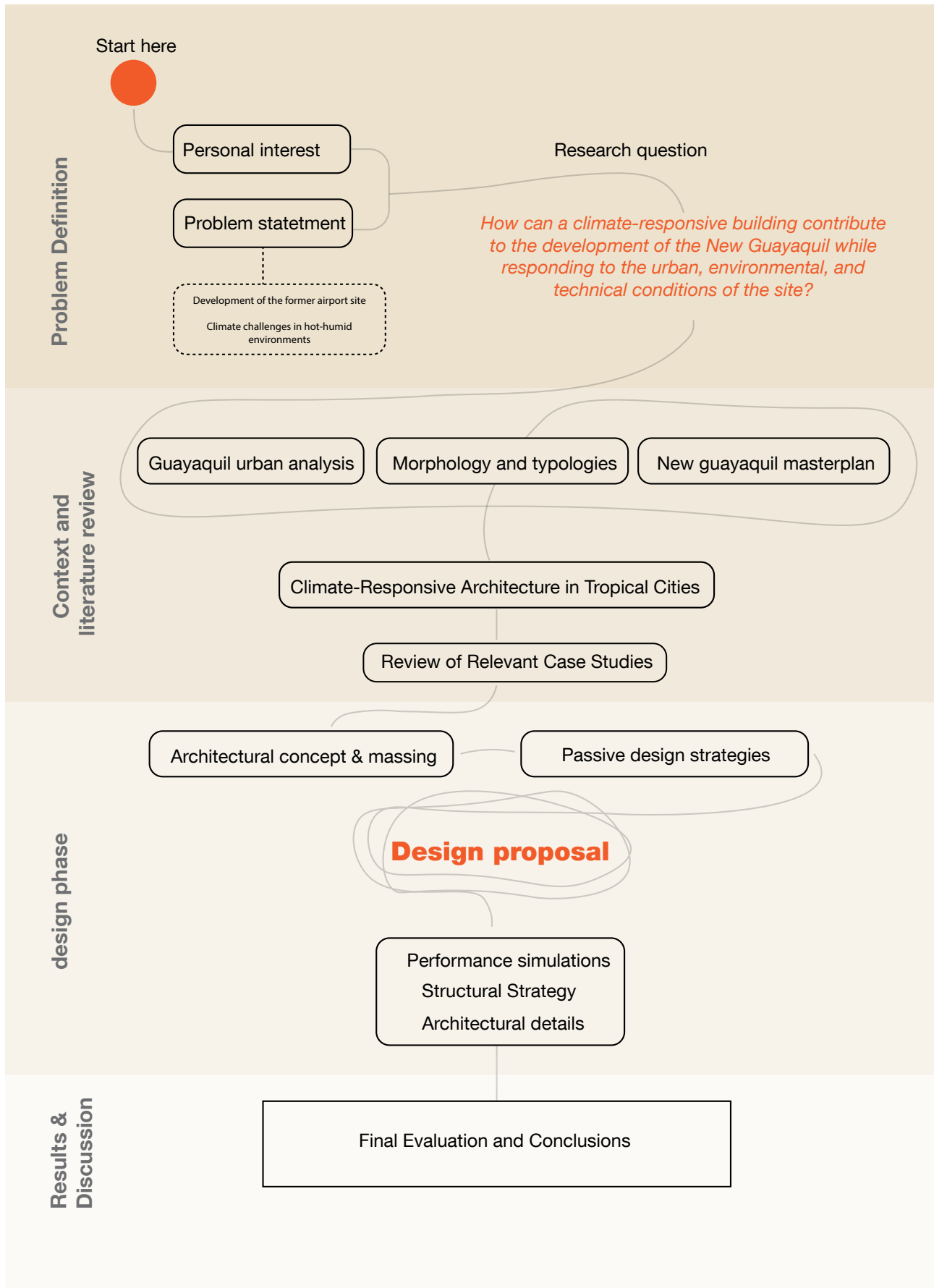


Figure 1. Methodology process. (Author, 2026).

Chapter 1 – Introduction and Research Framework defines the research topic, problem statement, main goal, research question, scope, and methodology. It introduces the thesis as an integrated design proposal for a climate-responsive mixed-use building within the context of New Guayaquil.

Chapter 2 – Urban and Climatic Context examines Guayaquil’s geographical condition, climatic context, urban morphology, architectural evolution, and the New Guayaquil Masterplan. This chapter establishes the broader urban and environmental background for the project.

Chapter 3 – Urban and Site Analysis provides a focused assessment of the selected study area. It analyses land use, mobility, local climate and comfort, built-up conditions, constraints, resources, SWOT analysis, and urban case studies that inform the design strategy.

Chapter 4 – Urban Design presents the urban vision, concept plan, strategies, and proposed plan for the intervention area. It defines how the project responds to the surrounding district and contributes to the transformation of New Guayaquil.

Chapter 5 – Architectural Design develops the building proposal, including local identity, reinterpretation of Guayaquil’s vernacular architecture, program definition, building parameters, massing studies, case studies, strategies, functional distribution, and architectural plans.

Chapter 6 – Structural Design presents the structural criteria and preliminary structural development of the proposal. It includes the structural system description, geotechnical assumptions, foundation strategy, load analysis, structural bay selection, and preliminary verification of representative beams and columns.

Chapter 7 – Energy and Daylight evaluates the environmental performance of the proposal. It defines the simulation workflow, energy scope, model assumptions, climate-based design criteria, building radiation analysis, and the effect of passive strategies on cooling demand and daylight performance.

Chapter 8 – Conclusions summarizes the main findings of the research and reflects on the contribution of the project. It discusses how an integrated urban, architectural, structural, and environmental approach can support the development of more climate-responsive buildings for New Guayaquil.

Chapter 2:

Context of guayaquil

2.1 INTRODUCING GUAYAQUIL

Geographical context

Guayaquil is Ecuador's largest urban agglomeration and the main port of the country, with a metropolitan population exceeding three million inhabitants (INEC, 2022). The city is located on the southwestern coast of Ecuador, along the Guayas River delta, approximately 50 kilometers from the Pacific Ocean. It lies just below the Equator line, within a broad tropical lowland that connects the Andean foothills with the coastal plain. This position has historically made Guayaquil a key territorial node linking the Sierra and Costa regions, as well as an important point of exchange between inland production areas and international maritime routes.



Figure 2. Geographic location of Ecuador within the American continent and its position on the Equator. (Author, 2026)



Figure 3. Nighttime panorama of Guayaquil. (Municipality of Guayaquil, 2014).

The city's historic core developed along the eastern bank of the Guayas River, forming a dense urban fabric characterized by a mix of colonial and early modern architecture. In contrast, the western edge, facing the Estero Salado, remained largely natural until the mid-20th century, when new infrastructure and residential projects began to extend the city's limits. Iconic landmarks such as Santa Ana Hill, Las Peñas, and the Malecón 2000 waterfront reflect Guayaquil's evolution from a port settlement to a modern metropolitan center that combines commercial activity, cultural heritage, and public space regeneration (BID, 2019).

Today, Guayaquil's urban identity is defined by its relationship with water, climate, and trade. Its riverside orientation continues to shape the city's urban form and landscape, while its equatorial location influences architectural and infrastructural development. The constant exposure to high humidity, heat, and intense solar radiation makes climate-responsive design an essential consideration for contemporary urban and architectural projects, particularly within large-scale developments such as New Guayaquil.

2.2 OVERVIEW OF THE CLIMATIC CONTEXT OF GUAYAQUIL

Guayaquil's climate plays a fundamental role in shaping both its urban environment and the performance of its buildings. As a coastal city located just south of the Equator, it is exposed to consistently warm temperatures, high humidity, and strong seasonal contrasts in precipitation. These climatic conditions have a direct impact on thermal comfort, energy consumption, and the design strategies that are suitable for the local context.

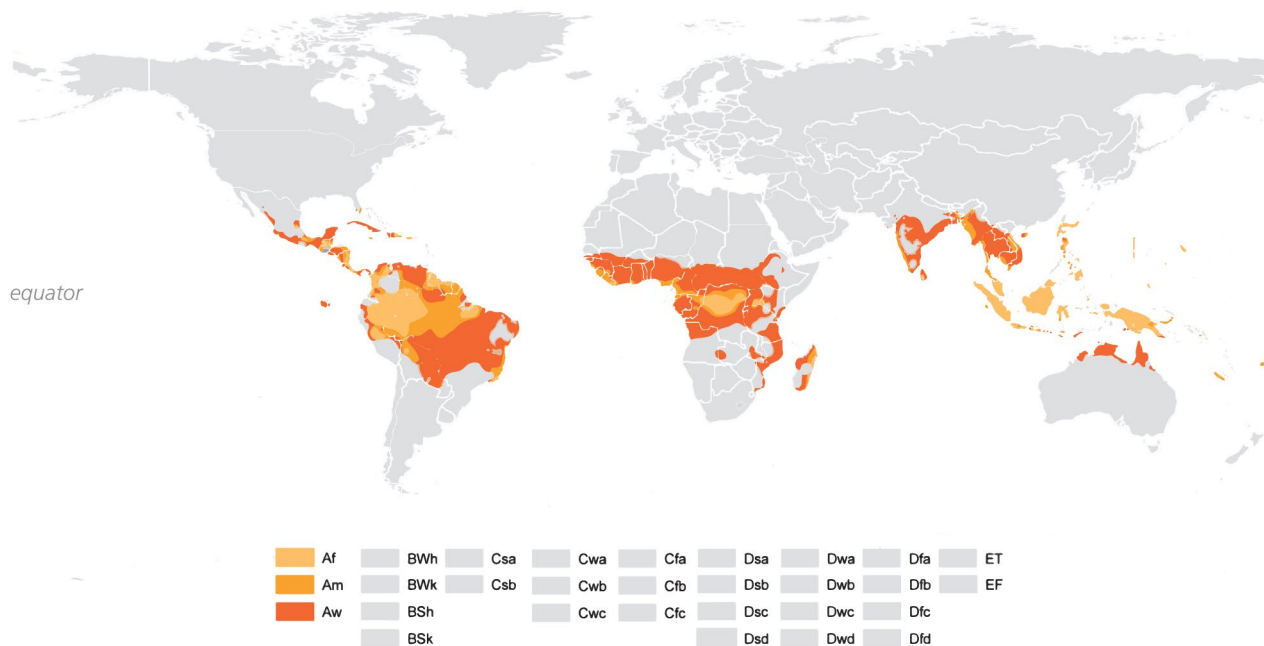


Figure 4. Köppen climate classification (Kottek, Grieser, Beck, Rudolf, & Rubel, 2006) (Wikipedia, Köppen climate classification, 2014)

Type	Description	Criterion
A	Equatorial climates	Minimum Temperature $\geq 18^{\circ}\text{C}$
Af	Equatorial rainforest, fully humid	Minimum Precipitation ≥ 60 mm
Am	Equatorial monsoon	Annual Precipitation $25(100 \text{ Pmin})$
As	Equatorial savannah with dry summer	Minimum Precipitation < 60 mm in summer
Aw	Equatorial savannah with dry winter	Minimum Precipitation < 60 mm in winter

Figure 5. Köppen climate classification (Kottek, Grieser, Beck, Rudolf, & Rubel, 2006) (Wikipedia, Köppen climate classification, 2014)

According to the Köppen–Geiger climate classification, Guayaquil is located within the tropical climatic belt and presents characteristics associated with equatorial and tropical savannah transitional conditions, shaped by its equatorial latitude, coastal position, and proximity to the Pacific Ocean. This climatic context is defined by consistently elevated solar exposure, high atmospheric moisture, and marked seasonal precipitation patterns, which collectively influence urban microclimatic behavior and building environmental performance. As highlighted by Kottek et al. (2006), tropical climate zones are characterized by environmental conditions that require context-responsive architectural strategies, particularly in relation to solar control, natural ventilation, and moisture management. Understanding this climatic framework is essential for informing architectural decisions related to orientation, solar protection, natural ventilation, material selection, and thermal comfort. These environmental conditions establish the parameters that guide the design strategies developed throughout the project.

2.2.1 Temperature

Guayaquil's thermal conditions remain remarkably stable throughout the year, reflecting the absence of pronounced seasonal variation typical of equatorial climates. Average outdoor temperatures consistently remain within a narrow range, with daytime highs generally around 30°C and only minor fluctuations between the warmest and coolest months. This thermal consistency confirms that the local design challenge is not seasonal adaptation, but rather the continuous mitigation of heat gains and overheating throughout the year.

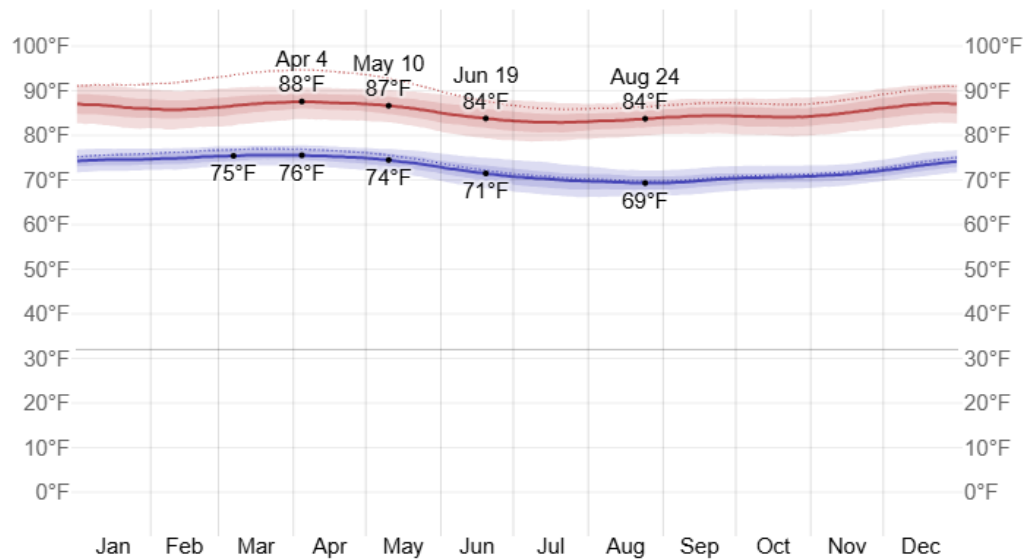


Figure 6. Average high and low temperatures in Guayaquil throughout the year. (Weatherspark 2026)

Beyond average monthly temperatures, the hourly thermal comfort distribution reveals that outdoor conditions remain above conventional comfort thresholds for a significant portion of the day, particularly during afternoon hours when solar gains and ambient heat accumulation peak. Comfortable outdoor conditions are largely limited to early morning and nighttime periods, emphasizing the importance of designing building envelopes and spatial configurations capable of buffering daytime heat and facilitating passive cooling during cooler nocturnal hours. These conditions highlight the importance of incorporating passive cooling measures, solar protection, and building configurations that minimize heat gains while taking advantage of the more favorable thermal conditions available during nighttime periods.

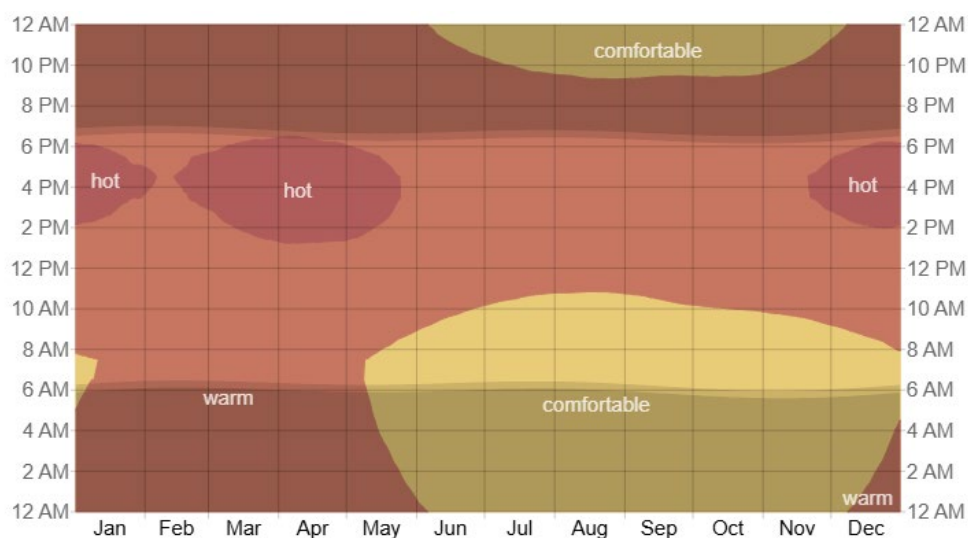


Figure 7. Hourly outdoor thermal comfort distribution throughout the year in Guayaquil. (Weatherspark 2026)

2.2.2 Wind Patterns

Guayaquil presents moderate wind speeds throughout the year, with average values generally ranging between 6 and 10 mph, and slightly stronger winds occurring during the drier season. Although wind intensity remains relatively stable annually, the prevailing wind direction shows a clear predominance from the west, with minor seasonal variation. This consistent wind pattern offers favorable conditions for the implementation of passive ventilation strategies, particularly through the orientation of openings and circulation spaces toward the dominant airflow direction. However, given the high humidity levels characteristic of the local climate, air movement should be understood primarily as a means of improving perceived thermal comfort rather than substantially reducing air temperature. Consequently, the integration of cross-ventilation paths, permeable transitional spaces, and ventilated internal courtyards becomes a relevant design strategy within the proposed architectural response (Givoni, 1998; Koenigsberger et al., 2010).

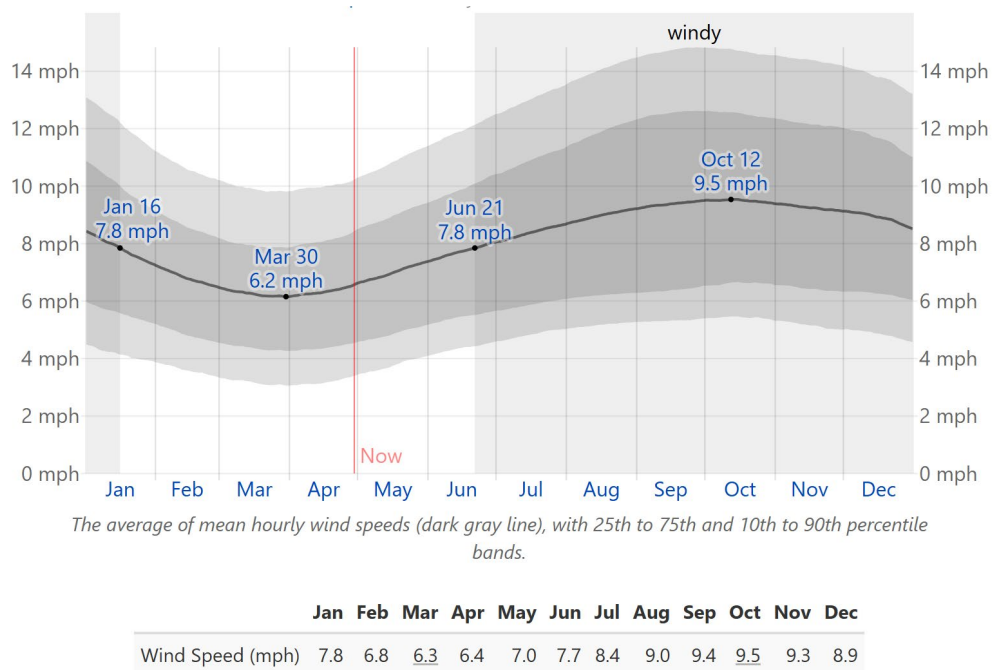


Figure 8. Average Wind Speed in Guayaquil. (Weatherspark 2026)

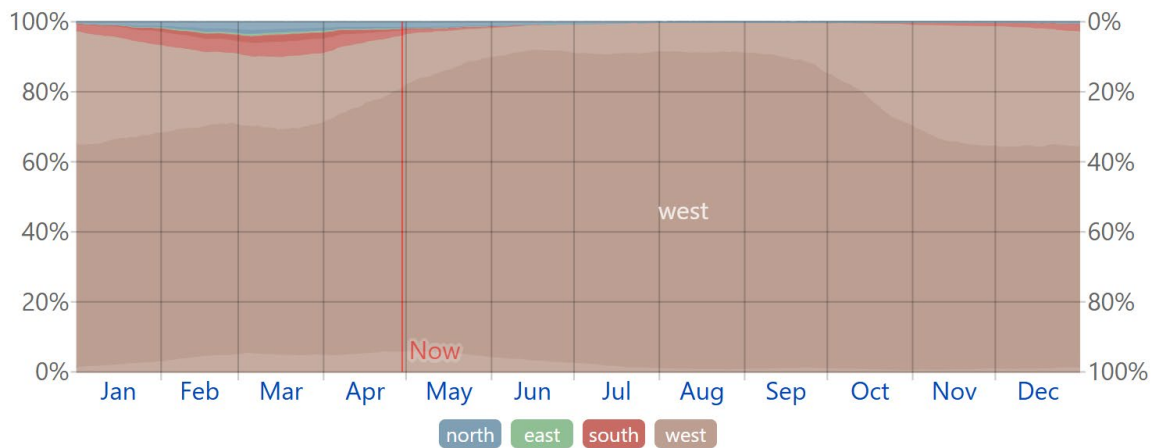


Figure 9. Average Wind Direction in Guayaquil. (Weatherspark 2026)

2.2.3 Humidity

Guayaquil experiences persistently high levels of atmospheric humidity throughout the year, with outdoor conditions remaining predominantly within the humid to muggy range and reaching oppressive levels during the wetter months. The highest discomfort associated with humidity occurs between January and April, when moisture content and perceived thermal stress significantly increase. Even during the relatively drier season, atmospheric humidity remains elevated compared to temperate climates, limiting the effectiveness of passive cooling strategies based solely on air movement. These conditions reinforce the need for design approaches that combine natural ventilation with solar protection, moisture-resistant materials, and strategies aimed at reducing latent heat accumulation within interior spaces (Givoni, 1998; Koenigsberger et al., 2010).

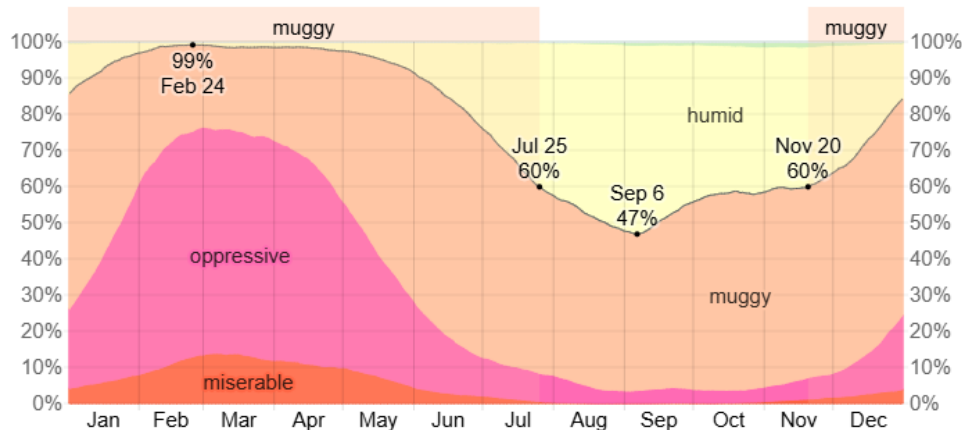


Figure 10. Annual outdoor humidity comfort levels in Guayaquil. (Weatherspark 2026)

2.2.4 Precipitation

Guayaquil presents a marked seasonal precipitation regime characterized by a pronounced wet season and an extended dry period throughout the year. Rainfall peaks between January and April, with the highest monthly averages occurring in February, while precipitation decreases drastically from June through November, reaching near-arid conditions during the driest months. This strong seasonal contrast influences both urban and architectural responses, requiring buildings to accommodate intense rainfall events during the wet season while maintaining effective environmental performance during prolonged dry periods. Consequently, roof design, drainage systems, water management strategies, and protected transitional spaces become critical components in the architectural response to the local climate (Koenigsberger et al., 2010).

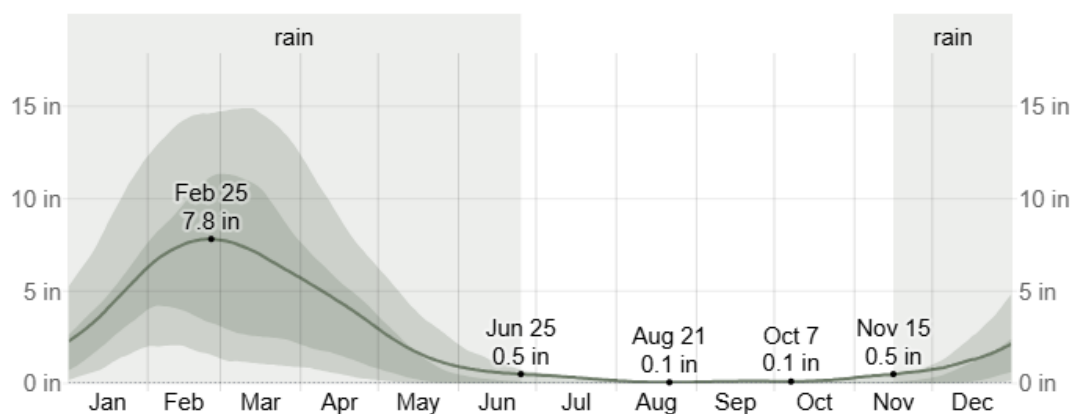


Figure 11. Average Monthly Rainfall in Guayaquil. (Weatherspark 2026)

2.2.5 Impermeable Surfaces and Ground Conditions

The former airport site is currently characterized by extensive impermeable surfaces, including roads, service areas, parking lots, and building footprints. This configuration limits evapotranspiration and contributes to increased surface temperatures and reduced microclimatic resilience, as widely documented in studies on urban climate and land-cover change (Oke et al., 2017; Santamouris, 2015). In addition, the prevalence of impermeable surfaces increases vulnerability to surface runoff and local flooding during intense rainfall events, which are common in the climatic context of Guayaquil (UN-Habitat, 2020).

These conditions highlight the importance of integrating permeable surfaces, shaded outdoor areas, and landscape-based solutions as effective strategies to mitigate thermal accumulation and improve environmental performance at the site scale, particularly in hot-humid urban environments (Givoni, 1998; Szokolay, 2014).

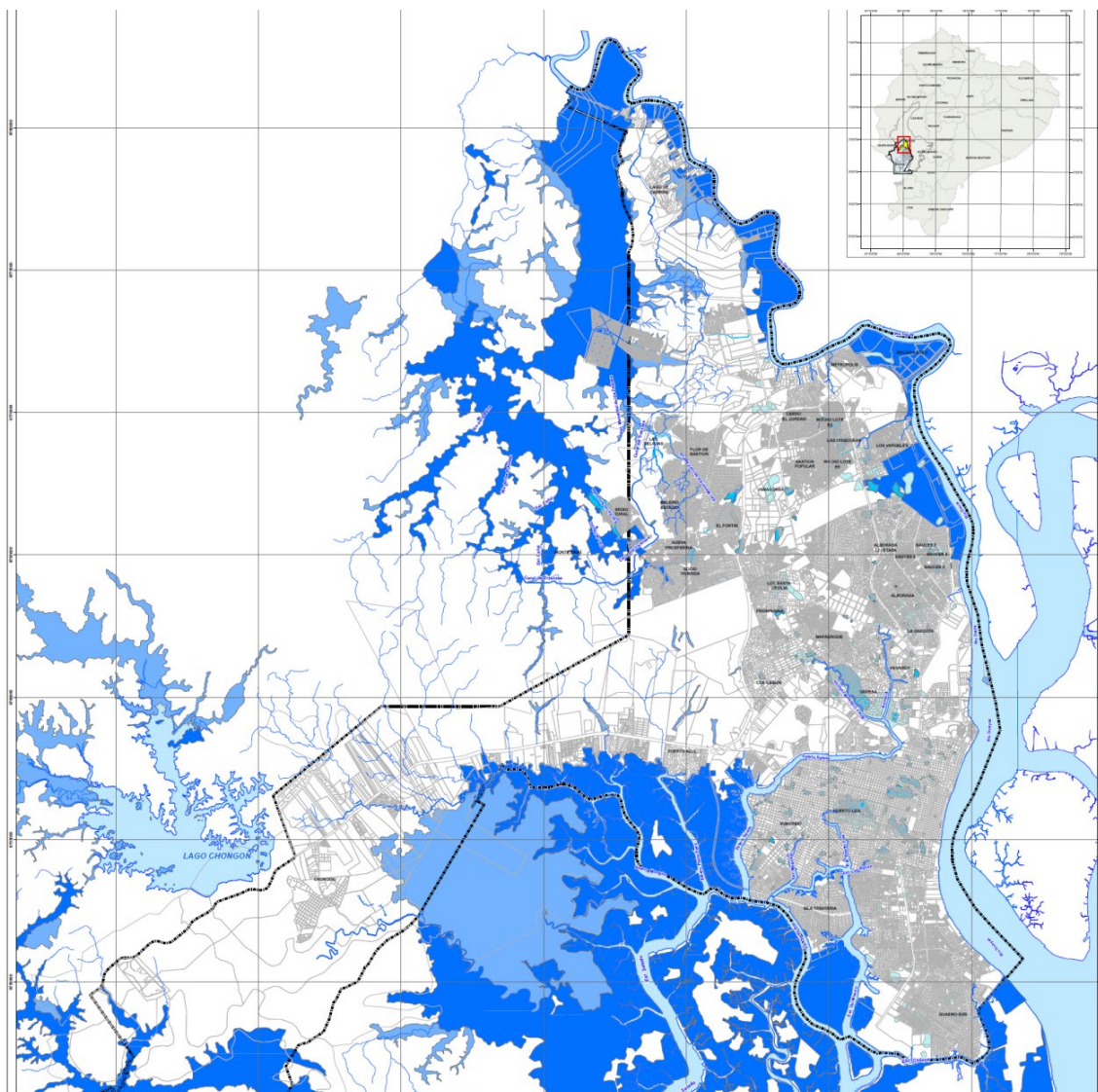


Figure 12. source: Guayaquil municipality

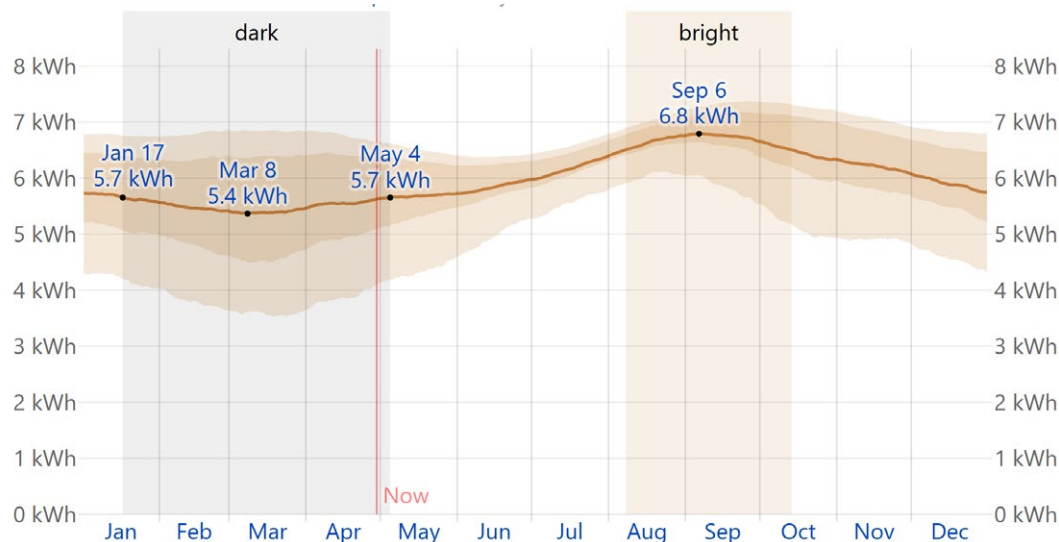
2.2.6 Solar Radiation

Due to its equatorial latitude, Guayaquil is exposed to high levels of solar radiation throughout the entire year, with limited seasonal fluctuation in incident solar energy. This consistent exposure results in continuous solar heat gains on building envelopes, making solar control a primary design consideration regardless of season. Unlike temperate climates, where solar gains may be beneficial during colder periods, in Guayaquil solar radiation constitutes a persistent thermal load that must be mitigated through architectural and envelope-based strategies.



Figure 13. Guayaquil solar Radiation. (Wunderground.com 2026)

The solar radiation data further indicate that daily shortwave solar energy remains elevated across all months, with peak values occurring during the drier season between August and October, when cloud cover is reduced and sky conditions become clearer. Even during the wetter months, incident solar radiation remains substantial, confirming that façade and roof exposure require year-round protection. These conditions support the implementation of permanent shading systems, recessed openings, ventilated envelope layers, and protected transitional spaces as fundamental components of the building's environmental response (Olgay, 2015; Givoni, 1998).



The average daily shortwave solar energy reaching the ground per square meter (orange line), with 25th to 75th and 10th to 90th percentile bands.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Solar Energy (kWh)	5.7	5.5	5.4	5.6	5.7	5.9	6.2	6.6	6.7	6.5	6.2	5.9

Figure 14. Average Daily Incident Shortwave Solar Energy in Guayaquil. (Weatherspark 2026)

2.2.7 Urban Heat Island Effect

The study area exhibits characteristics commonly associated with the urban heat island effect, primarily driven by high surface impermeability, extensive asphalted areas, and low vegetation coverage. Large roofs, parking areas, and transport infrastructure absorb and re-radiate heat, leading to higher ambient temperatures, particularly during daytime and early evening hours (Oke et al., 2017).

These conditions intensify cooling demand and reduce outdoor thermal comfort, especially in pedestrian areas. Previous studies on tropical urban environments highlight surface albedo, vegetation cover, and material thermal properties as critical factors for mitigating local thermal stress (Santamouris, 2015).

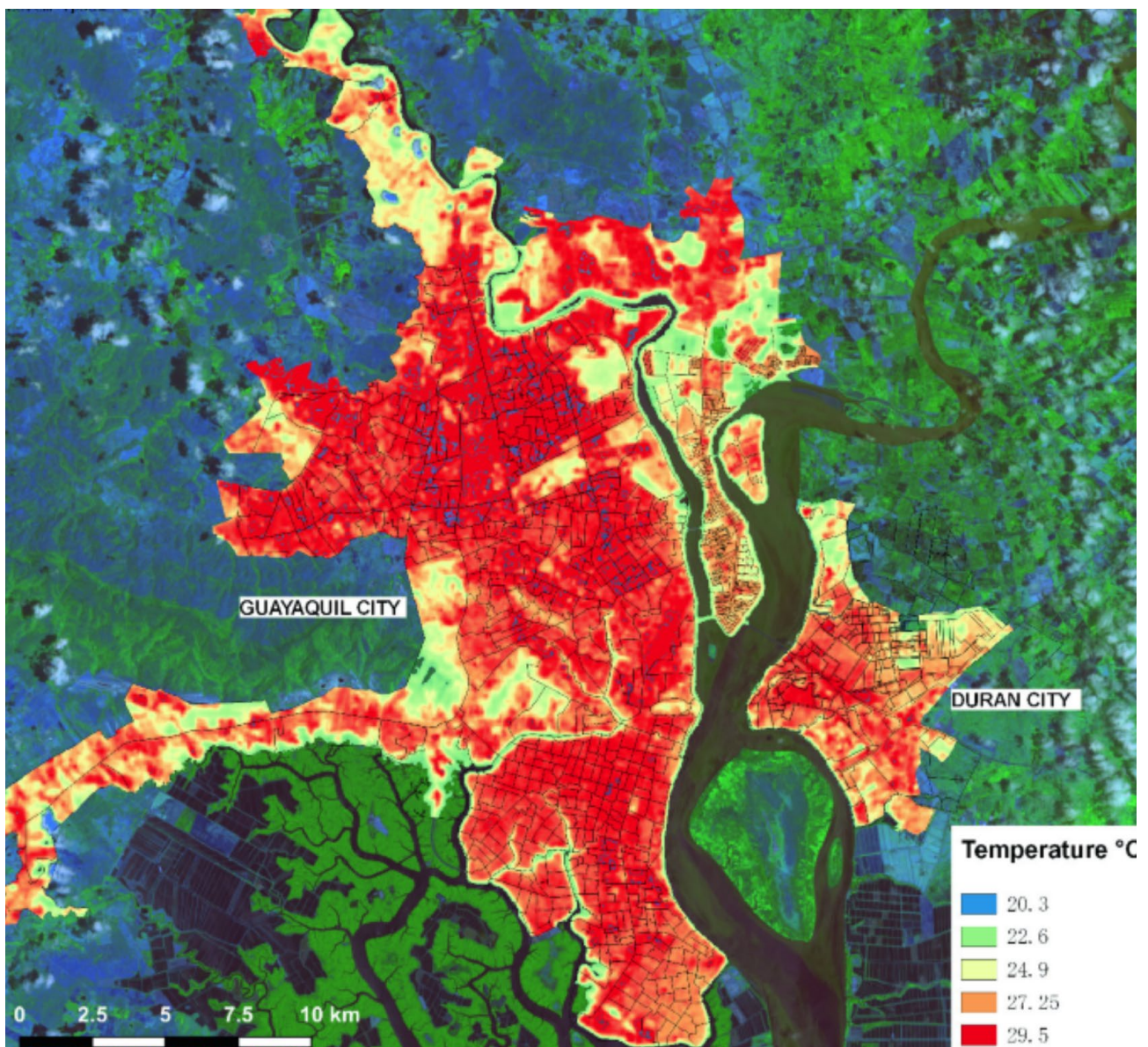


Figure 15. source: Enteria, Santamouris and Eicker (2021), **Urban Heat Island (UHI) Mitigation: Hot and Humid Regions**, Springer.

Overall, Guayaquil's climate imposes significant challenges for building performance:

**No heating demand,
High cooling loads,
Persistent humidity,
Low wind availability,
High solar exposure.**

These climatic conditions highlight the need for architectural strategies that improve thermal comfort while reducing dependence on mechanical cooling systems. Passive measures such as solar protection, natural ventilation, shaded transitional spaces, and climate-responsive envelope design become essential components of the architectural response. Understanding these environmental constraints provides the foundation for the design decisions developed throughout this research.

2.3 URBAN MORPHOLOGY AND ARCHITECTURAL EVOLUTION

Migration from the highlands, port-driven growth, and industrial development stimulated urbanization but also resulted in uncontrolled territorial expansion. Since the 1950s, the city's footprint has grown by almost five times its original size, gradually incorporating nearby municipalities such as Durán, Daule, and Samborombón (BID, 2019). This metropolitan growth occurred largely without coordinated planning instruments, generating fragmented settlement patterns, long commuting distances, and unequal access to public services.



Figure 16. Historical and contemporary views of Guayaquil's waterfront, illustrating the city's urban transformation over time. (Adapted from Archivo Histórico del Guayas and municipal photographic archives.)

Informal settlements played a significant role in this expansion. During the 1980s and 1990s, large areas of low-lying and environmentally fragile land—particularly along the Estero Salado and sections of the Guayas basin—were occupied without adequate infrastructure or sanitation systems (ONU-Hábitat, 2020). The reduction of green and mangrove areas, combined with increasing impervious surfaces, has intensified the urban heat-island effect, leading to elevated cooling demand and higher electricity consumption across residential districts (MAATE, 2021; Ludeña et al., 2021).

As a result, Guayaquil's metropolitan structure today is characterized by spatial inequality, infrastructure pressures, and increasing environmental challenges. These conditions highlight the need for integrated urban and architectural approaches capable of improving connectivity, public space quality, environmental performance, and long-term urban resilience.

This relocation creates the opportunity for the redevelopment of the former airport site, which later becomes the focus of the New Guayaquil Masterplan. Guayaquil has begun extending key infrastructure toward peripheral areas. One of the most significant initiatives is the construction of the new international airport in Daular, located southwest of the current urban center. This project is intended to meet future metropolitan needs and reduce pressure on the existing consolidated city, where natural and built constraints limit further large-scale expansion

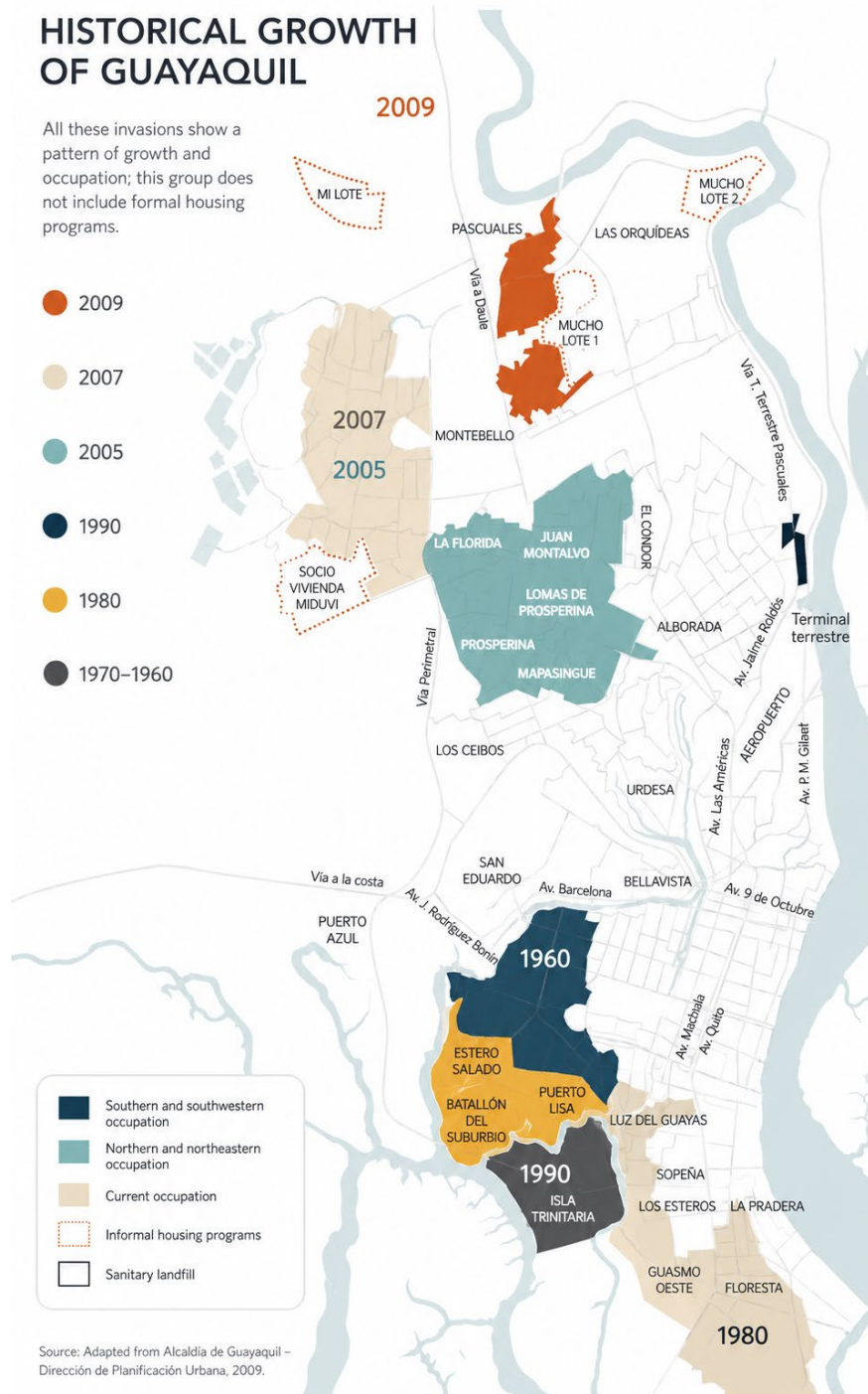


Figure 17. Crecimiento y asentamiento de las invasiones a lo largo del tiempo en la ciudad de guayaquil. (El universo, 2012)

2.3.1 Historical Patterns of Construction in Guayaquil

The architectural and construction history of Guayaquil reflects a complex interplay between environmental conditions, technological transitions, urban risks, and economic transformation. Over the past century, the city shifted from lightweight, climate-responsive vernacular structures to increasingly massive, industrialized and energy-intensive building typologies. Understanding this evolution is essential for contextualizing the material, thermal and functional challenges present in the contemporary built environment of the airport district. and fully glazed commercial buildings, the city now comprises typologies that perform poorly under tropical humidity and heat. Understanding this trajectory provides a valuable foundation for exploring contemporary architectural responses that reconnect functional requirements with the climatic realities of Guayaquil.

>1896

Vernacular Period



Figure 20. 1925. Palacio de la Gobernación del Guayas.

Early Guayaquil developed a highly adaptive architectural language suited to its humid tropical climate. Wooden houses elevated on stilts, with large operable openings, permeable facades, and shaded balconies, promoted cross-ventilation and reduced heat and moisture accumulation. These typologies—still partially observable in the historic areas of Las Peñas and Cerro Santa Ana—embodied principles of passive cooling, lightweight construction and climatic responsiveness (Urquiza, 2021). Their spatial and material qualities provided natural comfort without mechanical systems.



Figure 18. Vernacular architecture in the early guayaquil

1896

Guayaquil great fire

When a fire broke out in the commercial district of the city. Due to wooden buildings, strong winds, and the lack of effective firefighting systems, the fire spread rapidly.

The disaster destroyed a large part of Guayaquil's historic center.



Figure 19. 1896. Guayaquil after the fire.

Post-Fire Reconstruction

1896 - 1940

The Great Fire of 1896 triggered a profound transformation in building practices. Municipal authorities restricted combustible materials, encouraging the adoption of masonry, brick, cement blocks and early reinforced concrete systems. This period produced more compact, massive and fire-resistant buildings such as the Gobernación del Guayas (1920s), Club de la Unión (1930s) and Mercado Sur (1930s). While materially durable, these structures reduced porosity and ventilation, marking the early decline of climate-adapted design strategies (Bamba et al., 2021).



Figure 21. 1925. Palacio de la Gobernación del Guayas.



Figure 22. 1925. Mercado Sur, Guayaquil

Modernization and Reinforced Concrete

1940 - 1970

By the mid-20th century, reinforced concrete had become the dominant construction technology in Guayaquil, aligned with national modernization and urban growth. Buildings from this period—such as the Banco de Guayaquil (1950s), Filanbanco Tower (1960s) and institutional expansions like Hospital Luis Vernaza—featured heavy concrete frames, masonry infill, flat slabs and reduced openings. These typologies favored structural robustness and urban presence over climatic performance, often resulting in deeper floor plates and limited natural ventilation (Bajaña, 2020).



Figure 23. 1943. Luis Vernaza hospital

1970 - 2000

Industrial and Commercial Expansion

The acceleration of port activity, commercial development and logistic functions dramatically reshaped construction trends during this period. New building types included steel-framed warehouses with corrugated metal cladding, shopping centers and administrative blocks such as Policentro (1979) and La Previsora Tower (1991–1995). These buildings reflected the growing dependence on mechanically conditioned environments, prioritizing internal comfort through air-conditioning rather than through passive climatic adaptation. As documented in studies of Guayaquil's urban expansion, this era consolidated a built environment characterized by large impermeable volumes and minimal climatic adaptation (UEES, 2020; Universidad de Guayaquil, 2020).



Figure 25. 1995. La previsora



Figure 24. 1979. Policentro Comercial center

2000 >

Contemporary Globalized Period

Recent decades have intensified these patterns. Developments such as the José Joaquín de Olmedo International Airport (2006), Mall del Sol (1997–2010 extensions), and the high-rise towers of Puerto Santa Ana illustrate a strong influence of globalized construction trends: extensive curtain walls, reinforced-concrete high-rise structures, metal-clad logistic facilities and compact commercial volumes. Research on material and energy trends in Ecuador confirms that contemporary buildings rely heavily on concrete, aluminum-glass envelopes and uninsulated metal systems, with insufficient attention to passive cooling or thermal resistance (Torres-Quezada et al., 2022). These characteristics contribute to elevated cooling demands and amplify urban heat island effects across Guayaquil.

Figure 26. 2012. The point Building



PRESENT

2.3.2 Construction Systems and Materials today

The construction systems commonly found in the airport district of Guayaquil reflect a cost-driven and time-efficient building culture, resulting in envelopes with limited thermal performance. The existing building stock is mainly characterised by three dominant systems: reinforced concrete frames with concrete block masonry infill, steel portal-frame structures with lightweight metal cladding and roofing, and aluminium–glass façades in commercial and office buildings (Zhindón Andrade, 2016; Sánchez et al., 2016). While these systems respond effectively to structural, functional, and economic requirements, they are typically implemented without thermal insulation, solar control strategies, or climate-responsive detailing. As a consequence, buildings exhibit high thermal transmittance, significant solar heat gains, and a strong dependence on mechanical cooling, particularly under Guayaquil’s hot-humid climatic conditions. These recurring construction patterns provide a representative understanding of the local building stock and establish the baseline assemblies used later in the environmental evaluation of the project.

The following tables summarise the representative construction assemblies of existing residential, mixed-use, and commercial buildings in Guayaquil, including typical materials, layer compositions, and thermal properties. The values presented in the following tables are derived from documented case studies and academic references and are used as reference assemblies for the environmental assessment developed later in the research.

WALLS	System / Assembly	Layer Description (ext → int) (mm)	Typical Thickness (mm)	Thermal Conductivity λ (W/mK)	U-value (W/m ² K)	Ecuador suppliers
	Hollow concrete block + plaster	Exterior plaster (15) + hollow concrete block (120) + interior plaster (15)	150	Block: 0.90–1.10	2.2–2.8	Holcim, UCEM; local block makers
	Solid concrete block + plaster	Exterior plaster (15) + solid concrete block (150) + interior plaster (15)	180	Block: 1.30–1.60	2.8–3.4	UCEM; prefabricados locales
	Hollow block + air cavity	Exterior plaster (15) + hollow block (120) + air cavity (30) + interior plaster (15)	180	—	1.6–2.0	Local contractors
	Hollow block + EPS insulation	Exterior plaster + hollow block (120) + EPS (40) + gypsum board / plaster	200	EPS: 0.035	0.55–0.75	Panelco, Termopanel Ecuador
	Gypsum board on metal studs	Gypsum board (12.5) + air/insulation (50–75) + gypsum board (12.5)	75–100	Gypsum: ~0.17	—	Local suppliers
	System / Assembly	Layer Description (ext → int) (mm)	Typical Thickness (mm)	Thermal Conductivity λ (W/mK)	U-value (W/m ² K)	Ecuador suppliers
SLABS	RC slab (uninsulated)	Concrete slab (200)	200	Concrete: 1.7	3.5–4.0	Holcim, UCEM
	Corrugated metal sheet (uninsulated)	Metal sheet (0.5) + air	—	Metal: ~50	5.0–6.5	Novacero, Ideal Alambrec
	Metal sheet + ventilated air layer	Metal sheet + ventilated air gap + ceiling	—	—	2.5–3.5	Local contractors
	Metal sheet + EPS insulation	Metal sheet + EPS (40–50) + ceiling	60–80	EPS: 0.035	0.45–0.65	Panelco, Termopanel Ecuador
	Sandwich panel PU (50 mm)	Steel + PU insulation + steel	50	PU: 0.024	0.35–0.45	Metecno Ecuador
	System / Assembly	Layer Description (ext → int) (mm)	U-value (W/m ² K)	SHGC	Visible Transmittance (Tv)	Ecuador suppliers
WINDOWS	Single clear glass	6 mm monolithic	5.6–5.8	0.80–0.85	~0.85	Vidriera Nacional; local glazing shops
	Single tinted glass	6 mm monolithic tinted	5.6	0.60–0.70	~0.50	Local glazing shops
	Double glazing	4–12–4	2.7–3.0	0.55–0.65	~0.70	Tecnoglass, local suppliers

The assemblies presented represent typical construction solutions commonly found in Ecuadorian residential, commercial, and mixed-use developments. Values are indicative and were used to establish representative baseline conditions for the environmental evaluation developed in this research.

2.4 NEW GUAYAQUIL CITY MASTERPLAN

As Guayaquil continued to expand toward its metropolitan periphery, the city faced increasing pressure on the consolidated urban fabric. The availability of large, centrally located plots became extremely limited, and opportunities for structured, sustainable growth within the existing city boundaries were scarce. In this context, the decision to relocate the international airport to Daular—situated outside the urban core—created an unprecedented opportunity for Guayaquil. By moving aviation operations to the outskirts, a vast and strategically positioned area was freed at the heart of the city, opening the possibility for a new phase of urban expansion that does not rely on peripheral sprawl (Municipio de Guayaquil, 2022).

The release of the former airport site introduced a unique scenario: a continuous tract of land, highly accessible, connected to major road corridors, and adjacent to consolidated neighbourhoods. Few Latin American cities have been able to reclaim such a centrally embedded space, capable of accommodating large-scale development while simultaneously restructuring internal urban dynamics. This condition shifted attention from outward expansion to the requalification and densification of the existing city, allowing Guayaquil to rethink its long-term spatial and environmental strategies.



240.5

Hectares

5%

of Guayaquil's current
population

134,903

Future users



Figure 27. Image of the new Guayaquil's Masterplan. (Eastman, 2018)

In response, the Municipality of Guayaquil, together with international planning teams, prepared the New Guayaquil's Masterplan, a comprehensive vision for transforming the former airport area into a compact, mixed-use urban district. The plan proposes a network of public spaces, mobility corridors, residential clusters, commercial zones, and

ecological restoration areas, seeking to integrate the site with surrounding neighbourhoods that historically developed around the airport perimeter (Perkins & Will, 2023). Its urban structure prioritizes pedestrian movement, public transport, and blue-green infrastructure, aiming to improve connectivity and reduce dependence on private vehicles



The area of the former international airport of Guayaquil, located west of the consolidated city center and adjacent to the Estero Salado, represents one of the most strategic sites for urban regeneration in Ecuador. With the relocation of airport operations to the new Daular terminal, this extensive plot of approximately 240 hectares became available for redevelopment (Perkins & Will, 2023). Its central location, connectivity through major avenues, and proximity to consolidated neighborhoods make it an exceptional opportunity to rethink the city's internal structure.



The proposed New Guayaquil Masterplan, designed by Perkins & Will in collaboration with the Municipality of Guayaquil, envisions the creation of a mixed-use, compact, and sustainable urban district. The plan aims to transform the former airport area into a model of integrated urban development, combining housing, public services, commercial activities, and green infrastructure. It prioritizes pedestrian mobility, public transportation, and energy-efficient buildings as key strategies for reducing emissions and improving the city's environmental performance (Perkins & Will, 2023).



The New Guayaquil Masterplan provides a unique opportunity to explore how architecture can contribute to the transformation of the former airport site into a vibrant mixed-use district. Within this context, the project developed in this research is conceived as a climate-responsive building that integrates urban, architectural, environmental, and structural considerations, contributing to the broader vision of a connected, livable, and environmentally responsive urban environment.

Figure 28. Districts of the masterplan (Eastman, 2018)



Figure 30. Districts of the masterplan (Eastman, 2018)



Figure 31. Districts of the masterplan (Eastman, 2018)

Chapter 3:

Urban and site analysis

3.1 DEFINITION OF THE STUDY AREA

The study area is defined in relation to the project site located in Guayaquil and is established as the spatial framework for the site and urban analysis developed in this chapter. In order to correctly evaluate the relationships between the project and its surroundings, the analysis focuses on the immediate urban context, understood as the portion of the city where infrastructure layout, building configuration, and land-use patterns directly affect spatial and environmental conditions at the architectural scale.

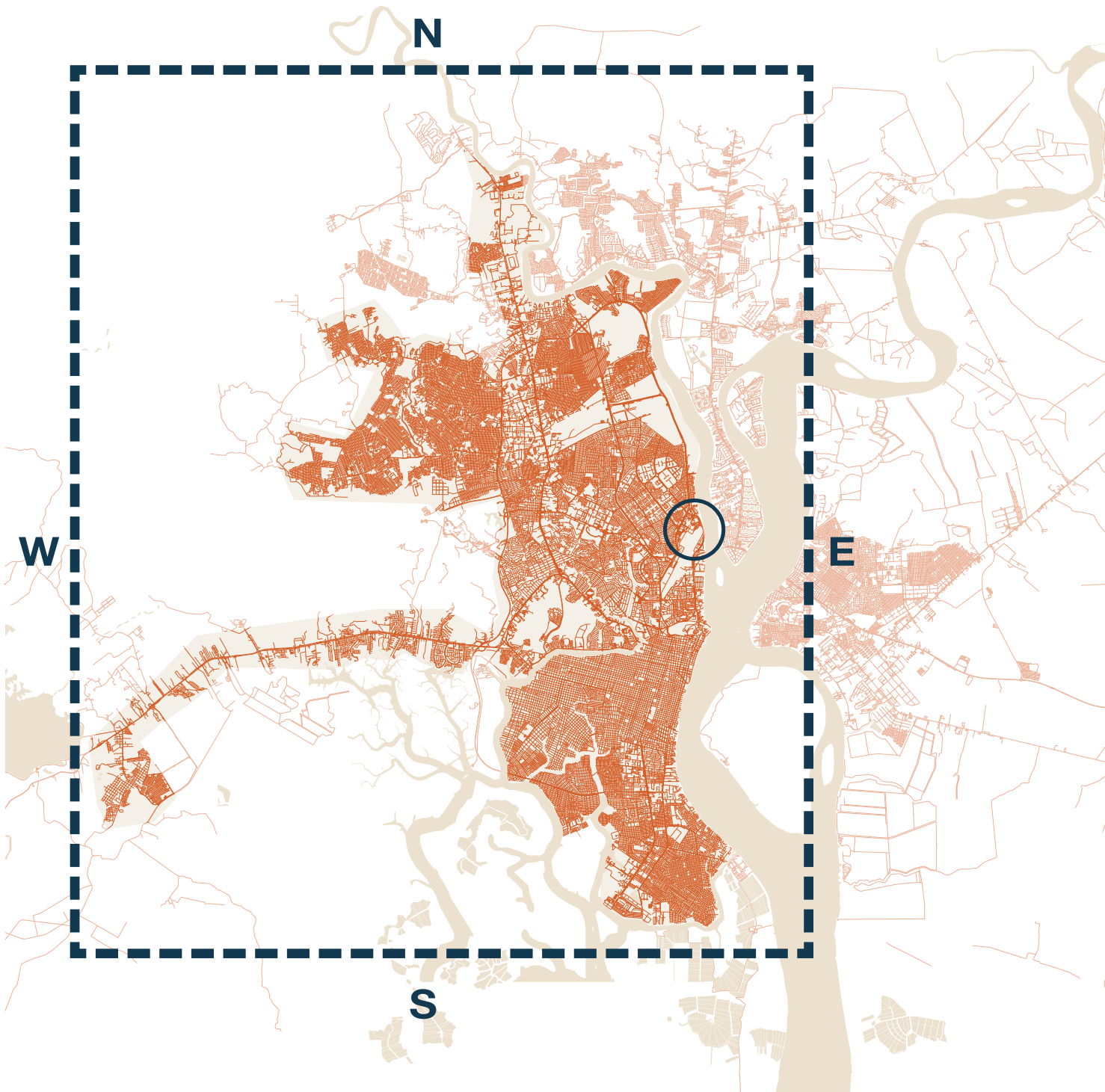


Figure 32. Map of Guayaquil. (Author, 2026).

3.1.1 Analysis area extent and planning assumptions

The study area is delineated through a perimeter extending approximately 300 to 600 metres from the project site. This range corresponds to the spatial scale at which the surrounding urban fabric exerts a direct influence on architectural, spatial, and environmental conditions relevant to the project. Within this distance, building massing and heights affect solar exposure and shading patterns, street layout and open spaces influence ventilation and pedestrian movement, and land-use distribution determines accessibility and functional relationships at the site scale.

For the purposes of this research, the analysis is conducted assuming the implementation of the New Guayaquil Masterplan as the reference planning scenario. Consequently, the proposed street network, mobility infrastructure, public transport routes, land-use regulations, and public space systems defined by the masterplan are taken as given.

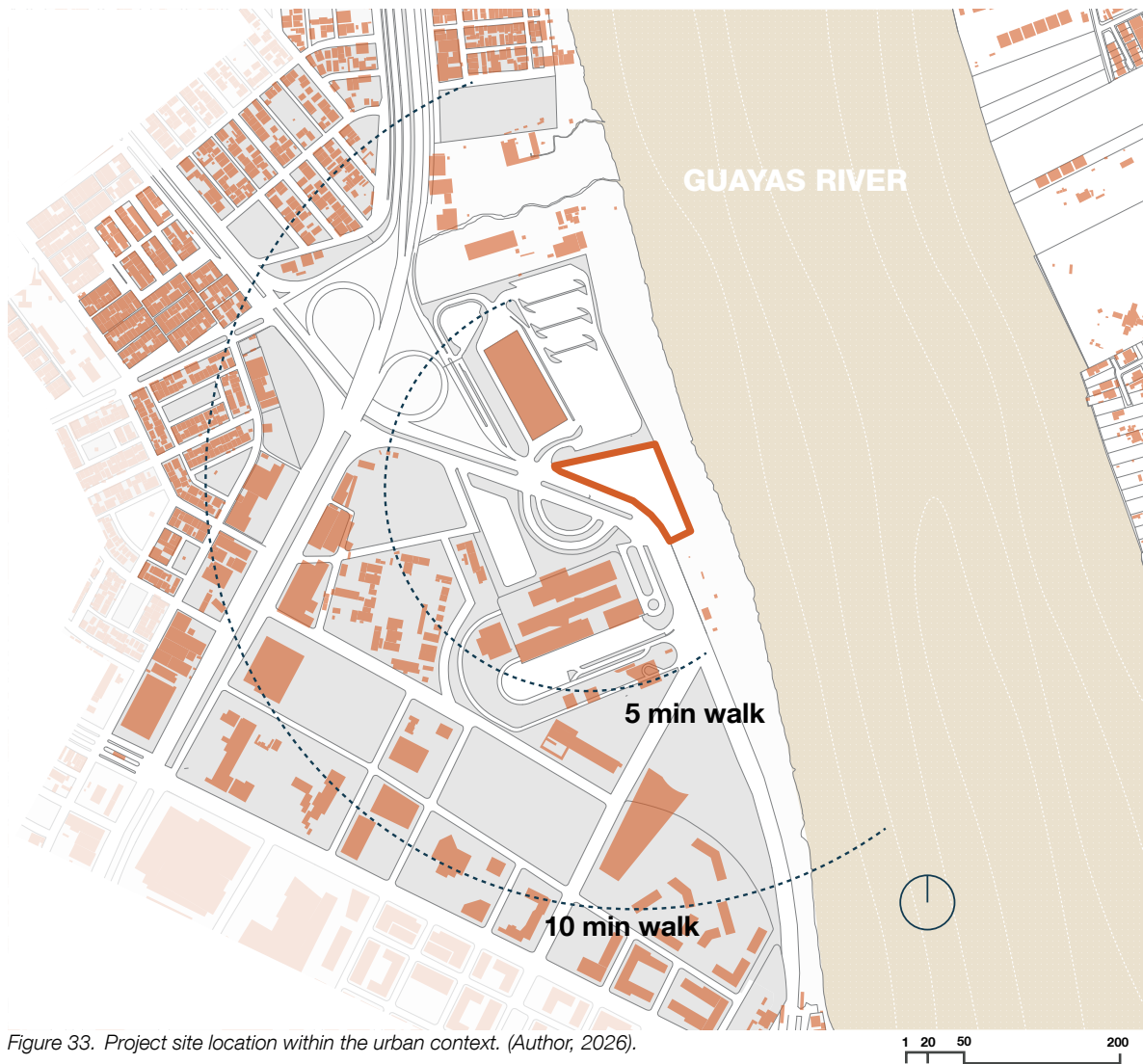


Figure 33. Project site location within the urban context. (Author, 2026).

Within this perimeter, the analysis incorporates:

- The masterplan-defined street network and mobility infrastructure,
- Planned public transport routes and nodes,
- Revised land-use and zoning provisions,
- Proposed public spaces, green corridors, and open areas,
- Surrounding plots and building envelopes as envisioned by the plan.w

3.2 SITE ANALYSIS

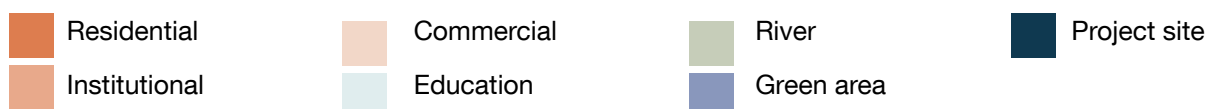
The project site is located within Guayaquil's emerging waterfront expansion area, characterized by the interaction between transportation infrastructures, residential urban fabric, institutional facilities, and the Guayas River waterfront.

3.2.1 Land Use

The surrounding urban fabric is characterized by a mixed-use condition composed of residential areas, commercial corridors, institutional facilities, and transportation infrastructures. The coexistence of these programs reinforces the site's potential to support future urban activation and continuous public activity along the waterfront.



Figure 34. Land use map. (Author, 2026).



3.2.2 Road network and public transportation

The area is characterized by strong multimodal connectivity through major vehicular corridors, public transportation systems, and pedestrian networks. The proximity to the airport terminal, intercity bus terminal, and Metrovía infrastructure reinforces the strategic accessibility of the site within the city.

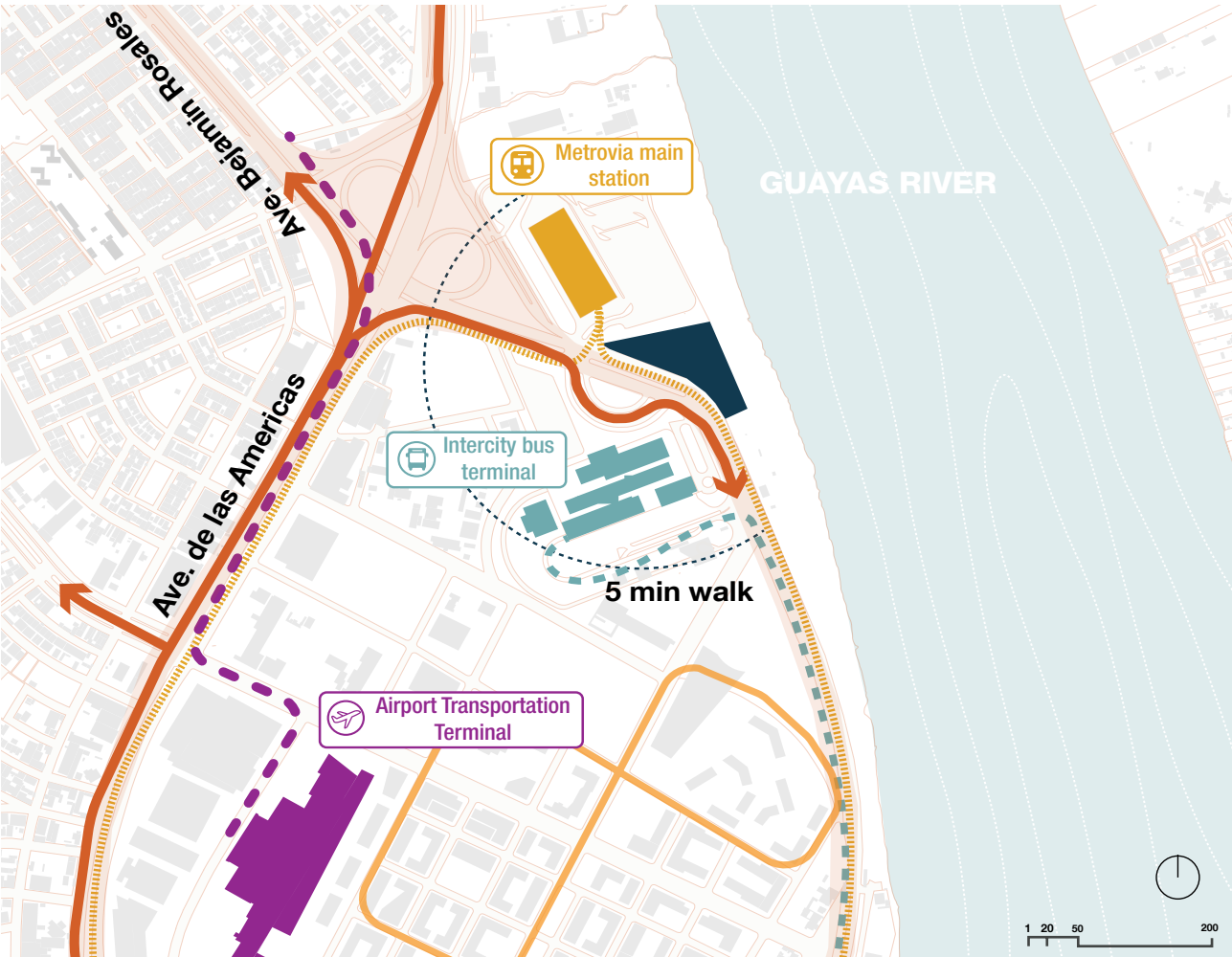


Figure 35. Road network and public transportation map. (Author, 2026).

- Connection to airport
- Intercity buses line
- City buses
- Future internal circulation
- Metrovia lines



Figure 36. Key transportation hubs located near the project site. (Author compilation, 2026).

The coexistence of airport, bus, and public transit infrastructures positions the area as one of the city's most accessible mobility corridors, creating opportunities for future urban activation and public integration.

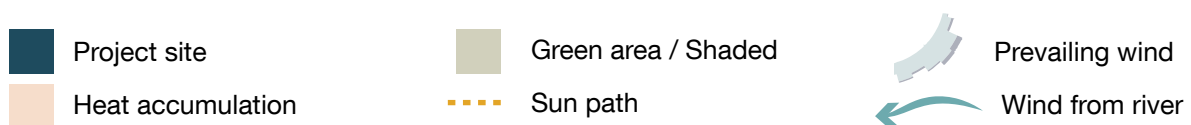
3.2.3 Local climate and comfort

The local climatic conditions of the site are strongly influenced by the presence of the Guayas River, prevailing southwest wind patterns, and extensive paved transportation infrastructures. While large vehicular surfaces contribute to heat accumulation and reduced pedestrian comfort, the waterfront condition generates opportunities for natural ventilation and passive cooling.

The analysis identifies the potential to improve urban thermal comfort through shaded public spaces, vegetation, permeability, and cross-ventilation strategies integrated into both the architectural proposal and the surrounding urban environment.



Figure 37. Local climate and comfort map. (Author, 2026)



3.2.4 Built up system

The surrounding built environment is characterized by a fragmented urban density composed of low-rise residential blocks, large infrastructural voids, and transportation-related facilities. While the western urban fabric presents a compact and consolidated condition, the waterfront edge is dominated by expansive open areas, parking surfaces, and isolated large-scale buildings.

In contrast, the southern portion of the site corresponds to part of Guayaquil's new masterplan development area, characterized by a more controlled and planned urban density. This emerging urban fabric introduces a more regular block structure and reflects the city's ongoing waterfront expansion strategy.



Figure 38. Project site within its immediate urban context. (Author, 2026).



3.3 CONSTRAINTS MAP

The site is currently affected by a series of physical, environmental, and urban constraints that limit its integration with the surrounding city fabric. Large-scale transportation infrastructures create barriers to pedestrian continuity, while extensive paved surfaces, fragmented public spaces, and waterfront vulnerability reduce overall urban quality and accessibility. These conditions highlight the need for strategies that improve connectivity, resilience, and environmental performance.



Figure 39. Constraints map.(Author, 2026)

- | | | |
|-----------------|----------------------------|-----------------|
| Low walkability | Project site | Traffic hotspot |
| Fragmentation | Hydrological vulnerability | |

3.4 RESOURCE MAP

Despite existing challenges, the site benefits from significant urban and environmental assets. Its proximity to major transportation terminals, the Guayas River waterfront, commercial activities, and future development areas provides strong potential for urban regeneration. These resources establish the foundation for a mixed-use, climate-responsive, and highly connected urban node.



Figure 40. Resource map. (Author, 2026)



3.5 SWOT



STRENGTHS

Existing transportation infrastructures and services concentrated in the area.

Compatibility with mixed-use development, supporting residential uses with active ground-floor services.

Strategic location within the metropolitan mobility network, allowing high accessibility and visibility.

Direct relationship with the riverfront, offering potential for landscape integration, environmental enhancement and public space activation.



WEAKNESSES

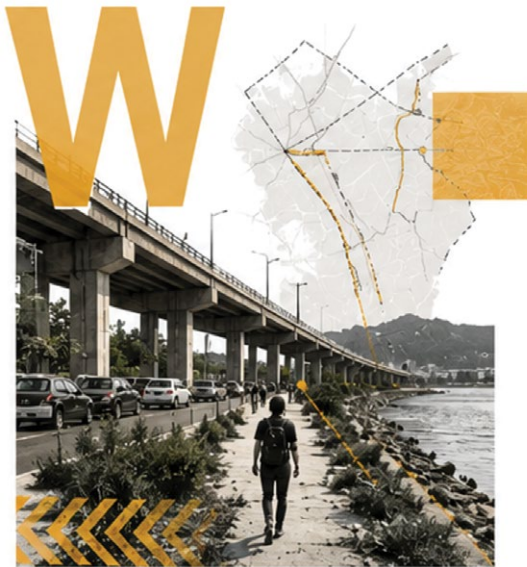
Poor integration between different transportation services, limiting intermodality and legibility.

Low quality and discontinuity of public space, with limited pedestrian comfort in hot-humid conditions.

Weak relationship between transport infrastructure and public space.

Limited pedestrian permeability and walkability due to large road infrastructures and vehicular prioritization.

Double barrier condition generated by the combination of the main road and the river.



OPPORTUNITIES

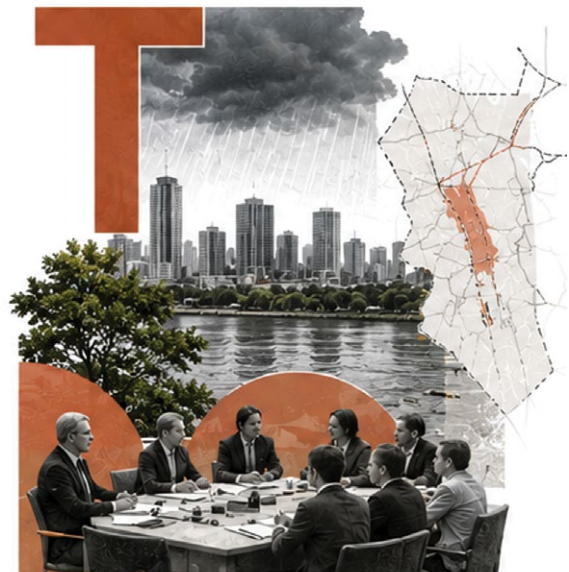
Development of a demonstrative mixed-use project capable of guiding future climate-responsive urban growth in the New Guayaquil district.

Availability of space to introduce climate-adapted public spaces, green infrastructure and shaded mobility corridors.

Redefinition of transportation infrastructure as active urban space, reinforcing the area's role as a multimodal node.

Reconnection of the river with the urban edge, transforming the waterfront into an active public space.

Opportunity to establish a more balanced relationship between mobility infrastructure, public space and urban life.



THREATS

The proximity to the Guayas River increases exposure to flooding and extreme rainfall events.

Intensification of urban climate stress, including heat accumulation and reduced outdoor comfort, which may limit public space usability if not properly addressed.

Fragmented institutional governance involving multiple actors responsible for transport, urban development and public space, which may hinder coordinated implementation.

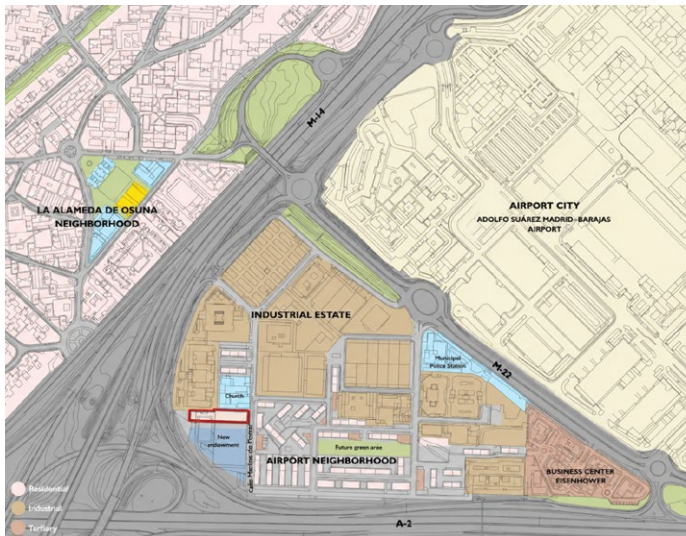
Future economic or planning decisions may influence the pace and direction of development.

3.6 CASE STUDIES

Barrio del Aeropuerto, Madrid

Urban Regeneration through Climate-Oriented Neighborhood Transformation

Originally developed during the mid-20th century as a residential enclave linked to airport-related growth, Barrio del Aeropuerto has progressively become spatially isolated due to surrounding large-scale infrastructure and mono-functional zoning patterns. Despite its strategic metropolitan location, the district remains disconnected from the broader urban fabric and suffers from limited accessibility, underperforming public spaces, and weak environmental quality



Existing Challenges

- Physical isolation due to airport and road infrastructure
- Mono-functional residential urban fabric
- Weak pedestrian connectivity
- Lack of quality public space
- Limited green infrastructure
- Ageing and inefficient building stock

Figure 41. Urban context and functional zoning of Barrio del Aeropuerto, illustrating its isolation between airport infrastructure, industrial estates, and major transport corridors. (Adapted from C40 Reinventing Cities, 2026.)

The current urban condition of Barrio del Aeropuerto is the result of infrastructure-led growth and mono-functional zoning patterns that have progressively isolated the neighborhood from the surrounding metropolitan fabric. Enclosed by highways, airport infrastructure, and industrial parcels, the district suffers from fragmented connectivity, weak pedestrian permeability, and limited public space quality. The predominance of single-use residential blocks further restricts urban vitality, resulting in a disconnected and underperforming urban environment despite its strategic location within Madrid's airport district.



Figure 42. Existing mono-functional residential fabric and underperforming public realm. (Google Maps Street View, 2026)

URBAN STRATEGIES



Figure 43. Proposed masterplan illustrating the urban restructuring strategy and spatial reorganization of Barrio del Aeropuerto. (C40 Reinventing Cities, 2026.)

Rather than proposing isolated architectural interventions, the regeneration strategy seeks to restructure the district through integrated urban principles aimed at reconnecting the neighborhood with the metropolitan fabric, improving environmental performance, and promoting long-term urban resilience.



Figure 44. Key urban regeneration strategies derived from the Barrio del Aeropuerto case study. (Author)

TRANSFERABLE LESSONS

The case study demonstrates how infrastructure-fragmented urban areas can be transformed through integrated regeneration strategies prioritizing connectivity, public space, mixed-use activation, and environmental infrastructure. These principles provide a relevant strategic framework for informing the redevelopment of the Guayaquil airport area.

Roma Tuscolana 1379

Transit-Oriented Development

Located in the south-eastern sector of Rome, Roma Tuscolana 1379 occupies a strategic transport-adjacent site previously characterized by fragmented urban fabric, underutilized land, and a predominantly transitional condition linked to surrounding mobility infrastructure. Despite its accessibility, the area lacked the spatial and programmatic qualities required to function as an urban destination. The winning C40 proposal reconceives the site as a climate-positive mixed-use district, transforming a mobility-dominated area into an active urban centrality.



Existing Challenges

- Strategic transport node within the urban system
- Area directly linked to metropolitan rail infrastructure
- Limited mix of uses and low activity outside peak hours
- Fragmented urban fabric and weak public space continuity

Figure 45. Existing rail corridor and urban context of the Roma Tuscolana 1379 site. (C40 Reinventing Cities, 2026.)

URBAN STRATEGIES

The proposal restructures the site through an integrated strategy combining mobility, mixed-use programming, public space, and green infrastructure.

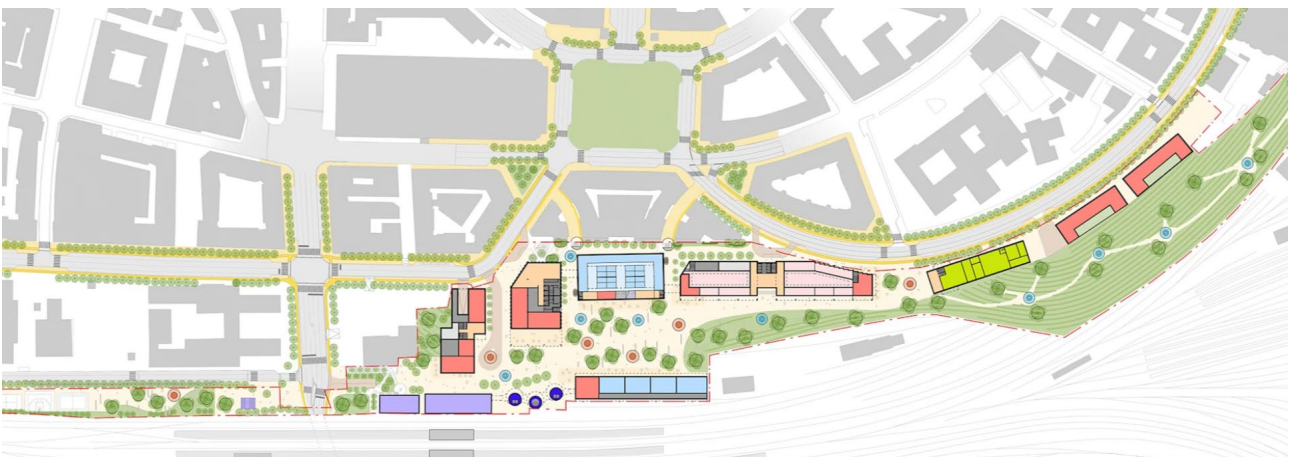


Figure 46. Masterplan of Roma Tuscolana 1379 illustrating the proposed urban restructuring strategy. (AFK Studios, 2024.)

“From a transport-oriented area to an active urban destination.”

From Transport Node to Urban Destination

Transforming Arrival into Permanence

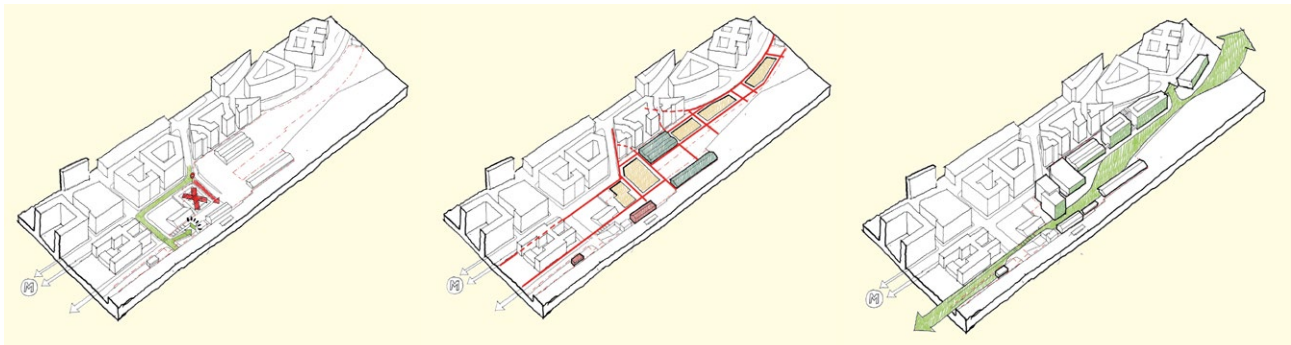


Figure 48. Conceptual transition from a transport-oriented area to an active urban destination through increasing levels of permanence and urban activity. (Author, 2026).

Rather than optimizing circulation alone, the project introduces spatial and programmatic mechanisms that transform transport infrastructure into a framework for permanence. Through the integration of mobility, mixed-use programming, and public realm design, arrival is redefined as the beginning of urban occupation rather than the end of movement.

Spatial Mechanisms of Permanence

Figure 47. Strategies diagram. (Source: AFK Studios, 2024.)



Mobility Integration

Transport infrastructure is embedded within the urban fabric rather than isolated from it.

Programmatic Layering

Mixed-use functions support different durations of stay throughout the day.

Green Public Interface

Landscape and public space operate as retention infrastructure.

TRANSFERABLE LESSONS

The Roma Tuscolana 1379 precedent demonstrates how transport-adjacent areas can evolve beyond their infrastructural role to become active urban destinations. Through the integration of mixed-use programmes, public space, landscape, and mobility systems, the project creates conditions that encourage permanence rather than transit. This approach provides a valuable reference for the redevelopment of the New Guayaquil district, where mobility infrastructure can become a catalyst for urban life rather than a physical barrier.

Chapter 4:

Urban design

4.1 VISION

The proposal is based on the idea that transportation infrastructure can become a catalyst for urban life rather than a space of transition. Located at the intersection of major mobility systems and the Guayas River waterfront, the site presents the opportunity to transform an area currently defined by movement into a destination that supports permanence, social interaction, and environmental quality. The project is structured around three complementary objectives: strengthening urban connectivity, enhancing blue-green infrastructure, and establishing a climate-responsive development.

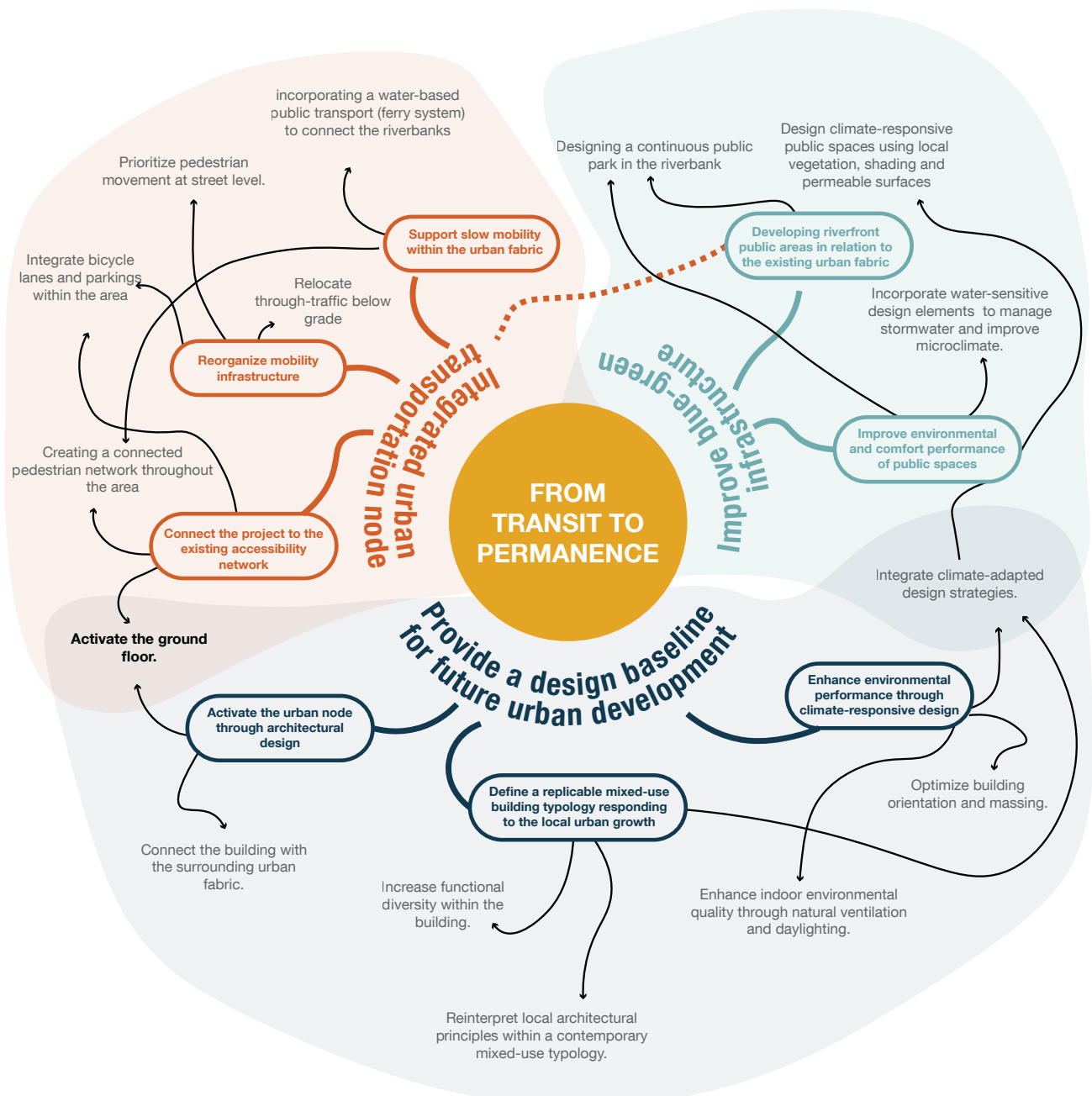


Figure 49. Project vision, objectives, and design strategies developed for the intervention. (Author, 2026).

Together, these objectives provide a framework for reconnecting fragmented urban systems, improving public space, and guiding future growth through the integration of mobility, landscape, and architecture. The resulting vision seeks to create a more connected, resilient, and livable urban node that contributes to both the local context and the broader development of New Guayaquil.

4.1.1 Strategies

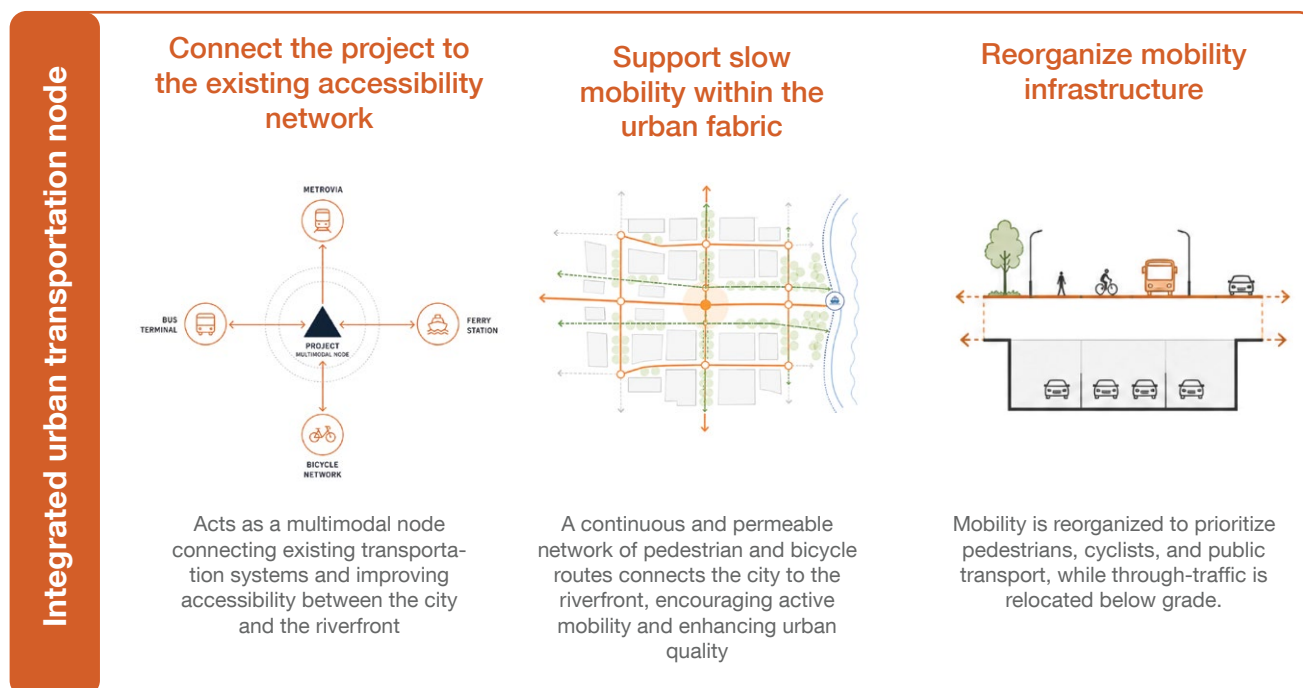


Figure 50. Urban mobility strategies integrating multimodal accessibility, active transportation networks, and traffic reorganization within the masterplan. (Author, 2026).

Strengthen connectivity and accessibility through an integrated multimodal mobility network.

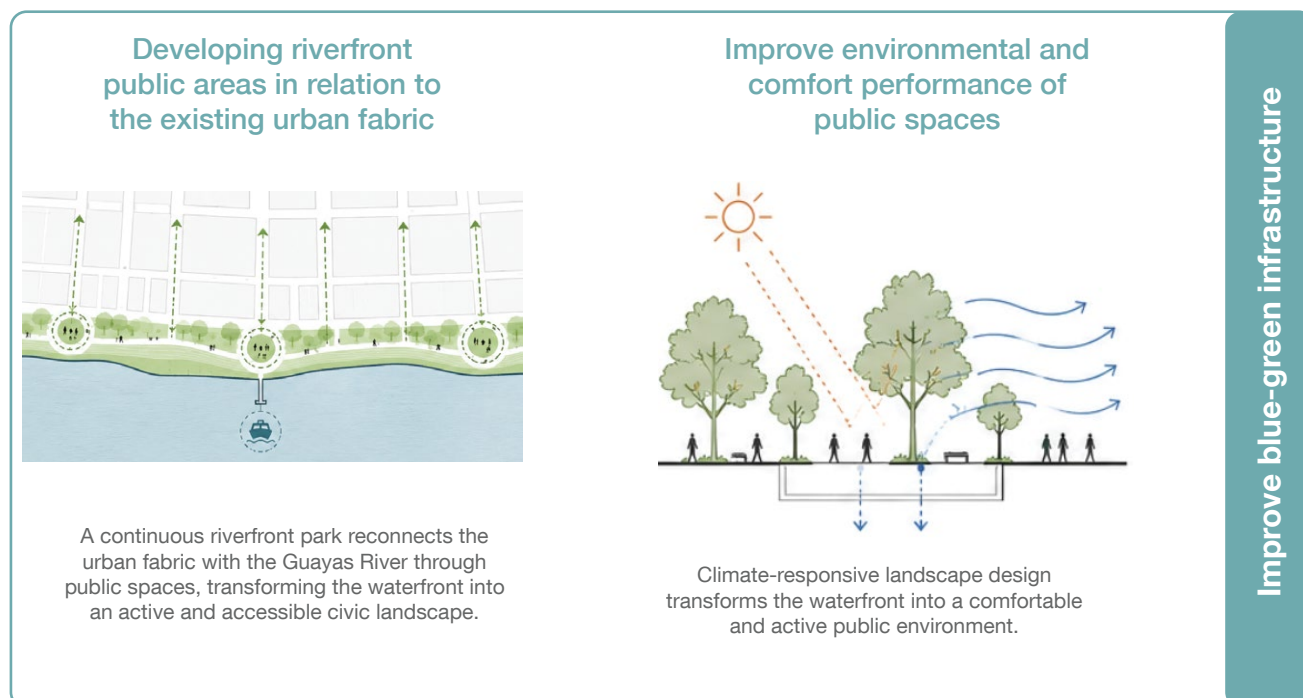


Figure 51. Blue-green infrastructure strategies connecting the urban fabric with the riverfront through public spaces, ecological corridors, and climate-responsive landscape design. (Author, 2026).

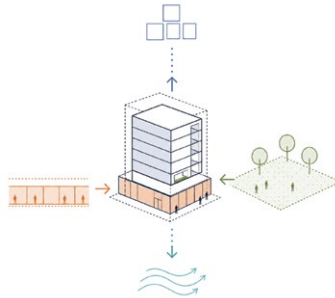
Reconnect the city with the river through public spaces, green corridors, and climate-responsive landscape strategies.

Activate the urban node through architectural design



Mixed-use programs and active ground-floor interfaces transform the transport node into a vibrant urban destination.

Define a replicable mixed-use building typology responding to the local urban growth



A flexible mixed-use typology is proposed as a replicable model capable of supporting future urban development.

Enhance environmental performance through climate-responsive design



Passive design strategies improve environmental performance, reducing energy demand while enhancing indoor comfort.

Figure 52. Architectural development strategies supporting urban activation, mixed-use growth, and climate-responsive building performance. (Author, 2026).

Establish a replicable architectural model capable of supporting future urban growth and environmental performance.

Key Spatial Components of the Masterplan

The proposed masterplan translates the project's urban vision into a spatial framework composed of complementary elements that organize movement, public life, and development. Anchored by the transportation hub and waterfront connection, the strategy combines public spaces, green infrastructure, and mixed-use programs to create an active urban environment that extends beyond mobility functions. Together, these components support the transformation of the site from a place of transit into a place of permanence, fostering social interaction, environmental quality, and long-term urban vitality.



Transportation hub

Central multimodal hub that integrates bus, taxi, private transport and pedestrian flows.



Mixed-Use Development

Combination of residential, commercial and community uses to activate the area throughout the day.



Ferry terminal

Waterfront terminal connected to the ferry system, reinforcing regional and cross-river mobility.



Waterfront Promenade

Public promenade along the river edge, offering recreation, views and access to the water.



Linear Park

Continuous green spine that improves environmental quality and connects key public spaces.



Public Plaza

Central open space for community gathering, events and daily activities.

Figure 53. Key spatial components of the masterplan. (Author, 2026).

4.2 CONCEPT PLAN

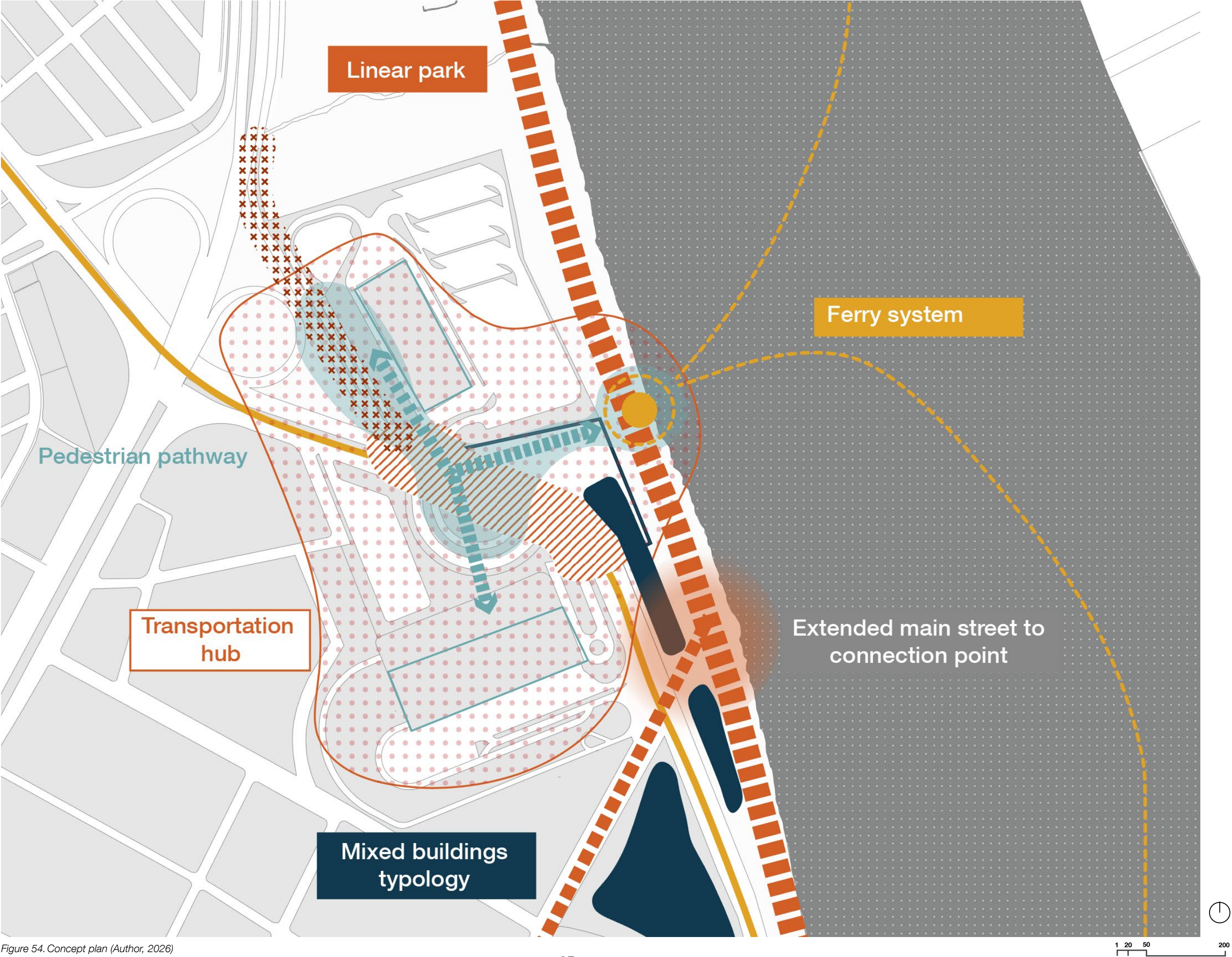


Figure 54. Concept plan (Author, 2026)

4.3 MASTERPLAN

1:1500



Figure 55. Masterplan proposal (Author, 2026)

Masterplan Systems

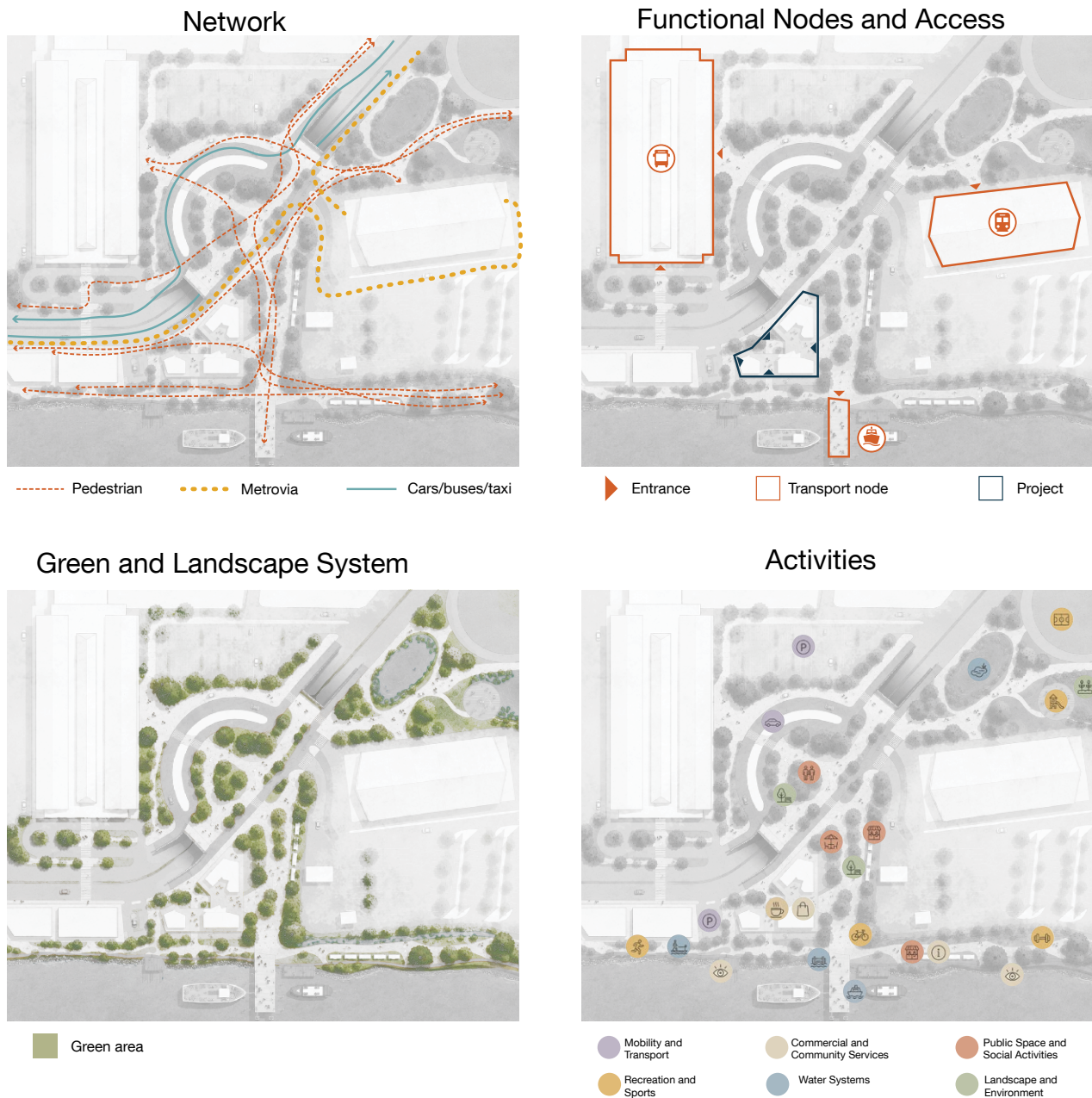


Figure 56. Masterplan systems and spatial organization. (Author, 2026).

The proposed masterplan translates the findings of the urban analysis into a spatial strategy that organizes mobility, public space, landscape, and future development within the site. Rather than functioning as an isolated intervention, the proposal establishes a network of connected spaces that strengthen accessibility, improve the relationship with the Guayas River, and support the future growth envisioned for New Guayaquil.

The project is structured around a series of complementary elements, including the transportation hub, ferry connection, linear park, waterfront promenade, public plazas, and mixed-use development areas. Together, these components create an active and accessible urban environment that encourages movement, social interaction, and everyday use beyond peak transit hours.

This masterplan establishes the urban conditions from which the architectural proposal emerges. By defining the spatial structure, circulation systems, landscape framework, and programmatic organization of the site, it provides the foundation for the mixed-use building developed in the following chapter.



Figure 57. Traditional residential architecture in Guayaquil.

Chapter 5:

Architectural design

5.1 LOCAL IDENTITY

Guayaquil's local identity was shaped by its condition as a tropical port city, where architecture responded to heat, humidity, river life, commerce, and everyday social interaction. During the late nineteenth century and the first decades of the twentieth century, the city was strongly associated with wooden domestic architecture, shaded pedestrian spaces, balconies, galleries, patios, and façades adapted to the tropical climate. This period is especially important because Guayaquil's architectural development between the end of the nineteenth century and the mid-twentieth century reflects the transition between traditional urban life and the modernization of the city (Compte Guerrero, 2020).

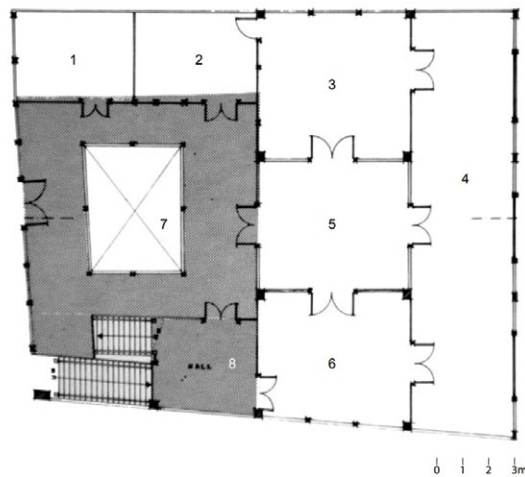


Figure 58. Visual interpretation of Guayaquil's vernacular architecture and its main climatic and social elements. (Author, 2026).

The traditional architecture of Guayaquil was characterized by wooden houses, shaded porticos, galleries, balconies, shutters, decorative railings, clay-tile roofs, patios, and deep roof overhangs. These elements were not only visual or ornamental; they created shade, allowed ventilation, protected pedestrians from sun and rain, and produced a continuous relationship between the house and the street. In particular, the soportal became one of the most representative architectural and urban elements of Guayaquil, defining both the image of the city and the way people occupied public space (Santana-Moncayo, 2015).

The ground floor also played an important role in the identity of Guayaquil as a commercial port city. The street was not only a space for movement, but also a place of exchange, encounter, commerce, and everyday activity. The soportal worked as a transitional space between the private house and the public street, supporting pedestrian circulation while also reinforcing the commercial character of the city (Santana-Moncayo, 2015). This relationship between architecture, shade, and commerce helped create a very specific urban atmosphere, where domestic life, public life, and economic activity were closely connected.

Inside the traditional house, the patio and the gallery were essential spatial elements. The patio organized domestic life around an open-air space, bringing light, air, vegetation, and social activity into the interior of the house. The galleries and balconies worked as intermediate spaces between inside and outside, allowing the house to remain connected to the street while still maintaining privacy and climatic comfort. This spatial logic was part



Planta alta de vivienda urbana. Foto Libro Patrimonio arquitectónico y urbano de Guayaquil. 1 Cocina / 2 Comedor / 3 Dormitorio / 4 Galería / 5 Sala / 6 Dormitorio / 7 Aire y luz / 8 Hall.

Figure 59. Typical layout of a traditional urban house in Guayaquil. (Peralta González, 2014).

of the broader architectural identity of Guayaquil, where domestic buildings were shaped by both climate and urban life (Santana-Moncayo, 2015).

Materially, old Guayaquil was strongly associated with wood. Timber appeared in structural posts, beams, façades, shutters, doors, balconies, and railings, producing a lighter and more permeable architecture than the masonry traditions more commonly associated with other Ecuadorian cities. This wooden architecture was especially visible in the domestic buildings of the late nineteenth and early twentieth centuries and remains part of the collective memory of Guayaquil's historic landscape (Compte Guerrero, 2020).

Color was another fundamental component of Guayaquil's historic image. The houses of Las Peñas are commonly associated with multicolored façades, wooden balconies, shuttered windows, and decorative details, creating a vibrant and recognizable urban landscape. The Municipality of Guayaquil describes Las Peñas through its multicolored houses with wooden balconies, while other heritage descriptions emphasize its colorful wooden houses and its role as one of the most emblematic historic areas of the city (Municipio de Guayaquil, 2025; World Monuments Fund, n.d.). These colors —blues, aquas, yellows, creams, greens, terracotta tones, reds, and white decorative trims— helped produce a tropical, festive, and highly recognizable image of the city.

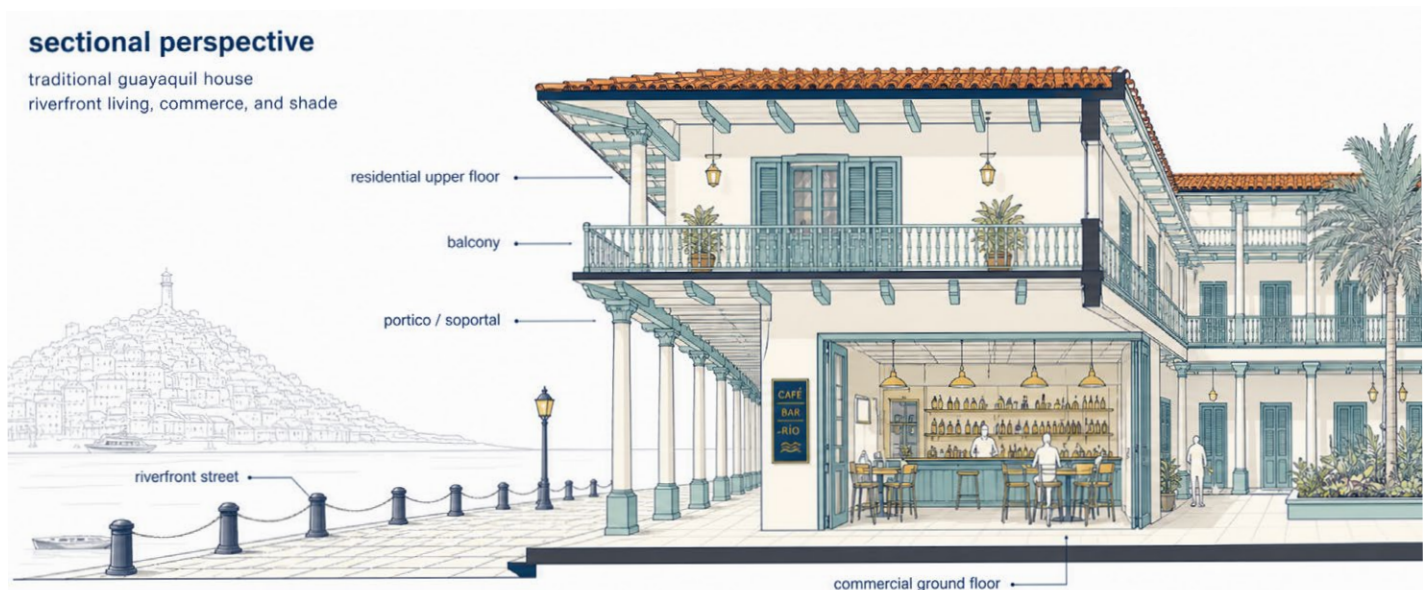


Figure 60. Sectional perspective of a traditional Guayaquil house, highlighting the portico, commercial ground floor, gallery, and central patio. (Author, 2026)

5.2 REINTERPRETATION OF GUAYAQUIL VERNACULAR ARCHITECTURE

Rather than replicating historical forms, the main idea is to extract the spatial and climatic logic embedded in traditional Guayaquil houses and translate these principles into a contemporary architectural language. The intention is not to reproduce vernacular architecture literally, but to reinterpret its underlying operative strategies, developed in response to climate, urban life, and social patterns, within a new mixed-use and vertical building typology.



Figure 61. Architectural and cultural references from Guayaquil. (Author compilation, 2026).

A vernacular language of shade, porosity, and collective space.

Through this process, vernacular domestic architecture becomes the conceptual framework for generating a contemporary building rooted in local identity while responding to present-day environmental and urban challenges.



PORTICOS AS URBAN INTERFACES

Reinterpreted as a shaded ground-floor threshold that mediates between street and building, activating the pedestrian realm while providing climatic protection.

COURTYARD AS VERTICAL VOID

Transformed into a central vertical void that organizes the project, bringing daylight, ventilation, and collective space into the core of the building.



GALLERIES AS PERMEABLE CIRCULATION

Reimagined as open circulation corridors facing the courtyard, promoting ventilation, visual connectivity, and social interaction.

ELEVANTED HOUSES AS CONTINUITY OF PUBLIC SPACE

Translated into a permeable elevated base that extends public space beneath the building and enhances urban porosity.



LOUVERED SHUTTERS AS PERMEABLE FACADE

Reinterpreted as a layered shading envelope that filters sunlight, improves comfort, and creates a breathable façade.

Figure 62. Translation of vernacular elements into contemporary design strategies. (Author, 2026).

5.3 PROJECT STRATEGY

The proposed programme is conceived as a direct response to the urban strategy established in the project's masterplan, which envisions the redevelopment area as a permanent and active mixed-use district capable of supporting long-term urban growth. In this context, the introduction of a mixed-use building typology contributes to the creation of a more diverse and resilient urban environment by integrating complementary functions within a single development.

The combination of commercial and residential uses supports the masterplan's objective of fostering continuous urban activity throughout the day while balancing economic productivity with permanent inhabitation. Commercial functions activate the district and provide local services, while residential uses introduce a stable population capable of sustaining everyday urban life beyond peak activity periods.

The inclusion of housing further responds to the projected growth of Guayaquil and the need to accommodate future inhabitation within newly developed areas of the city. As the redevelopment of the former airport site represents a new phase of urban expansion, the integration of residential uses becomes essential to establish the district as a lived-in extension of the city rather than a mono-functional commercial enclave.

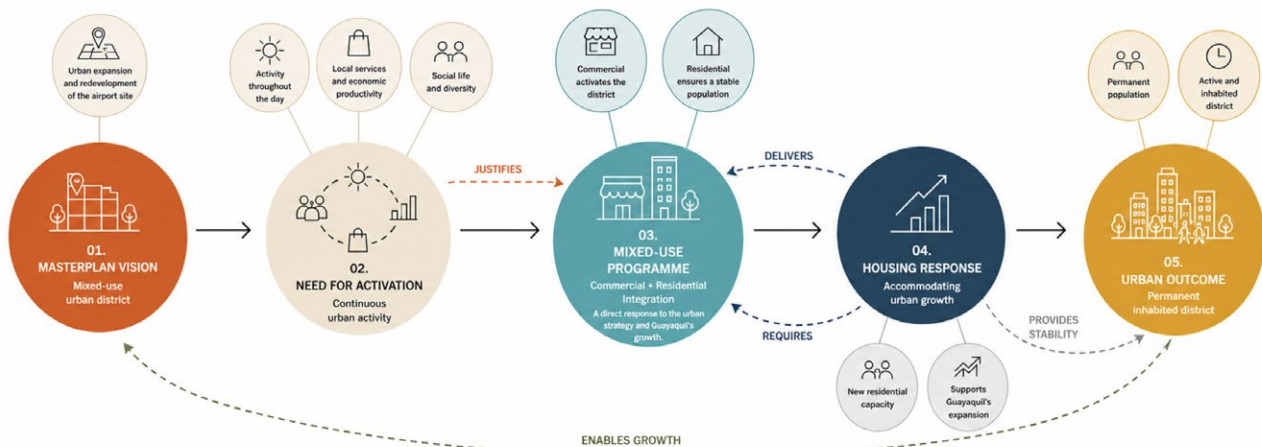


Figure 63. Mixed-use programme strategy. (Author, 2026).

BUILDING PARAMETERS

The proposed building envelope was developed according to the planning framework established by both the municipal regulations and the Ciudad Nueva Masterplan. The project adopts a mixed-use typology while complying with the permitted density, height limitations, setback requirements, and environmental buffer regulations.

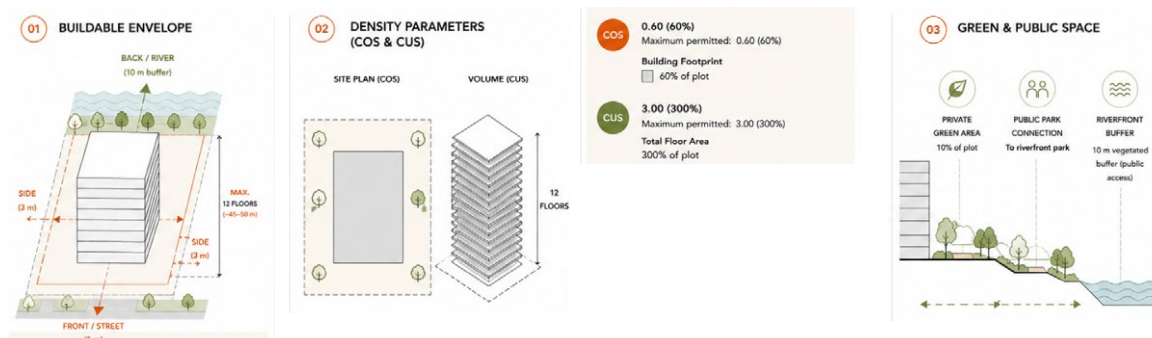


Figure 64. Building parameters and regulatory framework for the proposed development. (Author, 2026).

5.4 MASSING OPTIONERING

As an initial stage of the design process, a massing optioneering study was conducted to evaluate the impact of building shape, height, and orientation on energy performance. A series of simplified volumetric alternatives were developed and tested under identical climatic conditions, using cooling demand intensity (kWh/m²·yr) as the primary performance indicator due to the hot-humid climate of Guayaquil.

The analysis revealed that more compact geometries generally achieved lower cooling demand, while increased building height slightly improved thermal efficiency. Similarly, north–south orientations outperformed east–west exposures by reducing solar heat gains. These findings established a performance-based framework for the subsequent architectural development of the project, informing design decisions while balancing spatial, climatic, and urban considerations.

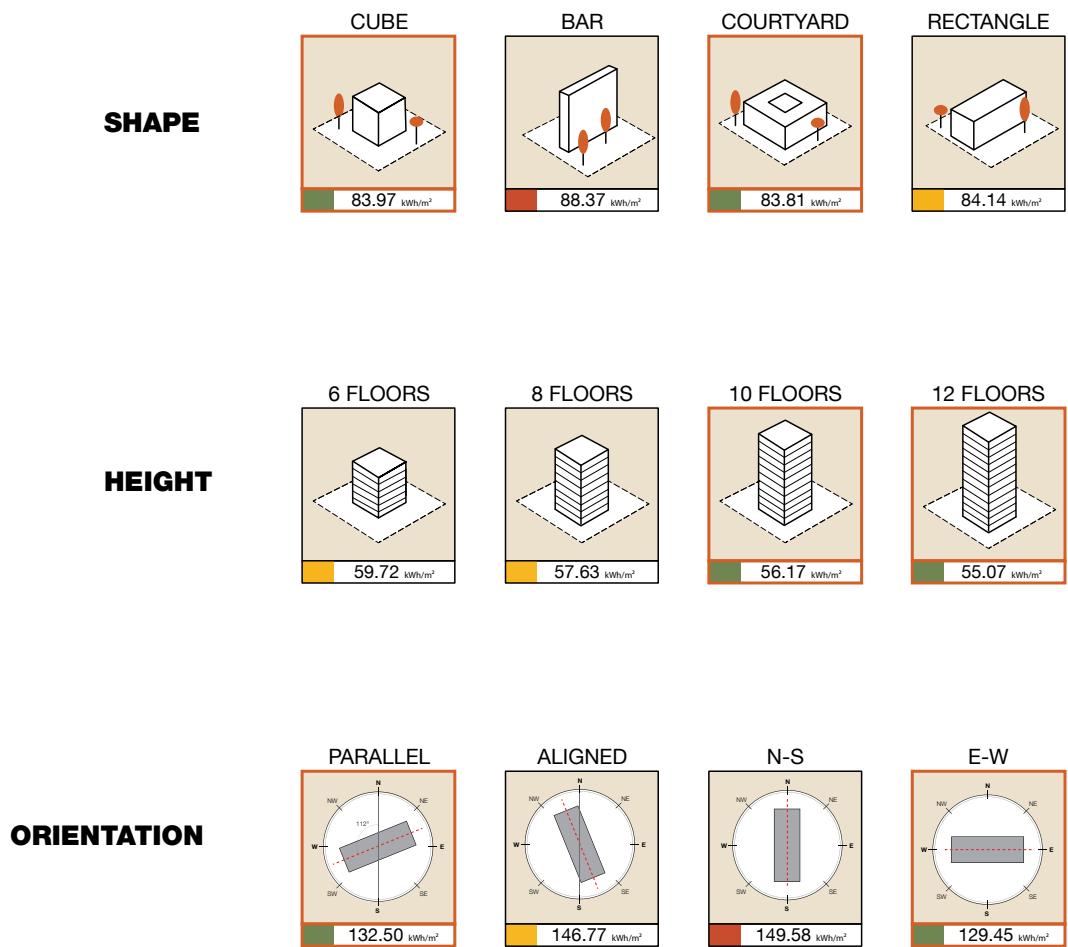


Figure 65. Massing optioneering study evaluating the influence of building shape, height, and orientation on cooling demand intensity (kWh/m²·yr) under Guayaquil climatic conditions. (Author, 2026)

The results indicate that geometric compactness, increased verticality, and north–south orientation generally contribute to lower cooling demand. While the compact cube achieved the best overall thermal performance, the courtyard configuration was selected for further development due to its spatial, social, and climatic potential. The optioneering process therefore informed the project not only through energy performance metrics but also through the integration of broader architectural and urban design objectives.

5.5 CASE STUDIES

To support the development of the proposed design, two international case studies were selected based on their relevance to the core research themes of this thesis: climate-responsive architecture in hot-humid environments, energy demand reduction through passive design, and mixed-use vertical urban living.

School of Design and Environment 4

Environmental Performance Benchmark

Located within the National University of Singapore campus, the School of Design and Environment 4 (SDE4) represents a significant benchmark in tropical climate-responsive architecture and low-energy building design. Developed as a net-zero energy academic building, the project challenges the conventional dependence on mechanically conditioned spaces in hot-humid climates by integrating passive environmental strategies as fundamental architectural drivers. Rather than treating sustainability as an applied technological layer, SDE4 embeds environmental performance within its spatial organization, façade articulation, and building systems



Figure 66. Exterior view of the School of Design and Environment 4. (Serie Architects, 2019.)

EXISTING CHALLENGES

- Hot-humid tropical climate with year-round cooling demand
 - High solar radiation and heat gain exposure
 - Conventional dependence on air-conditioning in institutional buildings
 - Need to balance thermal comfort, daylight access, and energy efficiency
- Limited applicability of temperate-climate NZEB strategies

Beyond its architectural significance, SDE4 provides a relevant analytical benchmark for understanding how environmental performance can be embedded within the design process in hot-humid climates. Its significance lies in the integration of climatic responsiveness, spatial quality, and energy-conscious design within a coherent architectural framework.

PASSIVE STRATEGIES

SDE4 employs a climate-responsive architectural approach tailored to hot-humid tropical conditions. Its porous spatial organization enhances natural airflow, daylight penetration, and visual openness, reducing dependence on enclosed conditioned environments. A prominent cantilevered roof provides extensive solar protection, minimizing direct heat gain while creating shaded transitional spaces. Additionally, the façade integrates layered shading systems, including perforated aluminum screens, high-performance glazing, and light shelves, which collectively reduce solar exposure while maintaining daylight access and visual comfort (National University of Singapore, 2019).



Figure 67. Sectional diagram illustrating SDE4's integrated passive and active environmental strategies. National University of Singapore, 2019)

ACTIVE STRATEGIES

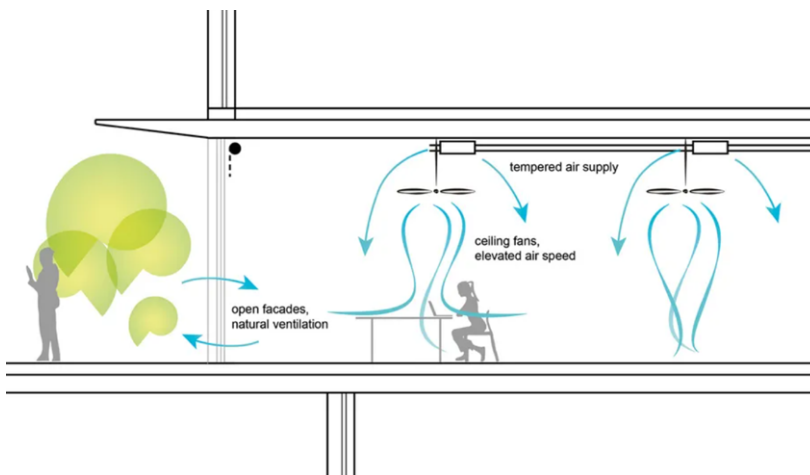


Figure 68. SDE4 hybrid environmental cooling strategy. (National University of Singapore, 2019.)

To complement its passive design, SDE4 incorporates active systems that improve operational efficiency and support net-zero performance. The building adopts a hybrid cooling strategy in selected conditioned zones rather than relying on full mechanical air-conditioning, significantly reducing energy demand. Ceiling fans enhance adaptive ther-

mal comfort through increased air movement, while smart controls optimize lighting and cooling operation based on occupancy and environmental conditions. Rooftop photovoltaic panels further contribute by generating renewable electricity to offset annual operational consumption (National University of Singapore, 2019).

KAMPUNG ADMIRALTY

Programmatic / Typological Benchmark

Located in northern Singapore, Kampung Admiralty represents a pioneering model of high-density mixed-use urban living that integrates residential, healthcare, commercial, and public community functions within a single vertical development. Conceived as a response to land scarcity, demographic change, and increasing urban density, the project reinterprets conventional horizontal neighborhood infrastructure into a vertically layered community. Rather than separating living, services, and public life, the project consolidates them within a climate-responsive architectural framework that prioritizes accessibility, social interaction, and collective urban living.



Figure 69. Exterior view of Kampung Admiralty, highlighting its mixed-use vertical organization and integrated greenery. (WOHA Architects, 2018.)

CLIMATIC STRATEGIES - URBAN UMBRELLA



Figure 70. Climatic strategy diagrams of Kampung Admiralty showing passive cooling, shading, and integrated vegetation systems. (Source: WOHA Architects, 2018.)

The integration of vegetation in Kampung Admiralty extends beyond aesthetics, functioning as climatic infrastructure that improves thermal comfort, reduces heat gain, and enhances the usability of open communal spaces. This strategy demonstrates how greenery can operate simultaneously as an environmental buffer and a social catalyst, offering relevant lessons for the incorporation of passive climatic landscapes within the proposed mixed-use tropical development (WOHA, 2018).

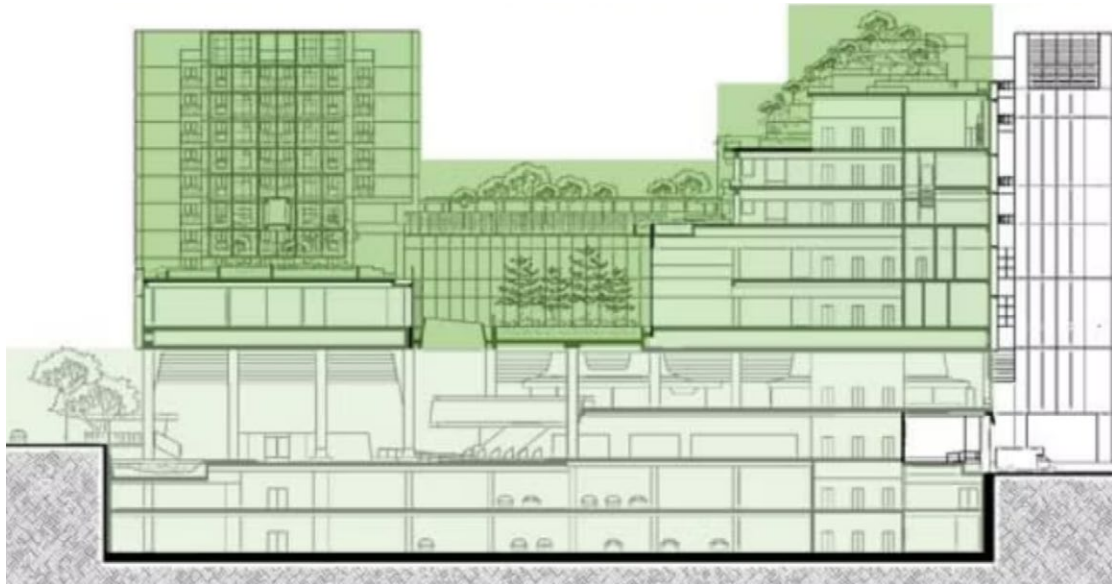


Figure 71. Programmatic sectional diagram of Kampung Admiralty showing its vertical mixed-use layering and integrated communal landscape. (Source: WOHA Architects, 2018.)



VERTICAL PROGRAM LAYERING

Collective Shared Spaces

Terraces, communal gardens, and intermediate gathering areas promote social interaction and collective living.

Public-Private Integration

The lower levels remain highly accessible and publicly activated, while upper residential levels provide more controlled domestic environments.

Climate-Responsive Openness

Semi-open circulation, shaded terraces, and environmental porosity support tropical comfort and passive usability.

TRANSFERABLE LESSONS

The Kampung Admiralty precedent illustrates how mixed-use vertical density can support urban livability when density is coupled with collective spaces, environmental responsiveness, and public accessibility. Rather than separating residential and public functions, the project demonstrates how layered programming and shared green infrastructure can foster socially active, climate-responsive communities. These principles directly inform the mixed-use spatial strategy of the proposed thesis project in Guayaquil.

5.6 PROGRAMME

The architectural program is organized around a central courtyard that functions as the social and environmental heart of the project. This space connects the different building functions while enhancing natural ventilation, daylight access, and visual continuity. Public and commercial activities are concentrated at the ground floor to encourage urban interaction and activate the surrounding public realm. Shared facilities are strategically positioned to support community life and create opportunities for social exchange, while the upper levels accommodate residential units, ensuring privacy and comfort. This arrangement establishes a gradual transition from public to private spaces, reinforcing the mixed-use character of the development and promoting a vibrant and integrated living environment.

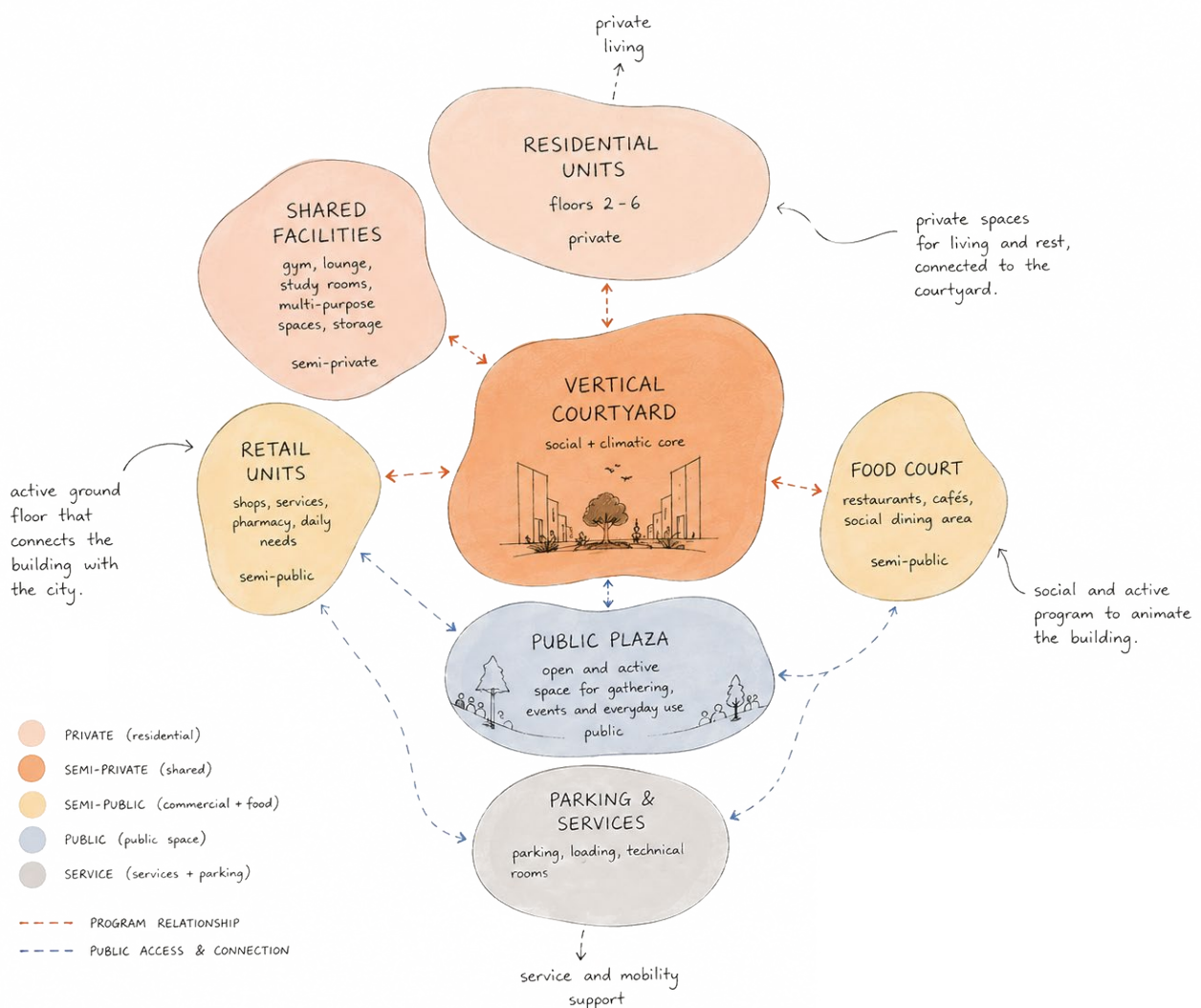
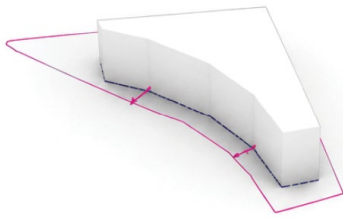


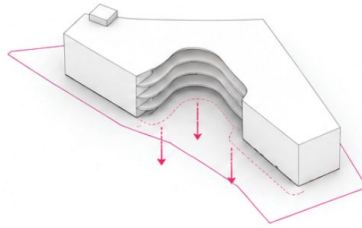
Figure 72. Architectural program organization of the proposed mixed-use building. (Author, 2026)

5.7 STRATEGIES

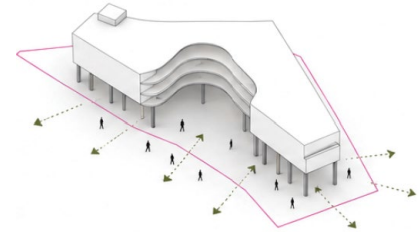
01 Offset to the site



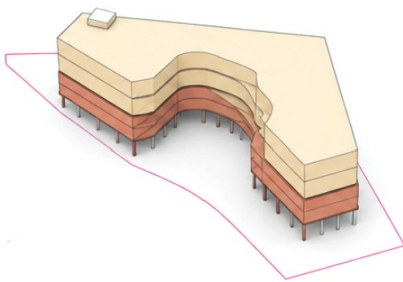
02 Courtyard subtraction



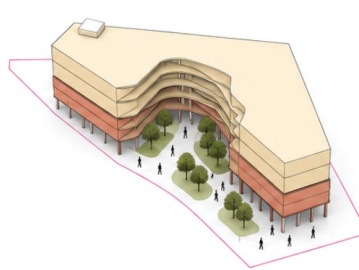
03 Ground floor permeability



04 Programme division



05 Central green area



06 Climate responsive facade



Figure 73. Architectural development strategies of the project. (Author, 2026).

The project is developed through a series of design strategies that respond to the site's geometry, climate, and urban context. A central courtyard is introduced to improve natural ventilation, daylight access, and social interaction, while an open ground floor enhances permeability and strengthens the connection with the surrounding public space. The program is organized vertically around this communal core, and a climate-responsive façade incorporates balconies, shading devices, and vegetation to improve environmental performance and user comfort.

Programme evolution

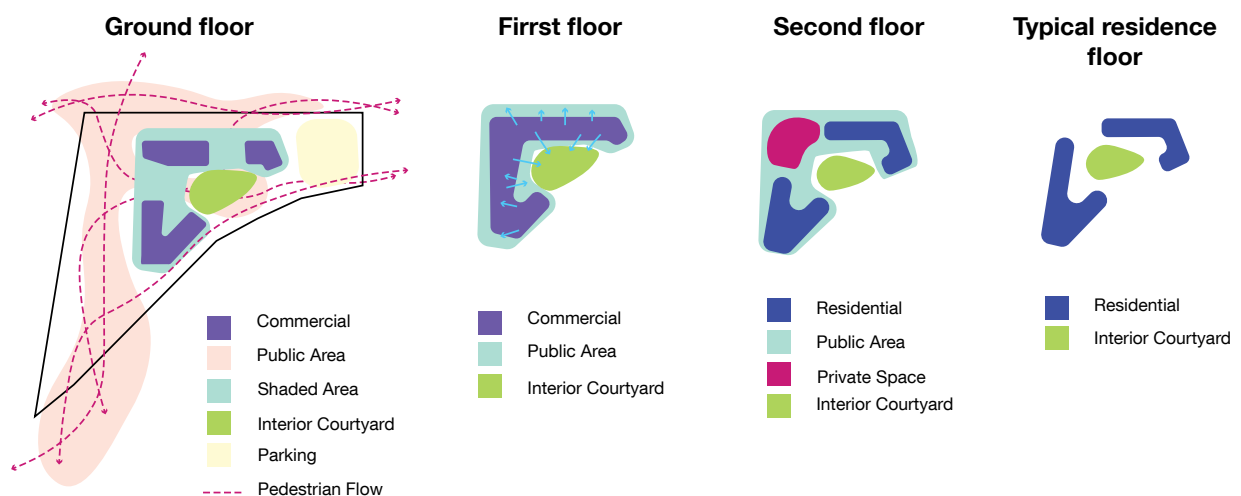
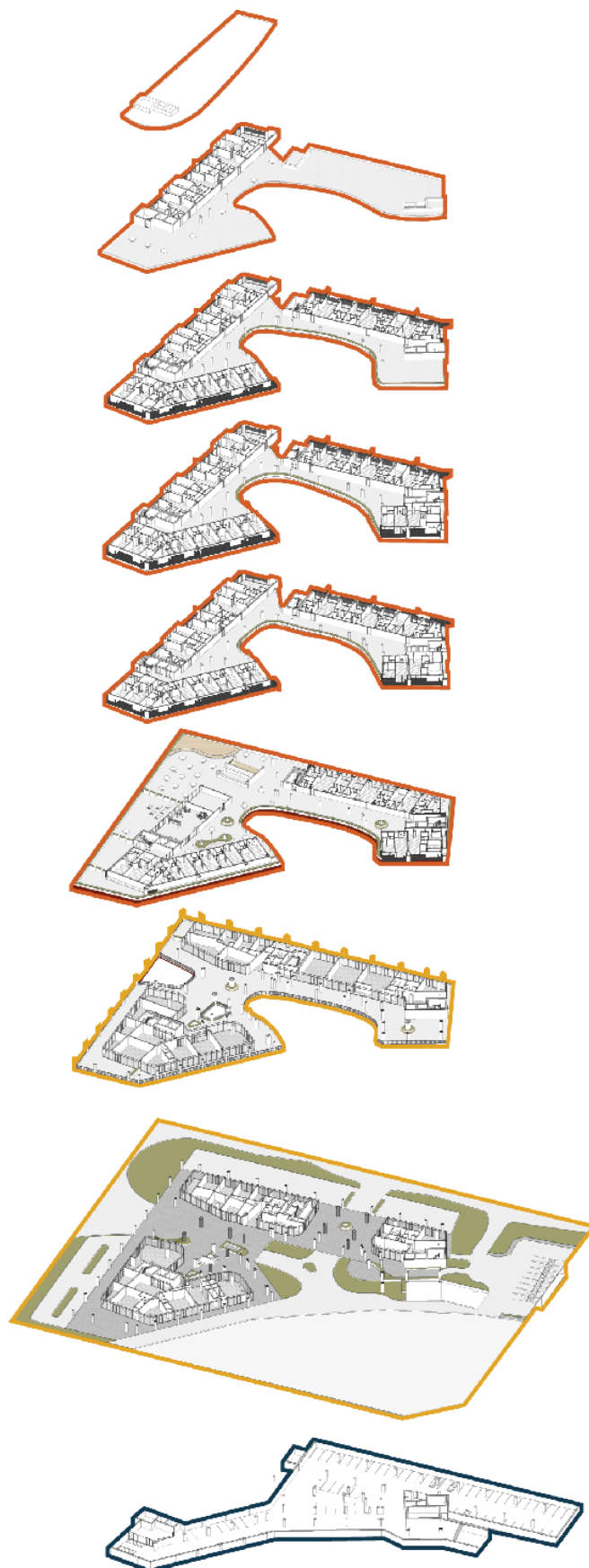


Figure 74. Programme evolution of the project. (Author, 2026).

5.8 FUNTIONAL DISTRIBUTION



Roof

Mechanical room
Pv pannels

Sixth floor

Residential Units

Fifth floor

Residential Units

Fourth floor

Residential Units

Third floor

Residential Units

Second floor

Shared Amenities
Co-Living Facilities
Residential Units

First floor

Commercial Units

Ground Floor

Public Space
Commercial Units
Administration
Lobby

Underground

Mechanical room
Parking
Storage Areas

Figure 75. Functional distribution of the proposed mixed-use programme. (Author, 2026).

5.9 RESIDENTIAL TYPOLOGIES

The residential component of the project is designed to accommodate different household structures and lifestyles while maintaining a consistent architectural language throughout the building. The proposed units are organized around the central courtyard, allowing access to natural light, cross-ventilation, and visual connections with shared spaces. Three residential typologies are introduced to provide flexibility and support a diverse residential community, ranging from individual occupants to small families.

Type A.1 – 2 Bedroom Apartment

Area: 113.00 m²

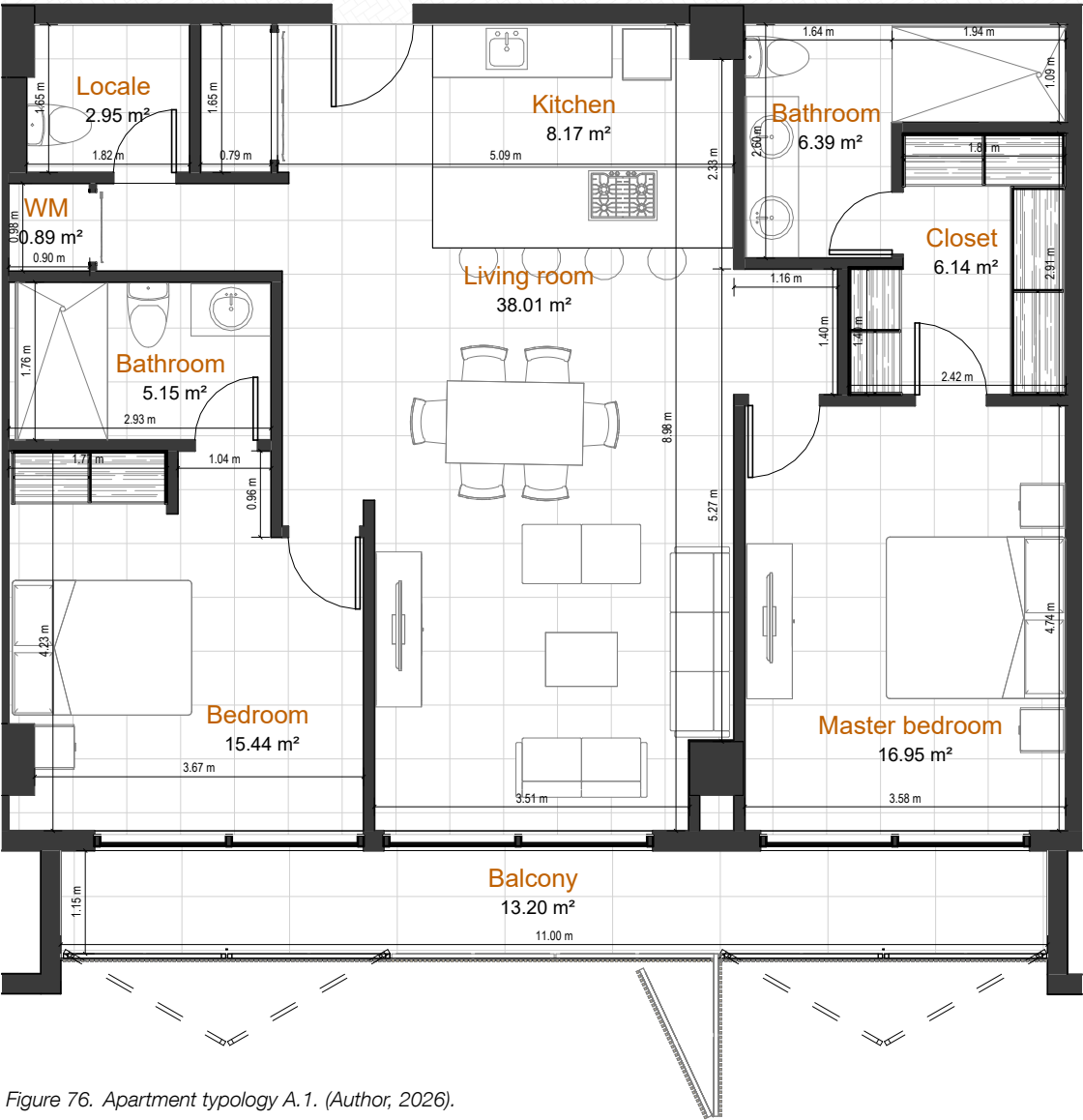


Figure 76. Apartment typology A.1. (Author, 2026).

Type A.2 – 2 Bedroom Apartment

Area: 113.00 m²

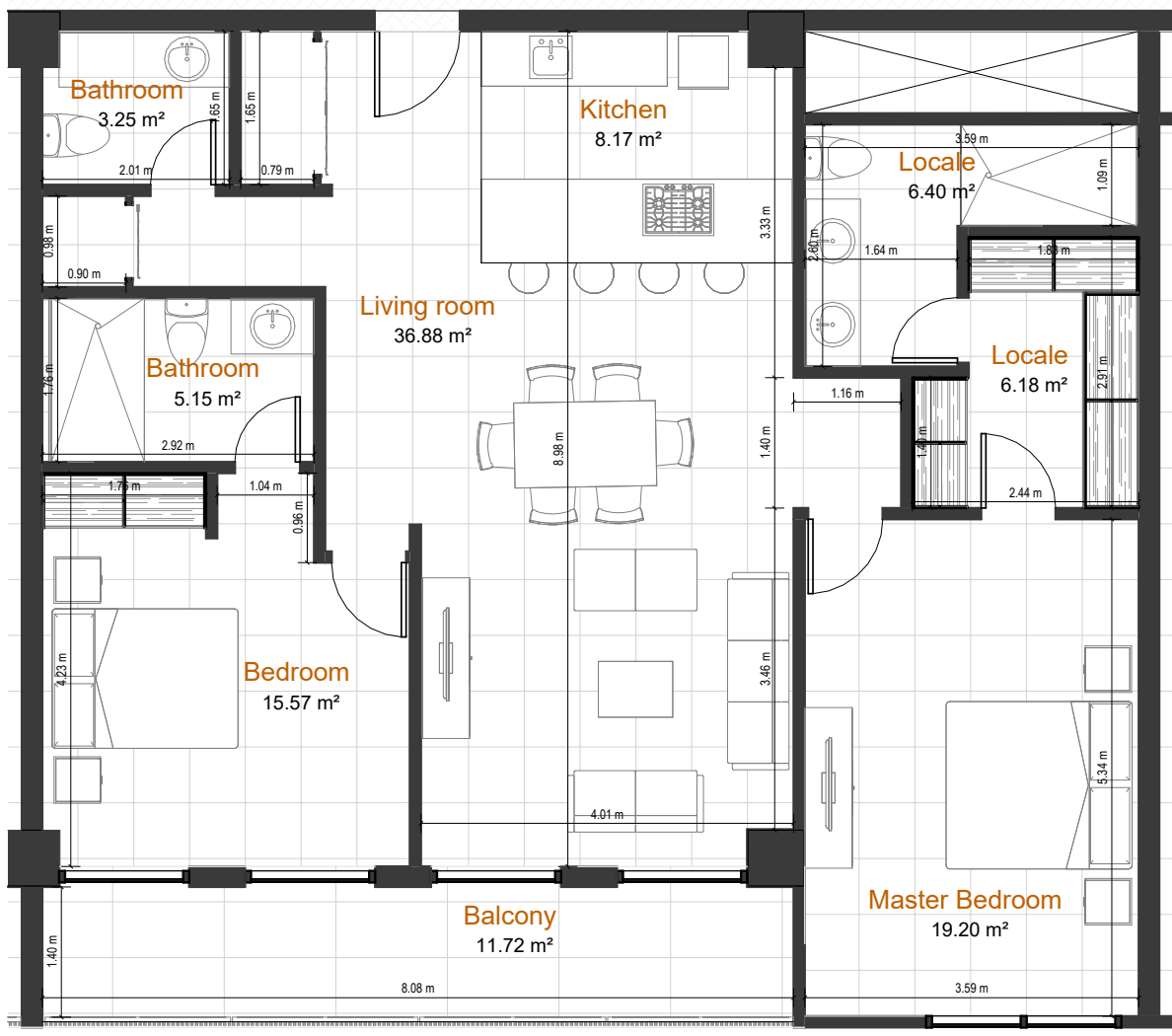


Figure 77. Apartment typology A.2. (Author, 2026).

Type B – One-Bedroom Apartment

Area: 57.4 m²

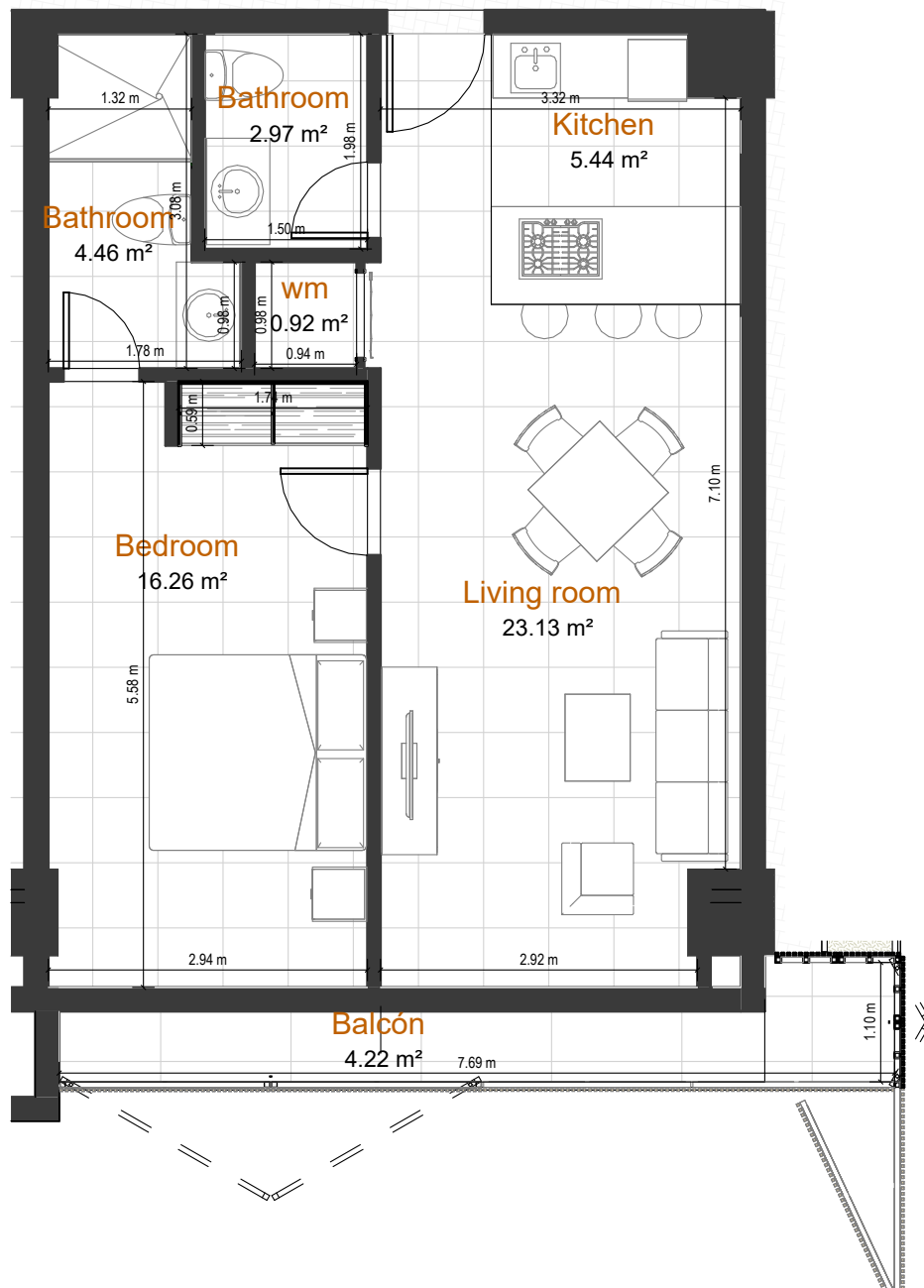


Figure 78. Apartment typology B. (Author, 2026).

Type C — Two-Bedroom Apartment

Area: 91.7 m²

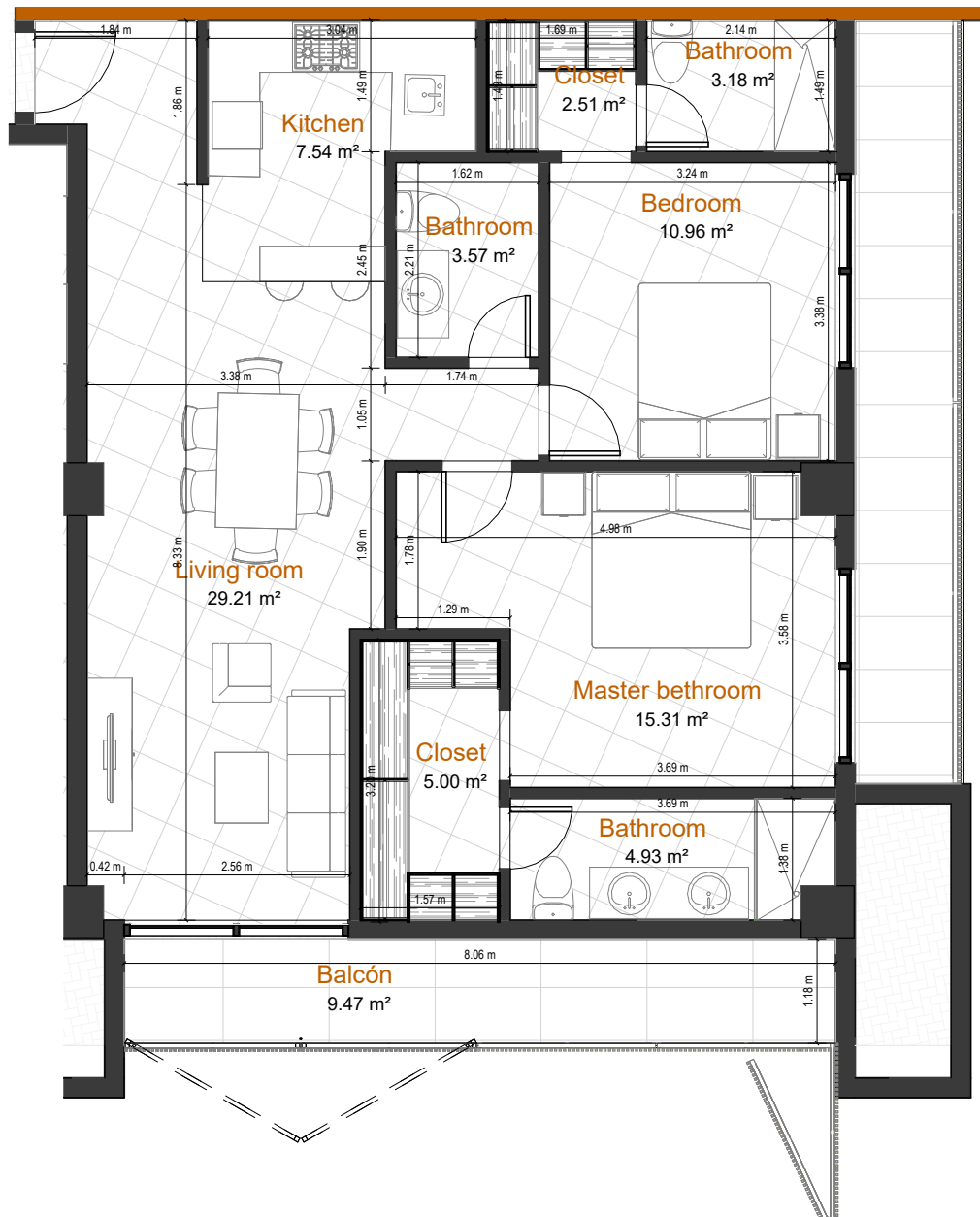


Figure 79. Apartment typology C. (Author, 2026).

Type D — Three-Bedroom Apartment

Area: 105.1 m²

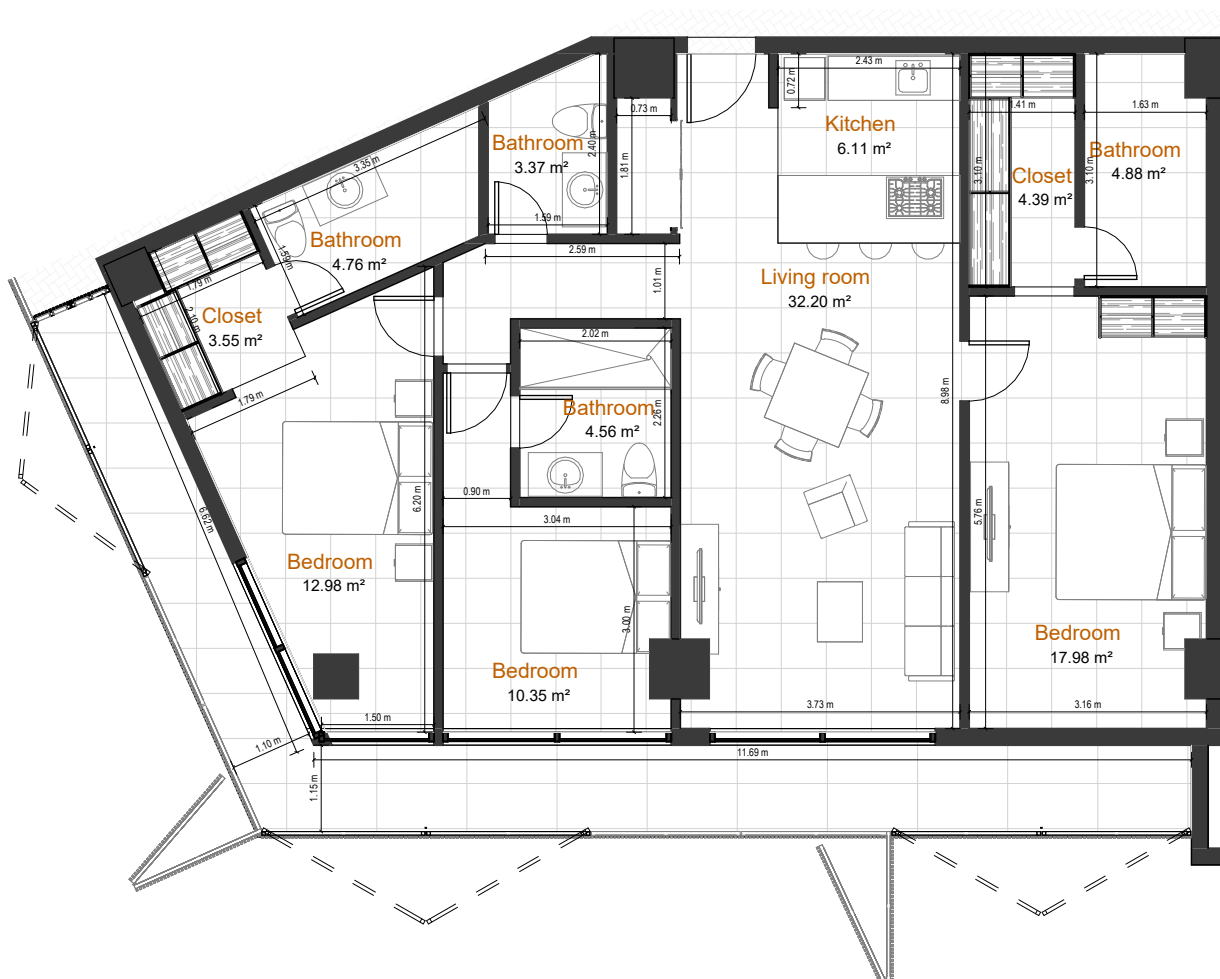


Figure 80. Apartment typology D. (Author, 2026).

Type E — Three-Bedroom Apartment

Area: 158.7 m²



Figure 81. Apartment typology E. (Author, 2026).

5.10 ARCHITECTURAL DRAWINGS

LEVEL -1 - Underground

1:300

Legend

- 1. Parking
- 2. Vertical circulation
- 3. Mechanical room
- 4. Ramp

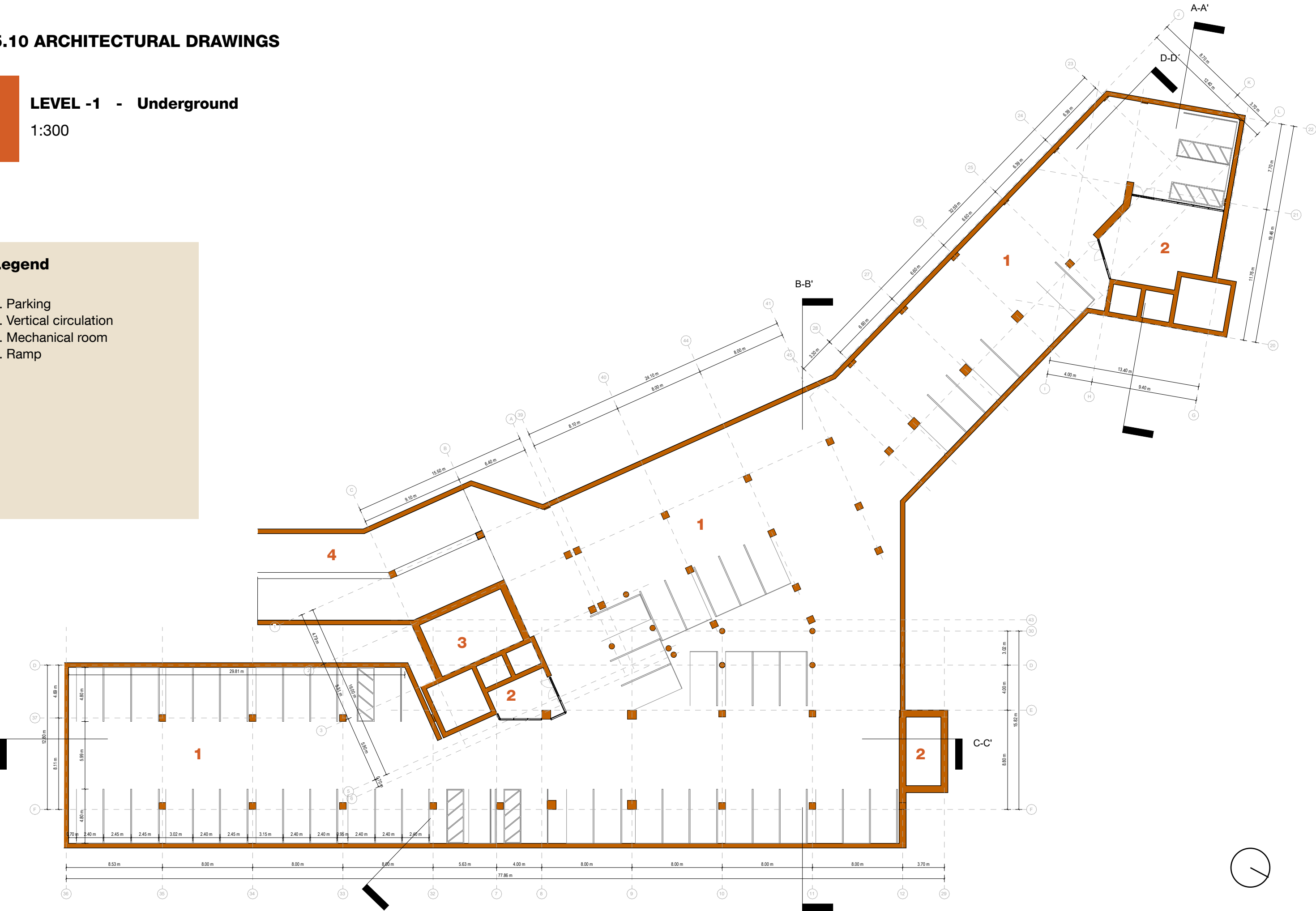


Figure 82. Underground plan. (Author, 2026).

LEVEL 0 - Ground floor

1:500

Legend

- 1. Lobby
- 2. Vertical circulation
- 3. Parking
- 4. Ramp
- 5. Bathroom
- 6. Plaza
- 7. Commercial Units
- 8. Rest area
- 9. Administration
- 10. Seating Area
- 11. Circulation
- 12. Cafeteria



Figure 83. Groundfloor plan. (Author, 2026).

100

Legend

1. Lobby
2. Vertical circulation
3. Bathroom
4. Commercial Units
5. Rest area
6. Seating Area
7. Circulation



Figure 84. First floor plan. (Author, 2026).

LEVEL 2 - Residencial floor

1:300

Legend

- 1. Lobby
- 2. Vertical circulation
- 3. Apartament
- 4. Gym
- 5. Bar
- 6. Seating Area
- 7. Circulation
- 8. Outdoor space
- 9. Multifunctional space



Figure 85. Second floor plan. (Author, 2026).

LEVEL 3 - Residencial floor
1:300

Legend

- 1. Lobby
- 2. Vertical circulation
- 3. Apartament
- 4. Circulation



Figure 86. Residential typical floor plan. (Author, 2026).

ROOF LEVEL
1:300

Legend

- 1. Vertical circulation
- 2. Rooftop
- 3. pv panels area



Figure 87. Roof floor plan. (Author, 2026).

SECTION A-A

1:300



Figure 88. Section A.A. (Author, 2026).

SECTION B-B

1:300

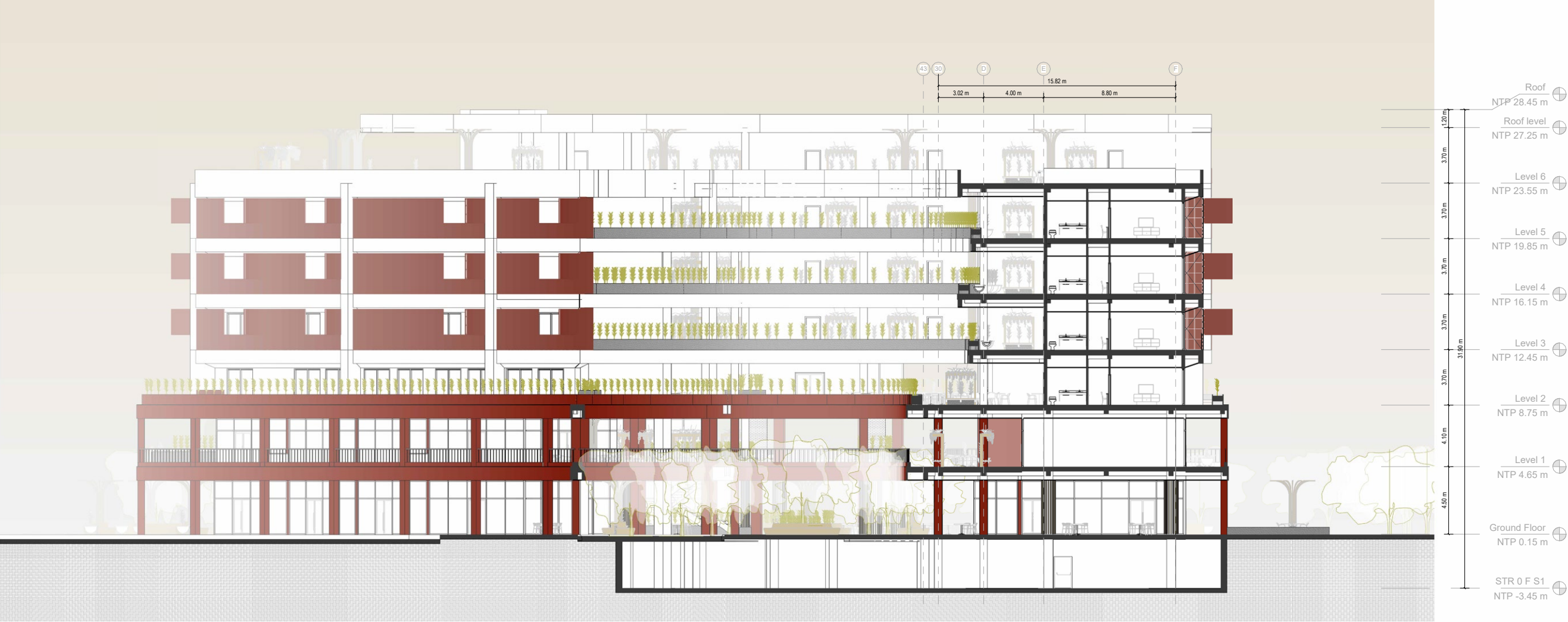


Figure 89. Section B.B. (Author, 2026).

SECTION C-C

1:300



Figure 90. Section C.C. (Author, 2026).

SECTION D-D

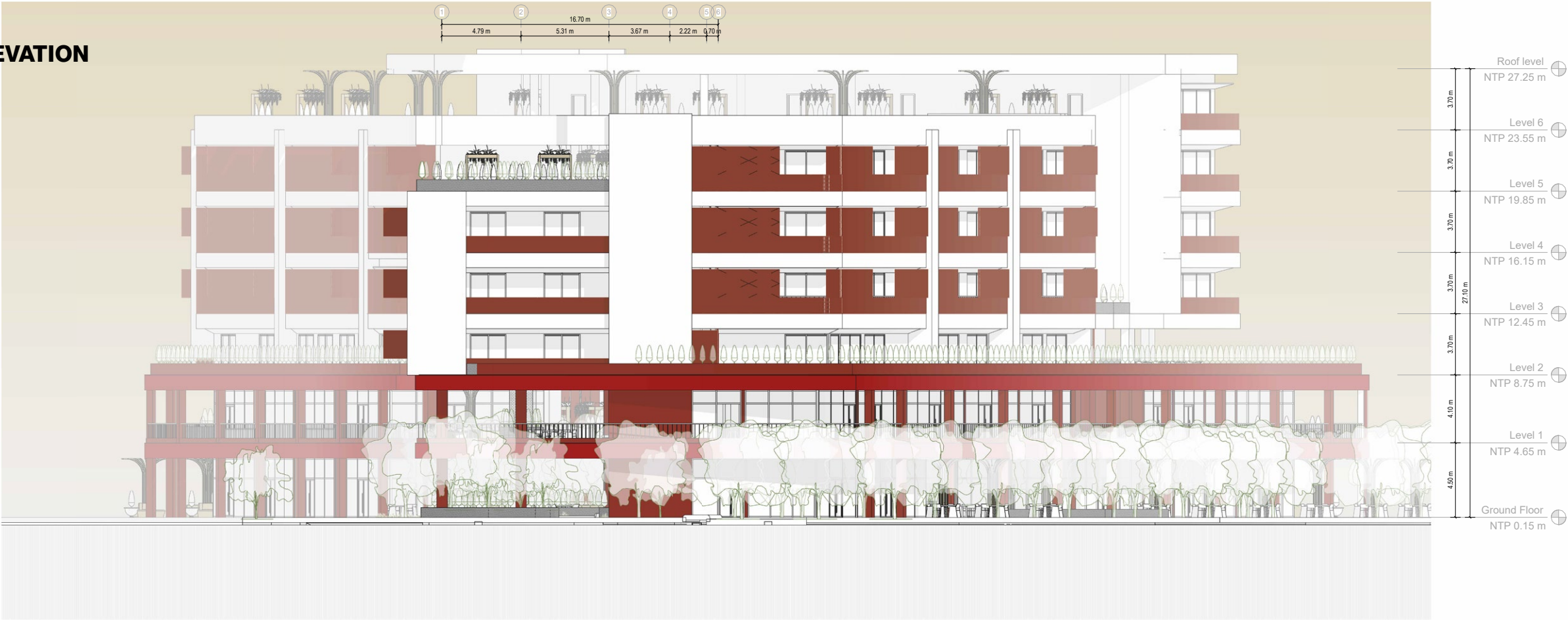
1:300



Figure 91. Section D.D. (Author, 2026).

SOUTH-EAST ELEVATION

1:300



SOUTH-WEST ELEVATION

1:300



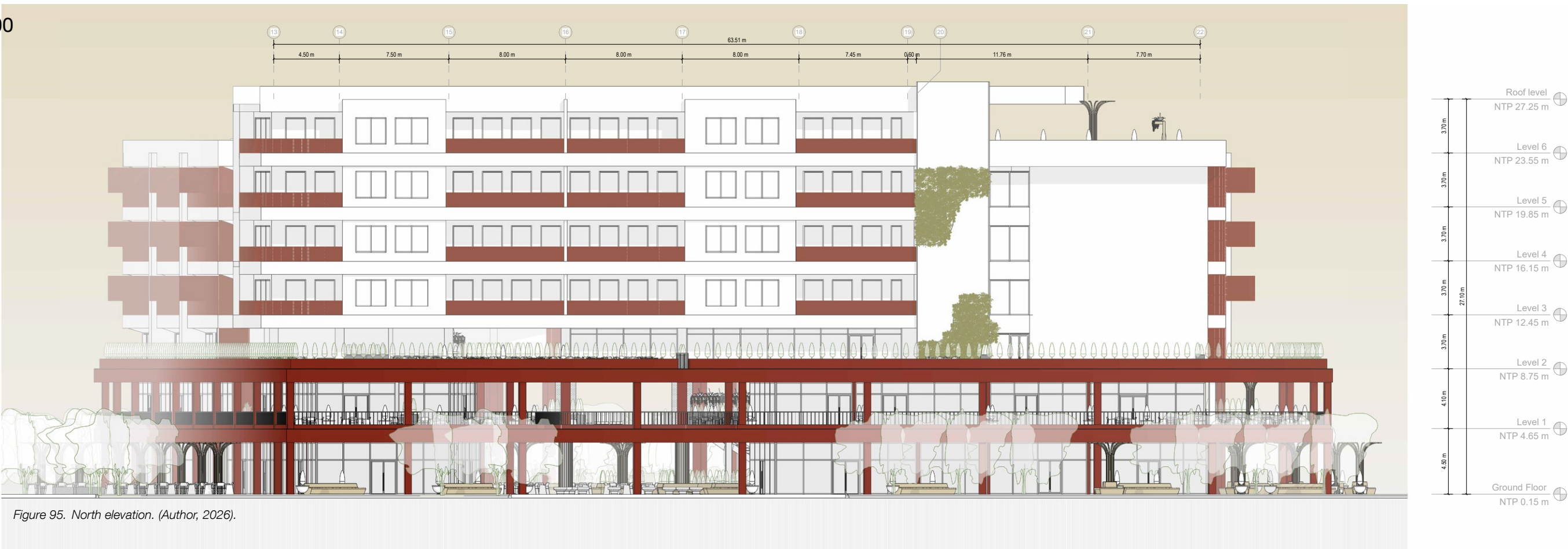
EAST ELEVATION

1:300



NORTH ELEVATION

1:300



5.11 ARCHITECTURAL VISUALIZATIONS



Figure 96. Waterfront view of the proposed mixed-use development. (Author, 2026).



Figure 97. Aerial view of the project within the masterplan context. (Author, 2026).



Figure 98. Riverfront public promenade and building frontage. (Author, 2026).



Figure 99. Nighttime view of the project along the Guayas River waterfront. (Author, 2026).



Figure 100. Central courtyard as the social and environmental core of the building. (Author, 2026).



Figure 101. Ground-floor public space and courtyard interface. (Author, 2026).



Figure 102. Open gallery circulation overlooking the central courtyard. (Author, 2026).



Figure 103. Perspective view from the Guayas River waterfront. (Author, 2026).



Figure 104. Main urban frontage and pedestrian-oriented public realm. (Author, 2026).

5.12 PASIVE STRATEGIES

DAYTIME STRATEGIES

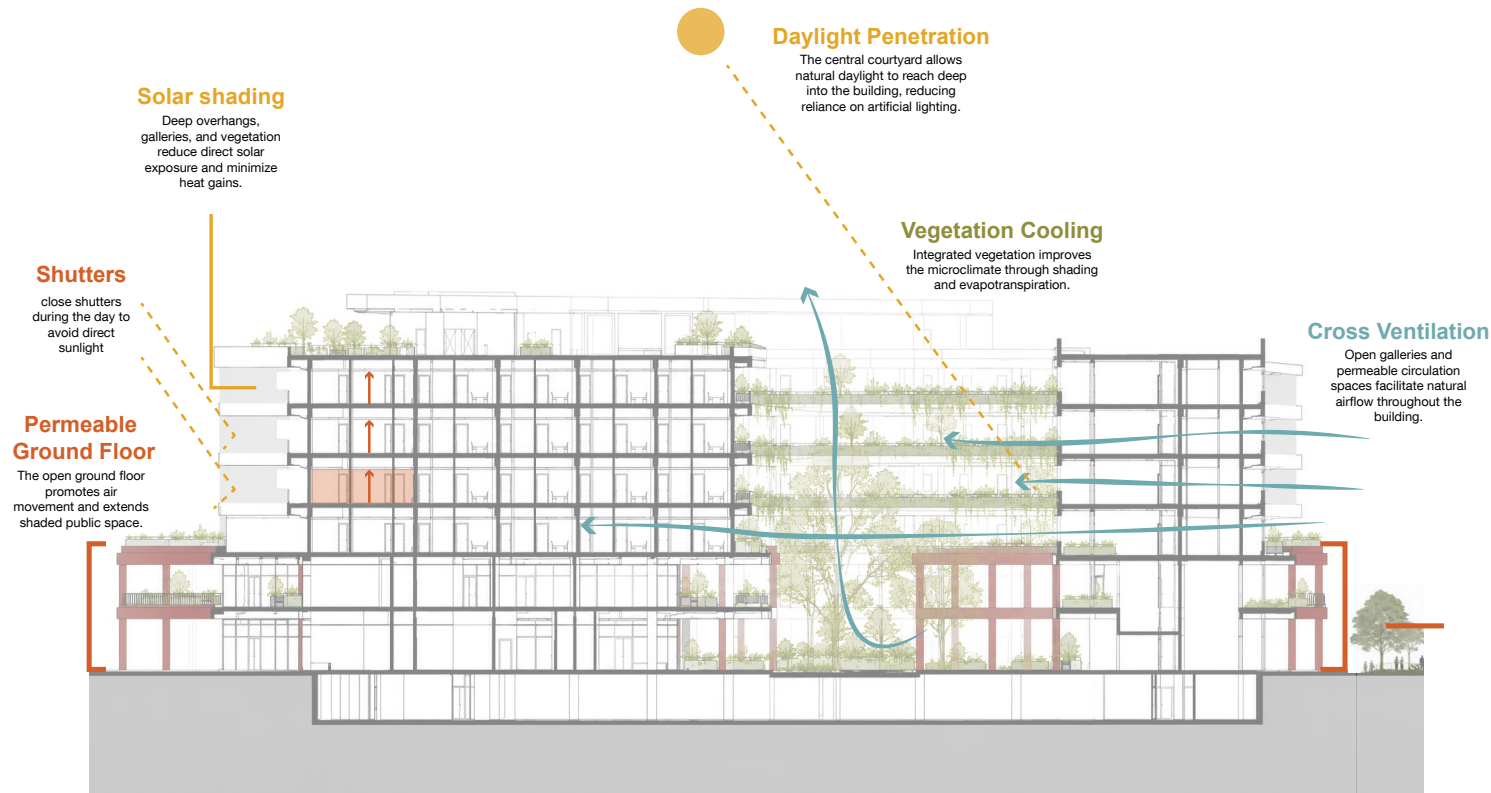


Figure 105. Passive design strategies implemented during daytime operation. (Author, 2026).

NIGHTTIME STRATEGIES

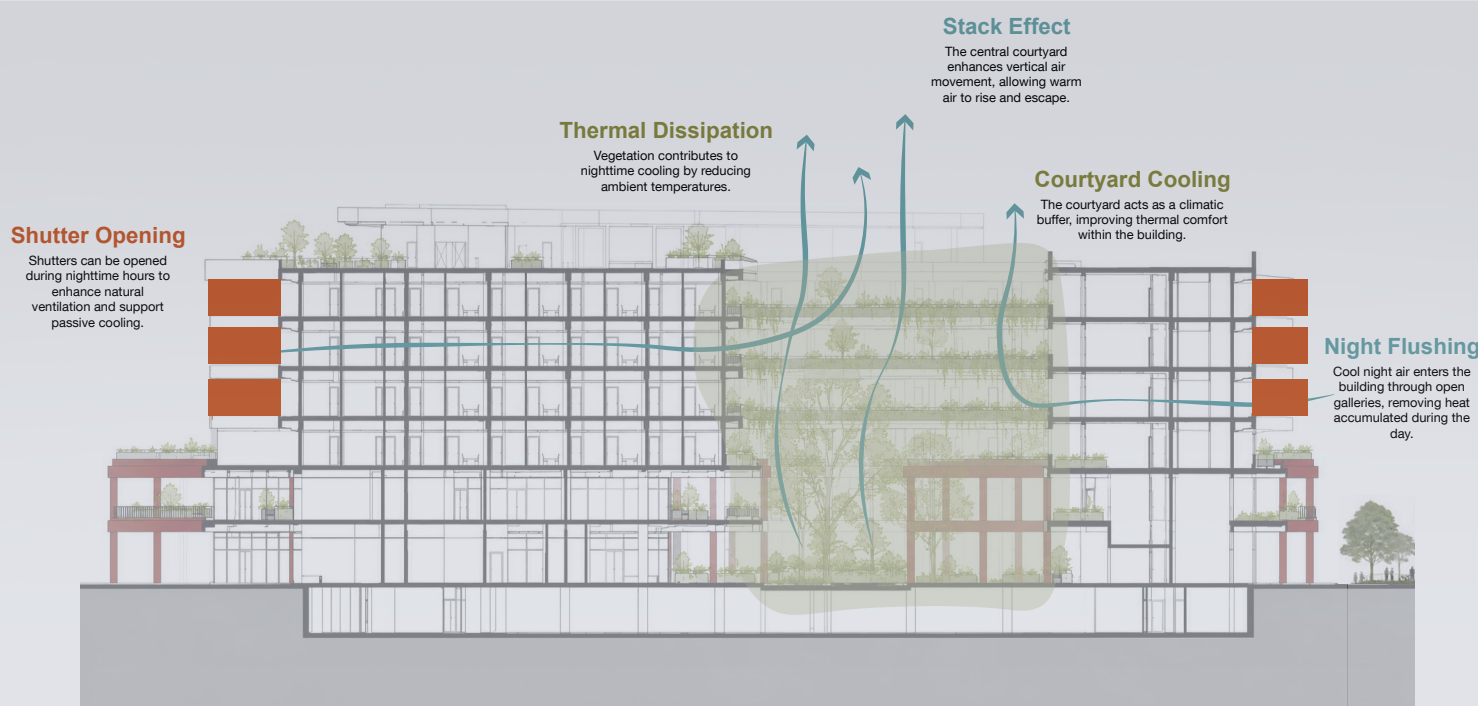


Figure 106. Nighttime passive strategies supporting thermal comfort and natural ventilation. (Author, 2026).

DAYTIME STRATEGIES

During daytime operation, the building relies primarily on passive environmental strategies to reduce solar heat gains and improve indoor thermal comfort under Guayaquil's tropical climate. Deep overhangs, open galleries, and operable shutters create multiple layers of solar protection, limiting direct solar radiation while still allowing natural daylight to penetrate interior spaces. The central courtyard functions as the climatic core of the project, bringing daylight deep into the building and promoting continuous air movement between the two building volumes. This configuration supports cross-ventilation across residential and mixed-use areas, reducing the dependence on mechanical cooling systems during occupied hours.

In addition, the extensive integration of vegetation throughout terraces, galleries, and the courtyard contributes to microclimatic regulation through shading and evapotranspiration. The permeable ground floor further enhances natural airflow by allowing air to circulate freely beneath and through the building, creating shaded public spaces that improve environmental comfort at the pedestrian level. Together, these strategies establish the first layer of environmental performance, significantly reducing the building's cooling demand before any active systems are required.

NIGHTTIME STRATEGIES

At night, the building shifts from heat protection to heat dissipation. As outdoor temperatures decrease, the operable shutters can be opened to maximize natural ventilation and facilitate airflow through residential units and common areas. Cooler air enters the building through the open galleries and courtyard, while warmer air accumulated during the day rises naturally through the central void and escapes through the upper levels. This process is reinforced by the stack effect generated by the vertical courtyard, which acts as a natural ventilation chimney. Simultaneously, the vegetation integrated throughout the building contributes to nighttime cooling by reducing surrounding air temperatures and creating a more comfortable microclimate within the courtyard. The combination of cross-ventilation, stack effect, and thermal dissipation allows the building to release stored heat and recover thermal comfort during the evening hours. As a result, the need for mechanical cooling is reduced, improving overall energy efficiency while enhancing indoor environmental quality.

5.13 ACTIVE STRATEGIES

DAYTIME STRATEGIES

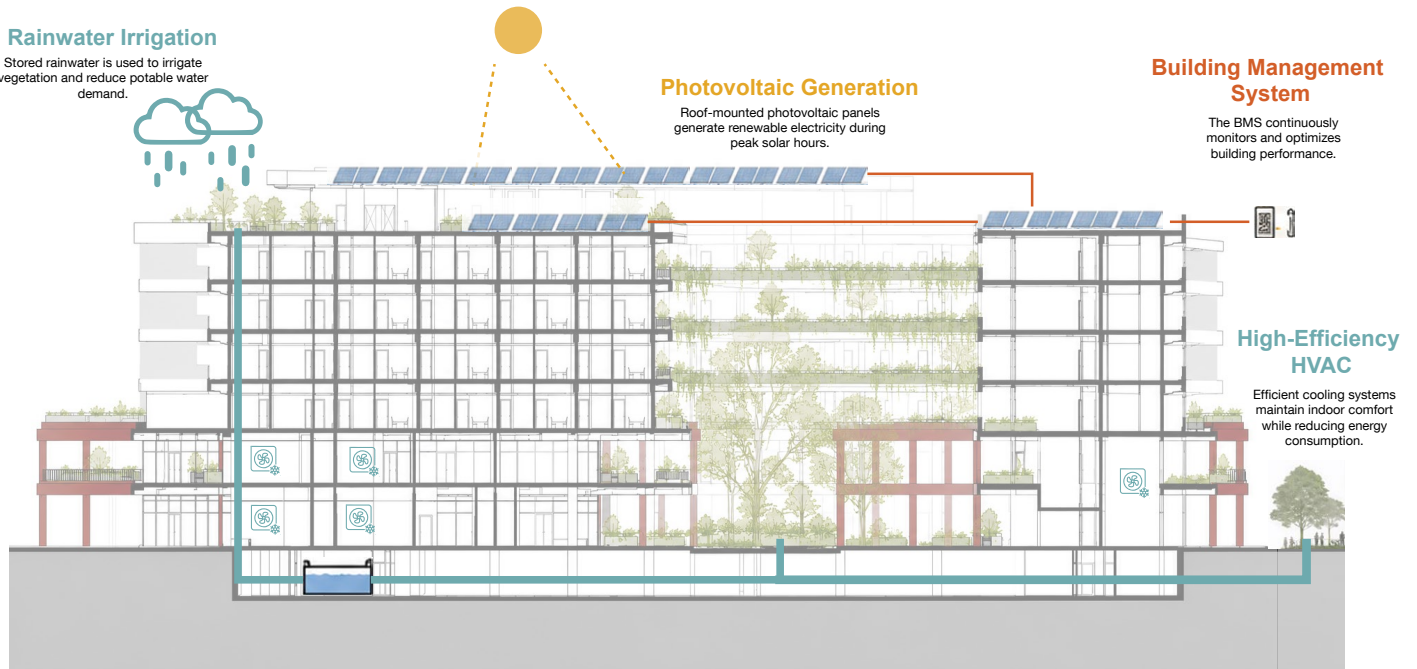


Figure 107. Active systems integrated to improve building energy performance. (Author, 2026).

NIGHTTIME STRATEGIES

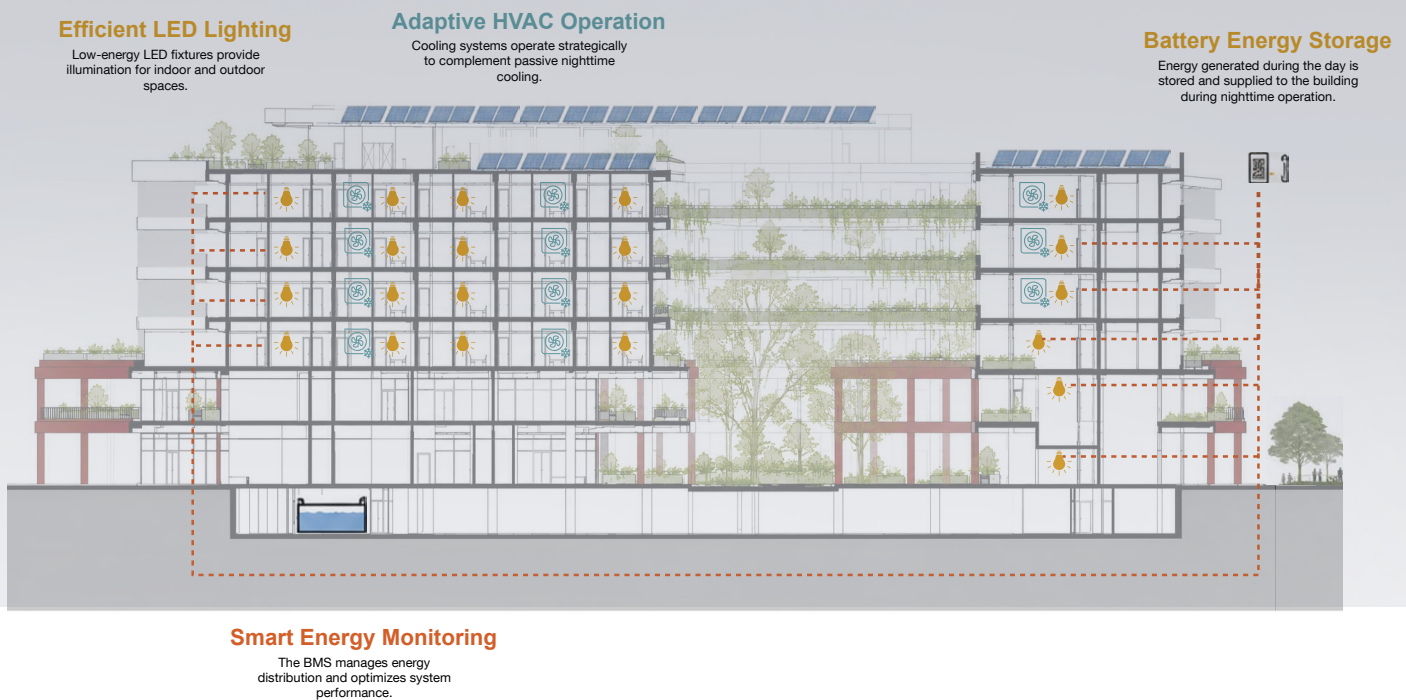


Figure 108. Nighttime active strategies for energy efficiency and building operation. (Author, 2026).

DAYTIME STRATEGIES

The active systems are designed to complement the passive strategies and provide additional support during periods of peak environmental demand. Throughout the day, photovoltaic panels installed on the roof convert solar radiation into renewable electricity, supplying part of the building's operational energy requirements and reducing dependence on the electrical grid. High-efficiency HVAC systems are intended to operate only when passive cooling strategies are no longer sufficient to maintain indoor comfort, thereby minimizing energy consumption while ensuring acceptable thermal conditions for occupants.

Rainwater collected from the roof surfaces is stored and reused for landscape irrigation, reducing potable water demand and supporting the extensive vegetation integrated throughout the project. The Building Management System (BMS) acts as the central control platform, continuously monitoring energy generation, cooling demand, water consumption, and system performance. By coordinating the interaction between renewable energy production, cooling systems, and water management, the active strategies improve operational efficiency and contribute to the long-term environmental performance of the building.

NIGHTTIME STRATEGIES

During nighttime operation, the focus of the active systems shifts from energy generation to energy management and optimization. Electricity produced by the photovoltaic panels during the day can be stored through battery energy storage systems and redistributed to support essential building functions after sunset. Efficient LED lighting provides illumination for circulation areas, communal spaces, and outdoor environments while maintaining low energy consumption. Adaptive HVAC controls respond to changing environmental conditions and can operate strategically in conjunction with the passive cooling provided by the courtyard and natural ventilation systems. The Building Management System continuously supervises energy flows, occupancy patterns, and system performance, ensuring that stored energy is distributed efficiently and only where required. In parallel, irrigation cycles may be scheduled during nighttime hours to minimize evaporation losses and improve water-use efficiency. Through the integration of energy storage, smart controls, efficient lighting, and optimized HVAC operation, the building maintains occupant comfort while reducing overall operational energy demand during the evening and nighttime periods.

Chapter 6:

Structural design

6.1 STRUCTURAL DESIGN CRITERIA

The structural strategy for the proposed building was conceived as an integrated component of the architectural design process, responding simultaneously to the environmental conditions of Guayaquil, the spatial configuration of the project, and the local construction context. Given the scale of the proposal, its mixed-use nature, and its geometrically articulated organization, the structural system needed to provide not only stability and seismic reliability, but also coherence with the architectural concept and realistic constructability.

As the project is located in Guayaquil, seismic considerations became a fundamental design criterion from the earliest stages of the proposal. According to the Ecuadorian Construction Code (NEC-SE-DS, 2015), the city is situated within one of the country's highest seismic hazard zones, making structural regularity, continuity, and overall stability essential aspects of the design approach.

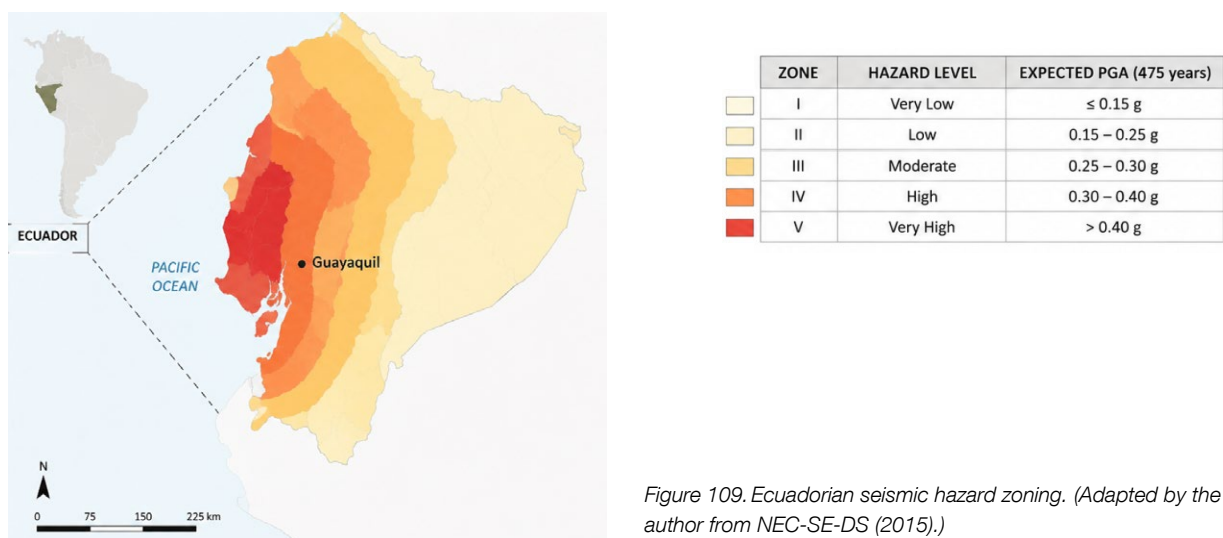


Figure 109. Ecuadorian seismic hazard zoning. (Adapted by the author from NEC-SE-DS (2015).)

Reinforced concrete was selected as the primary structural material due to its proven suitability in seismic regions, durability in humid tropical climates, fire resistance, and its widespread use in conventional construction practices in Guayaquil and the broader Ecuadorian context. Beyond these technical considerations, this material also aligns with the architectural intentions of the project, whose spatial organization incorporates curved internal transitions, non-orthogonal geometries, and a fluid relationship between structural order and spatial continuity.

The proposed structural system is based on a reinforced concrete frame complemented by vertical structural walls concentrated within the core and moment framing, providing the primary framework for stability and lateral resistance. A conventional one-way reinforced concrete beam-and-slab system was selected as the principal floor structure, offering a clear structural hierarchy, constructive simplicity, and compatibility with the span ranges and spatial organization proposed in the project.

From a regulatory perspective, the structural design framework is primarily based on the Ecuadorian Construction Code (Norma Ecuatoriana de la Construcción), particularly NEC-SE-DS for seismic design principles and NEC-SE-HM for reinforced concrete structural design. As this thesis represents a preliminary architectural and structural feasibility study rather than a detailed engineering design package, the analysis is developed through conceptual assumptions, preliminary load estimations, and representative structural verification intended to assess the overall viability of the proposed system.

6.2 STRUCTURAL SYSTEM DESCRIPTION

Given the overall scale, articulated geometry, and seismic context of the project, the building is not conceived as a single continuous structural body, but rather as a set of independent structural blocks separated through movement joints. This strategy responds to the need to accommodate differential structural displacements, thermal expansion, concrete shrinkage, and seismic deformation, while reducing the structural irregularities associated with a large and geometrically complex footprint.

In seismic regions, the separation of structurally independent building volumes is a recognized strategy to prevent adverse interaction between adjacent structural masses during seismic events, particularly pounding effects caused by differential movement (NEC-SE-DS, 2015). In reinforced concrete construction, movement joints also contribute to controlling deformations associated with thermal variation and material shrinkage (ACI Committee 224, 2001). As this thesis constitutes a preliminary structural feasibility study, the separation between structural blocks is considered conceptually, with an initial joint range conceptually assumed as preliminary seismic separation joints, subject to detailed engineering verification.

Based on these criteria, the project is subdivided into four principal structural blocks, each representing a more controlled and structurally manageable unit within the overall composition. This subdivision allows the irregular geometry of the architectural proposal to be rationalized into clearer structural zones while preserving the continuity of the spatial concept.

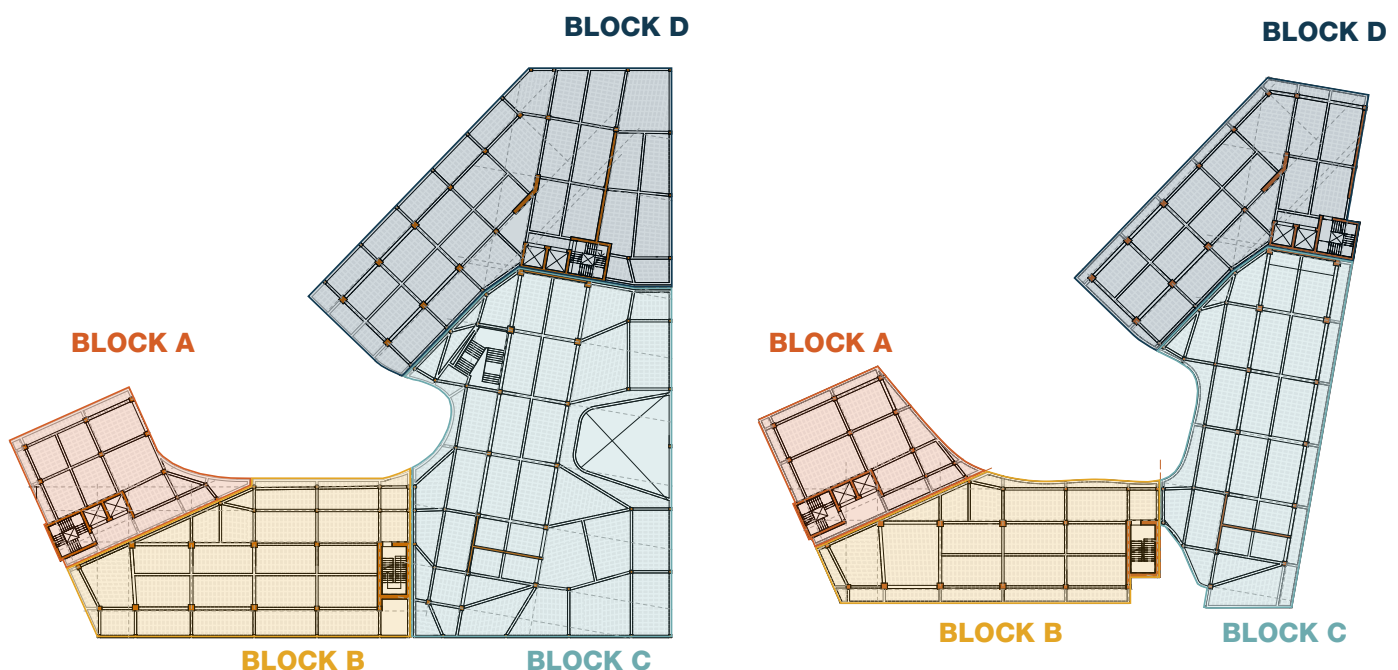


Figure 110. Structural zoning and separation of the building into independent structural blocks.
(Author, 2026).

Across these structural units, the building follows a reinforced concrete structural system composed of columns, primary and secondary beams, and one-way ribbed slab systems. Lateral stability is provided through a combination of reinforced concrete shear walls concentrated within the circulation cores and selected moment-resisting frames located along strategic perimeter axes. This hybrid system improves stiffness distribution, reduces torsional effects associated with the irregular geometry and eccentric locations of the circulation cores, and maintains compatibility with the architectural organization of the project.

In addition to the primary frame system, reinforced concrete shear walls concentrated within the vertical circulation cores contribute significantly to the global stability of the building, particularly under seismic actions. In high seismic contexts such as Guayaquil, these elements play a fundamental role in controlling lateral displacements and providing a clear vertical path for horizontal force transfer toward the foundation system (Paulay & Priestley, 1992). Their integration within the building cores also allows structural performance to be aligned with the architectural organization of the project while minimizing interference with interior spatial flexibility.

LEVEL 3 - Residencial floor

1:300

- Moment Resisting Frame Beam (MRF)
- Primary Beam
- Rib direction
- Perimeter / Cantilever Beam
- Shear wall
- Structural Joint



Figure 111. Commercial floor typical structural plan. (Author, 2026).

LEVEL 3 - Residencial floor

1:300

- Moment Resisting Frame Beam (MRF)
- Primary Beam
- Rib direction
- Perimeter / Cantilever Beam
- Shear wall
- - - Structural Joint



Figure 112. Residential floor typical structural plan. (Author, 2026).

6.3 GEOTECHNICAL ASSUMPTIONS AND FOUNDATION STRATEGY

Due to this proximity, the site is expected to present soil conditions associated with alluvial and estuarine deposits, potentially characterized by soft compressible strata and elevated groundwater presence, conditions commonly associated with river-adjacent urban environments (Das & Sobhan, 2018). These factors are particularly relevant for the structural design of a large reinforced concrete building, as they directly influence settlement control, foundation selection, and below-grade structural containment. The inclusion of an underground parking level further reinforces the need for an integrated substructure strategy capable of addressing both vertical load transfer and lateral soil retention.

Under these assumptions, shallow foundation systems were considered less appropriate for the scale and expected loading conditions of the project. Instead, the foundation strategy is conceptually developed as a reinforced concrete piled raft system, combining a continuous foundation slab at basement level with deep foundation elements positioned beneath the principal structural load concentrations. This approach allows the basement slab to function simultaneously as a structural foundation platform and as a load-distribution element, while transferring vertical loads toward deeper and more stable strata, a strategy commonly adopted in conditions involving weak near-surface soils and high structural demands (Poulos, 2001).

Given the presence of the underground parking level, reinforced concrete retaining walls are also incorporated as part of the substructure strategy, providing below-grade soil containment and contributing to the structural organization of the basement perimeter. As this proposal remains within the scope of a preliminary structural feasibility study, the foundation configuration is presented as a conceptual strategy intended to establish structural coherence rather than a finalized engineering solution.

KEY FOUNDATION ASSUMPTIONS

- Site located adjacent to the Guayas River
- Assumed alluvial soil conditions
- One underground parking level incorporated
- Deep foundation system conceptually adopted
- Reinforced concrete retaining walls at basement perimeter

Conceptual section



Figure 113. Conceptual foundation strategy illustrating the proposed piled raft system

Based on these assumptions, the following plan illustrates the conceptual foundation layout and structural load distribution strategy adopted for the project.

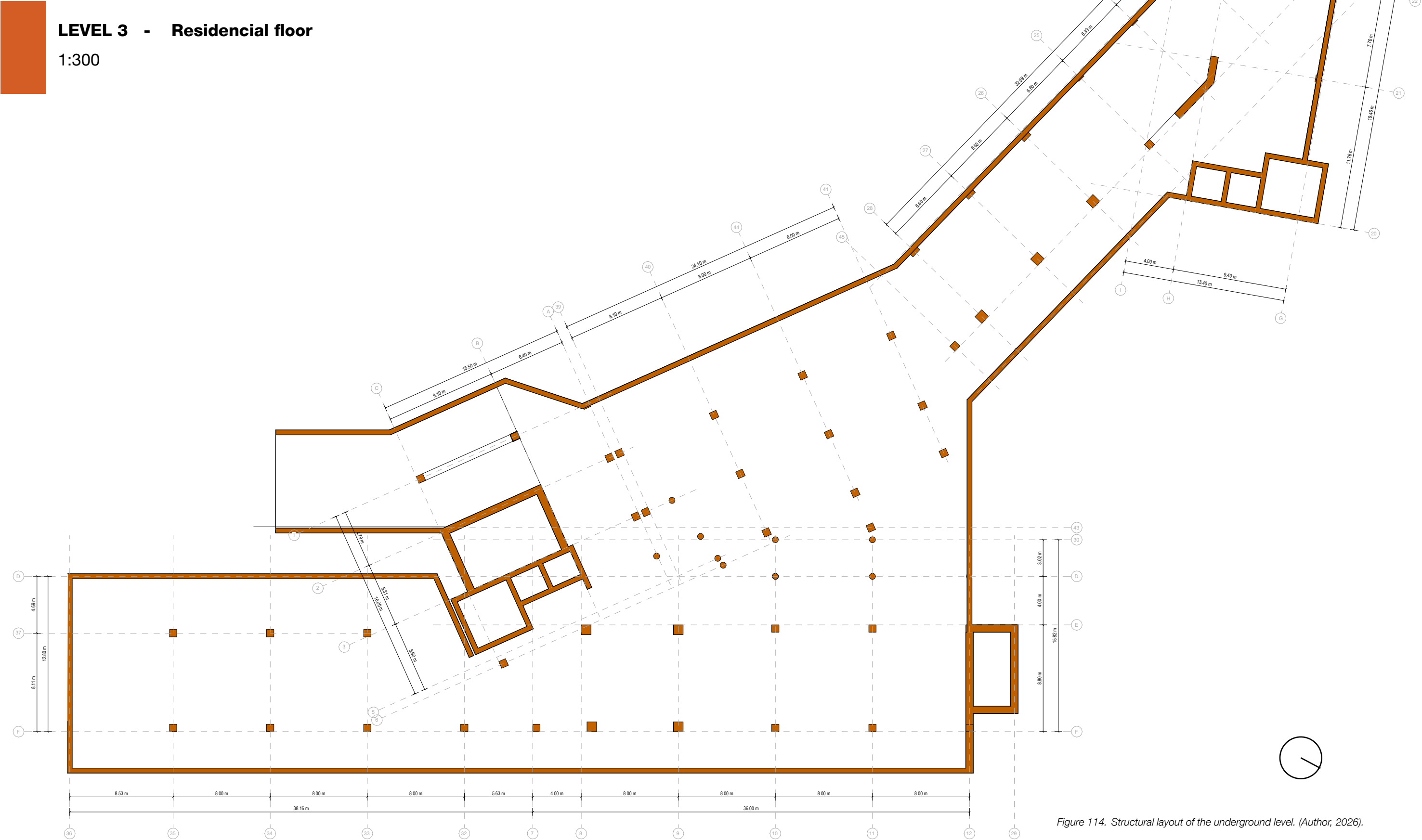


Figure 114. Structural layout of the underground level. (Author, 2026).

6.4 REPRESENTATIVE STRUCTURAL ASSESSMENT APPROACH

The structural assessment is developed through a representative analytical approach rather than a full engineering verification of the entire building. Given the scale, geometric complexity, and segmented structural organization of the project, a complete structural analysis would exceed the scope of this research.

To establish a coherent and manageable assessment, Block B was selected as the representative structural sector due to its regular geometry, repetitive structural logic, and clear load-transfer organization. Compared to the more irregular areas of the project, this block provides a controlled structural condition suitable for preliminary evaluation.

Within this sector, a representative structural bay was selected to define load assumptions, preliminary structural sizing, and the simplified verification of key load-bearing elements. The analysis focuses on one representative beam and one representative column, allowing the overall feasibility of the proposed structural strategy to be assessed within the scope of the thesis.

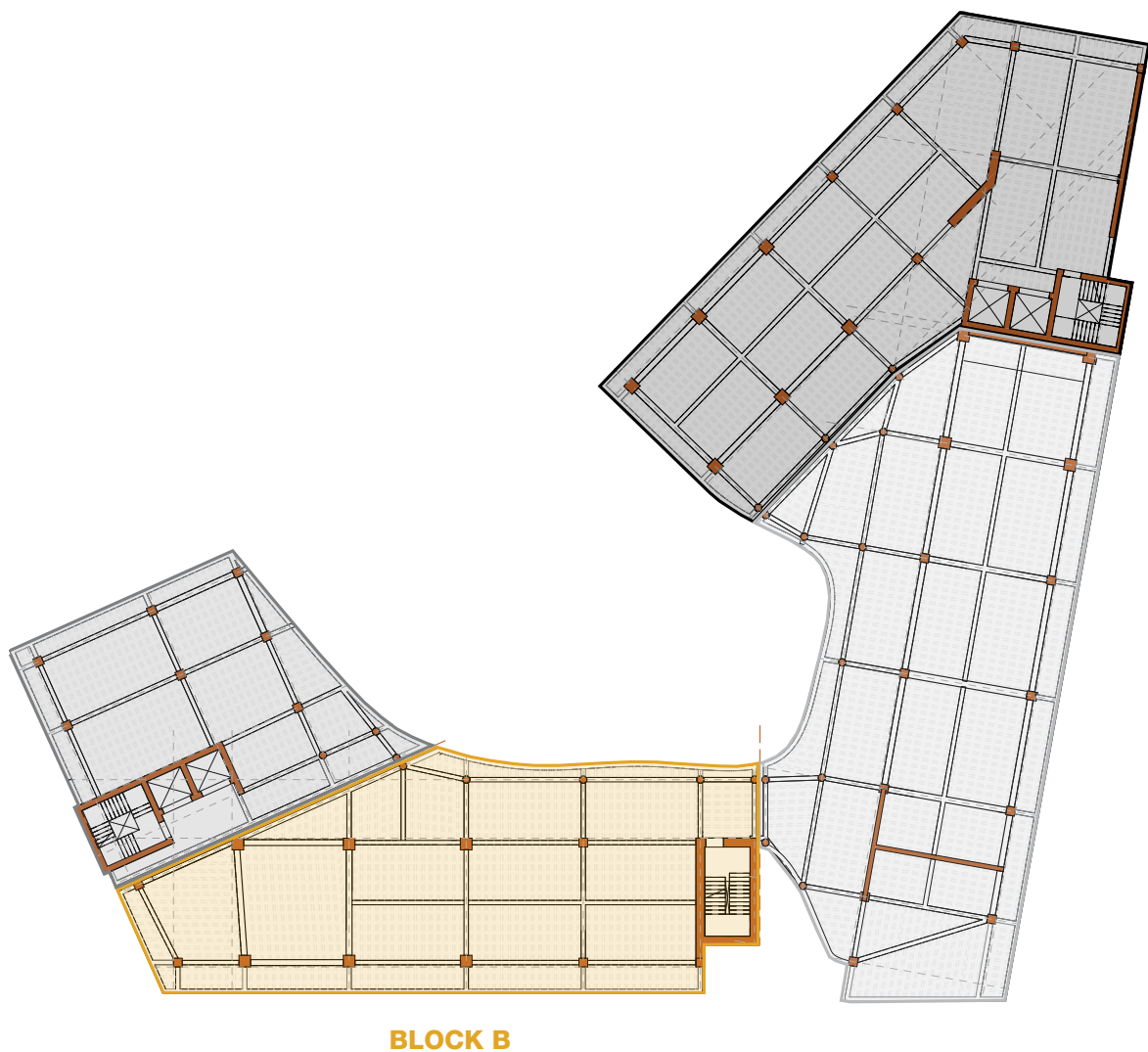


Figure 115. Representative structural sector selected for preliminary structural evaluation. (Author, 2026).

6.5 LOAD ANALYSIS

Following the Ecuadorian Construction Code (NEC-SE-CG), structural actions considered in this preliminary assessment are classified into permanent, variable, and accidental/environmental loads. Since this thesis develops a representative structural feasibility verification rather than a full structural engineering design package, the quantitative assessment focuses on gravity loads acting on a representative structural bay, while environmental and seismic actions are acknowledged through the global structural strategy.

PERMANENT LOADS

Permanent loads include the self-weight of structural and non-structural elements that remain constant throughout the building's service life. In this preliminary assessment, these include the reinforced concrete structural system, floor build-up layers, suspended ceilings, internal partitions, façade shading elements, and fixed rooftop equipment associated with the NZEB strategy.

DEAD LOADS		
STRUCTURAL LOADS		
Load component	Adopted load	Source
Reinforced concrete unit weight	24.0 kN/m³	According to NEC-SE-CG
One-way ribbed RC slab self-weight	4.0 kN/m²	25 cm total depth (preliminary conceptual assumption)
Representative RC beam self-weight	4.32 kN/m	30 × 60 cm beam
Representative RC column self-weight	8.64 kN/m	60 × 60 cm column
NON STRUCTURAL LOADS		
Load component	Adopted load	Source
Ceramic tile + cement mortar floor finish	0.60 kN/m²	NEC-SE-CG material unit weight table (3 cm assumed finish build-up)
Plain concrete screed / leveling layer	1.10 kN/m²	NEC-SE-CG material unit weight table (5 cm assumed screed layer)
Gypsum suspended ceiling	0.20 kN/m²	NEC-SE-CG ceiling load table
Lightweight internal partitions	1.00 kN/m²	ASCE 7 conceptual partition allowance
External aluminum shading screen	0.50 kN/m²	Manufacturer-based estimate from lightweight perforated aluminum façade systems
Rooftop photovoltaic system + mounting structure	0.25 kN/m²	Manufacturer technical data for lightweight rooftop PV systems

Figure 116. Table of permanents loads

LIVE LOADS

Variable loads represent occupancy-dependent actions that may change over time according to building use. In this mixed-use proposal, live loads are assigned based on NEC-SE-CG occupancy classifications for residential, commercial, circulation, parking, and roof maintenance functions.

LIVE LOADS		
Building area	Adopted load	NEC-SE-CG occupancy classification
Basement parking	2.00 kN/m ²	Passenger vehicle garage
Commercial ground floor	4.80 kN/m ²	Retail / commercial first floor
Residential rooms	2.00 kN/m ²	Multifamily residential occupancy
Residential public halls / corridors	4.80 kN/m ²	Public halls and circulation
Roof (maintenance access only)	1.40 kN/m ²	Roof maintenance

Figure 117. Live loads. (Author, 2026).

Environmental Actions and Design Scope

Environmental actions such as wind and rain are acknowledged within the NEC-SE-CG framework. However, since the representative structural verification focuses on a typical beam and column under gravity loads, these actions are not quantified in the member check. Instead, wind and seismic effects are addressed at the level of global structural strategy, while rain load is considered relevant mainly for roof drainage and water accumulation control.

6.6 LOAD COMBINATION

Once the permanent and variable loads have been defined according to NEC-SE-CG, the representative structural verification requires the adoption of a design load combination for ultimate limit state assessment. Since this preliminary structural check focuses on gravity actions acting on a representative beam-column system, the governing combination considers only permanent and live loads.

$$1.2D+1.6L$$

D = permanent loads

L = live loads

This combination is applied to the selected representative structural bay in order to estimate the design actions acting on the primary beam and supporting column under typical occupancy conditions.

6.7 REPRESENTATIVE STRUCTURAL BAY SELECTION

To develop the preliminary structural verification, a representative structural bay was selected within the most regular portion of the residential structural grid, where the load transfer path can be clearly identified and the structural behavior is considered representative of the overall system. This approach allows the structural feasibility of the proposal to be assessed without undertaking a full building-wide structural analysis.

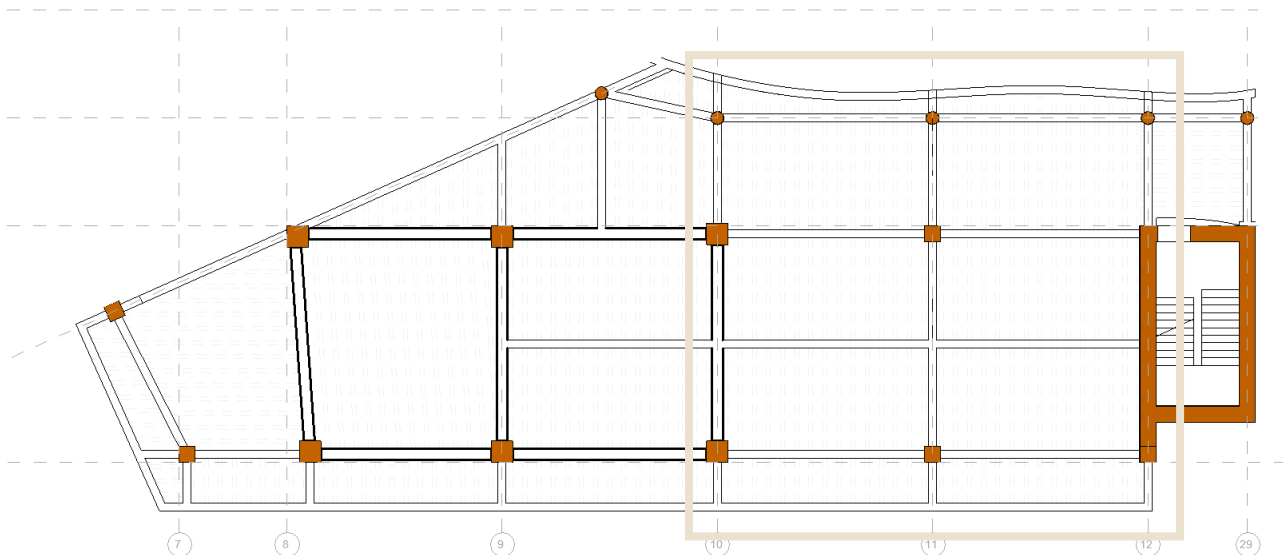


Figure 118. Representative structural bay selected for preliminary beam and column verification. (Author, 2026).

Location: Block B (regular residential grid)
Structural system: reinforced concrete frame
Floor system: one-way ribbed slab
Representative beam span: 8.0 m
Supporting column section: 60 × 60 cm
Purpose: preliminary gravity-load verification

The selected module consists of an interior reinforced concrete beam spanning between primary structural supports, together with its corresponding vertical load-bearing column. This location was intentionally chosen to avoid façade irregularities, perimeter conditions, and localized architectural exceptions that could distort the interpretation of the typical structural behavior

The floor system in this area is based on a one-way ribbed reinforced concrete slab, which transfers gravity loads toward the selected beam through a clearly defined tributary area. The beam therefore represents a typical gravity-load element, while the supporting column allows the cumulative vertical load transfer through the building height to be conceptually verified.

6.8 PRELIMINARY STRUCTURAL PREDIMENSIONING CRITERIA

Prior to the representative structural verification, preliminary dimensions were established using conceptual structural sizing criteria commonly applied during early-stage reinforced concrete design. These proportional rules provide an initial approximation of feasible structural dimensions based on span length, expected load transfer, and structural hierarchy, serving as a preliminary validation of the proposed architectural system.

Structural element	Adopted dimension	Preliminary sizing criteria	Application
Reinforced concrete beam	30 × 60 cm	L / 20 to L / 24	initial sizing + preliminary verification refinement
Moment Resisting Frame Beam	30 × 80 cm	Increased stiffness and strength for seismic actions	Lateral force resisting system
Reinforced concrete column	60 × 60 cm	Preliminary proportion based on tributary load and building height	Conceptual RC vertical support
Moment Frame RC Column	70 × 70 cm	Increased section to accommodate axial load and bending moments	Moment resisting frame system
One-way ribbed slab	25 cm total depth	L / 20 to L / 25	Typical slab spanning criterion
Shear walls	30 cm	Preliminary seismic lateral stability assumption	Global structural system
Basement retaining walls	35–40 cm	Conceptual substructure assumption	Soil retention strategy

Figure 119. Preliminary structural predimensioning criteria. (Author, 2026).

These dimensions were selected to establish a coherent structural baseline compatible with the architectural proposal and the seismic context of Guayaquil, and are subsequently tested through the representative beam and column verification.

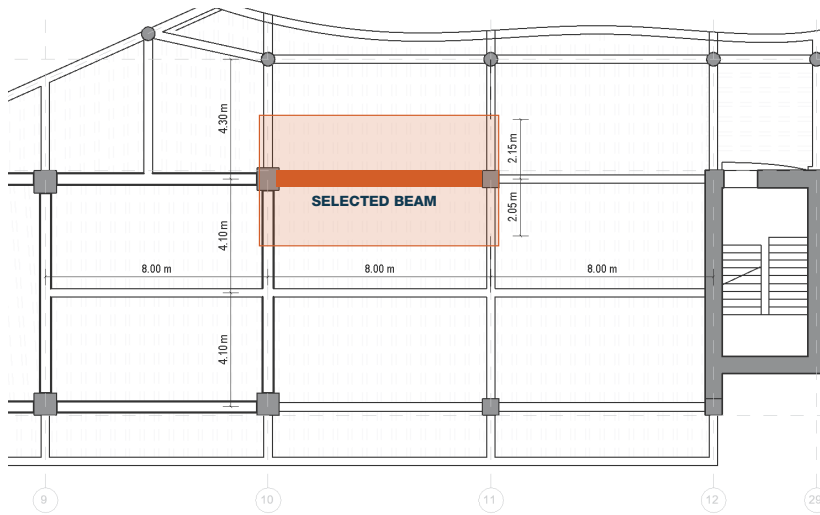
6.9 REPRESENTATIVE PRIMARY BEAM VERIFICATION

The representative primary beam selected for the preliminary verification is located within Block B, as part of the main structural framework of the tower. This element was chosen because it reflects the typical load-transfer behavior of the proposed reinforced concrete beam-and-slab system, receiving gravity loads from the adjacent floor panels and transferring them toward the vertical support structure. Its analysis serves as a representative structural feasibility check within the broader architectural proposal.

Material assumptions

Material	Adopted value	Source
Concrete compressive strength, (f'_c)	28 MPa	Equivalent to approx. 280 kg/cm ² , a standard commercial structural concrete range available in Ecuador; Holcim Ecuador lists structural concrete strengths in the range of 180–300 kg/cm ² at 28 days. (Holcim Ecuador S.A.)
Reinforcing steel yield strength, (f_y)	420 MPa	Equivalent to Grade 60 / Grade 420 reinforcement commonly used for reinforced concrete; Ecuadorian suppliers such as Adelca refer to NTE INEN 2167 and ASTM A706 for reinforcing bars. (portaldisenso.com)

Figure 120. Materials assumptions. (Author, 2026).



Parameter	Value
Beam type	Primary reinforced concrete beam
Span, (L)	8.00 m
Beam section	30 × 60 cm
Width, (b)	300 mm
Total depth, (h)	600 mm
Effective depth, (d)	≈ 540 mm
Tributary width	4.20 m

Figure 121. Representative beam selected for preliminary structural verification and sizing. (Author, 2026).

The highlighted beam represents a typical primary structural member within the proposed reinforced concrete system. Its regular geometry and clearly defined tributary area make it suitable for preliminary flexural and shear verification.

Load Calculation

Permanent loads acting on the representative beam include the self-weight of the one-way ribbed slab, floor finishes, screed or leveling layer, gypsum suspended ceiling, and lightweight internal partitions, resulting in a total area dead load of **6.90 kN/m²**. Considering the tributary width of 8.00 m, this corresponds to an equivalent line load of:

$$6.90 \times 4.20 = 28.98 \text{ kN/m}$$

In addition, the self-weight of the primary reinforced concrete beam (30 × 60 cm) is calculated using the concrete unit weight established by NEC-SE-CG (24 kN/m³). Therefore, the total permanent line load acting on the beam is:

$$0.30 \times 0.60 \times 24 = 4.32 \text{ kN/m}$$

Thus, the total permanent line load acting on the beam is:

$$D = 28.98 + 4.32 = 33.30 \text{ kN/m}$$

For the residential floor, the adopted live load according to NEC occupancy criteria is 2.00 kN/m², which, when converted over the same tributary width, results in:

$$L = 2.00 \times 4.20 = 8.40 \text{ kN/m}$$

Load Combination

The adopted ultimate gravity load combination is:

$$w_u = 1.2D + 1.6L$$

$$w_u = 1.2(33.30) + 1.6(8.40)$$

$$w_u = 53.40 \text{ kN/m}$$

Conceptual section

For this preliminary verification, the beam is conservatively modeled as a simply supported element, and we calculate the design bending moment and shear force

$$\begin{aligned}M_u &= \frac{w_u L^2}{8} & V_u &= \frac{w_u L}{2} \\M_u &= \frac{53.40 \times 8.00^2}{8} & V_u &= \frac{53.40 \times 8.00}{2} \\M_u &= 427.20 \text{ kNm} & V_u &= 213.60 \text{ kN}\end{aligned}$$

Flexural Verification

The flexural capacity of the adopted 30 × 60 cm reinforced concrete beam was verified under Ultimate Limit State (ULS) conditions by comparing the design bending demand with the estimated flexural resistance of the section.

$$\phi M_n \geq M_u$$

Adopted longitudinal reinforcement: 5Ø25 providing: $A_s = 5 \times 491 = 2455 \text{ mm}^2$

Using standard reinforced concrete design assumptions consistent with NEC-SE-HM / ACI methodology, the estimated flexural capacity of the beam is:

$$\phi M_n \approx 437 \text{ kNm}$$

Verification:

$$\begin{aligned}\phi M_n &\geq M_u \\437 \text{ kNm} &\geq 427.20 \text{ kNm}\end{aligned}$$

Shear check

The shear capacity was verified by comparing the design shear demand with the available concrete shear resistance.

$$\phi V_n \geq V_u$$

Concrete shear resistance:

$$\phi V_c \approx 109.3 \text{ kN}$$

Comparison:

$$\begin{aligned}\phi V_n &\geq V_u \\109.3 \text{ kN} &< 213.60 \text{ kN}\end{aligned}$$

Insufficient

Shear verification was performed by comparing the design shear demand with the available shear resistance of the reinforced concrete section. Since the concrete contribution alone is insufficient, transverse reinforcement is required as expected in conventional reinforced concrete design.

additional shear reinforcement is required

Adopted preliminary reinforcement:

$$\phi 10@20cm$$

Estimated total shear capacity with stirrups:

$$\phi V_n \approx 243\text{ kN}$$

Final verification:

$$\phi V_n \geq V_u$$

$$243\text{ kN} \geq 213.60\text{ kN}$$

Shear verification satisfied.

6.10 REPRESENTATIVE COLUMN VERIFICATION

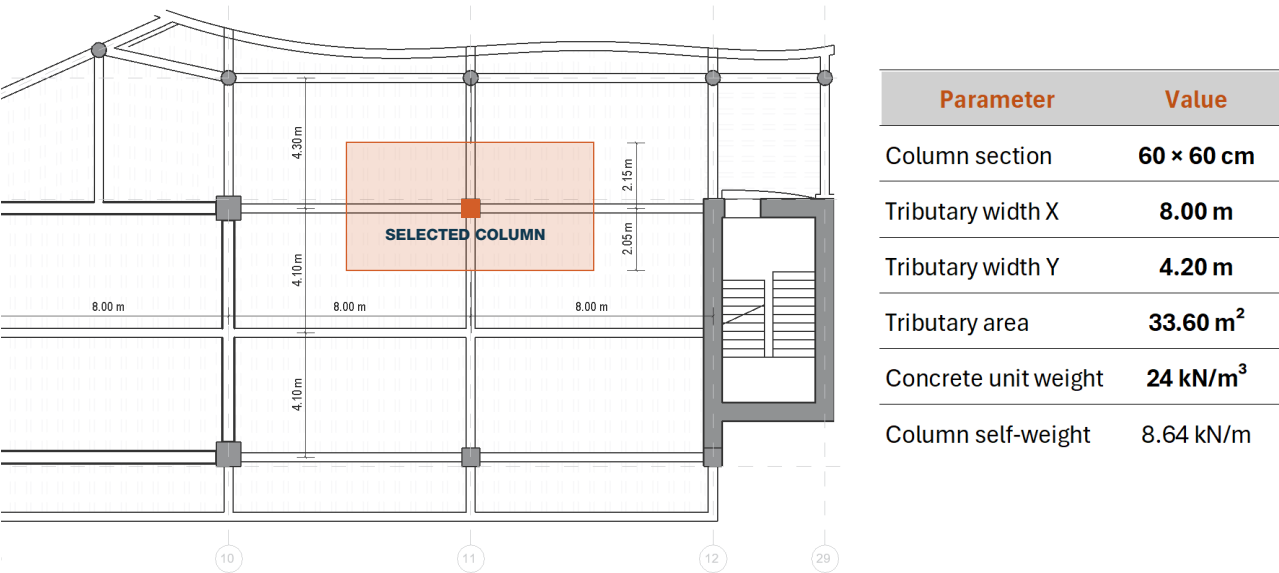


Figure 122. Representative column selected for preliminary structural verification and sizing. (Author, 2026).

The selected representative column is located within the regular structural grid of Block B and receives gravity loads from the tributary floor area defined by the surrounding beam layout. Its tributary area is calculated as 8.00m×4.20m, resulting in 33.60 m² per floor. Unlike the beam verification, which considers a single floor, the column verification considers the cumulative vertical load transferred from the upper levels of the building.

Load Calculation

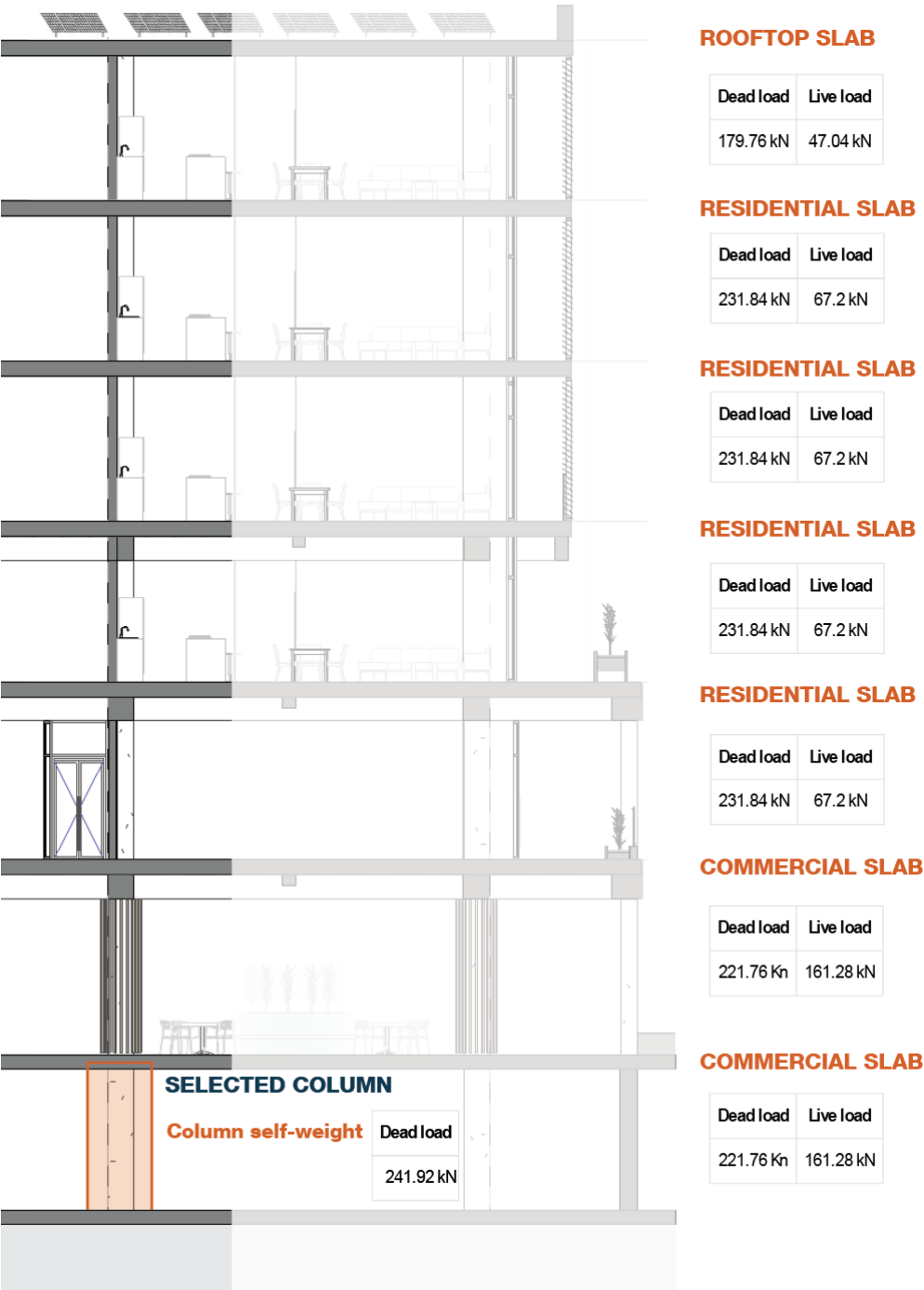


Figure 123. Load calculation process for the representative column. (Author, 2026).

The axial loads transferred to the selected column were calculated from the tributary area (33.60 m^2) of each supported level. For the residential floors, dead loads include the one-way ribbed slab self-weight, floor finishes, screed, suspended gypsum ceiling, and lightweight internal partitions, while live loads correspond to residential occupancy according to NEC-SE-CG. For the commercial floors, dead loads include the structural slab, floor finishing layers, ceiling/services allowance, and façade glazing allowance, with higher live loads reflecting commercial occupancy. The roof level includes slab self-weight, screed, and photovoltaic system allowance, with maintenance live load only. Finally, the self-weight of the reinforced concrete column was calculated separately using the adopted concrete unit weight (24 kN/m^3).

Ultimate axial load

$$P_u = 1.2D + 1.6L$$

$$P_u = 1.2(1792.56) + 1.6(638.40)$$

$$P_u = 3173.51 \text{ kN}$$

Preliminary axial capacity check

For the adopted 60 × 60 cm reinforced concrete column:

$$A_g = 600 \times 600 = 360000 \text{ mm}^2$$

Using the adopted concrete compressive strength:

$$f'_c = 28 \text{ MPa}$$

Using the adopted concrete compressive strength:

$$P_{\text{capacity}} = 0.35 f'_c A_g$$

$$P_{\text{capacity}} = 0.35(28)(360000)$$

$$P_{\text{capacity}} = 3528 \text{ kN}$$

Comparison with the design axial load:

$$P_u = 3173.51 \text{ kN}$$

$$3528 \text{ kN} > 3173.51 \text{ kN}$$

Axial compression check satisfied.

Chapter 7:

Energy and daylight

7.1 ENVIRONMENTAL DESIGN WORKFLOW

Achieving a low-energy and climate-responsive residential environment in Guayaquil requires a design approach focused on reducing cooling demand, controlling solar heat gains, and maintaining adequate daylight performance. Due to the project's scale and mixed-use complexity, the analysis adopts a selective simulation methodology rather than a full technical simulation of the entire building. It combines a whole-building environmental overview with detailed simulations of representative residential units, allowing the study to focus on the façade as the main interface between climate, comfort, and energy demand.

The process begins with climate-based design criteria derived from Guayaquil's hot-humid equatorial conditions and its classification as a humid very hot climate zone, where cooling demand reduction becomes the main environmental priority (MIDUVI, 2018; Johansson et al., 2018). A whole-building solar radiation analysis is then carried out to map solar exposure across the proposed volume and identify representative façade conditions. Based on this reading, comparable apartment units are selected for more detailed energy and daylight simulations.

A baseline scenario is established using conventional envelope characteristics and residential split air-conditioning assumptions. Through a comparative orientation analysis, the most critical case is selected and used to test passive façade strategies, including WWR adjustment, balcony depth, external shading, and envelope improvements. The most effective measures are then integrated into an optimized façade configuration and translated into a simplified whole-building model. Finally, rooftop photovoltaic potential is assessed as a complementary active strategy, framing the project as an NZEB-oriented approach based first on demand reduction and then on renewable energy integration (Sartori et al., 2012).

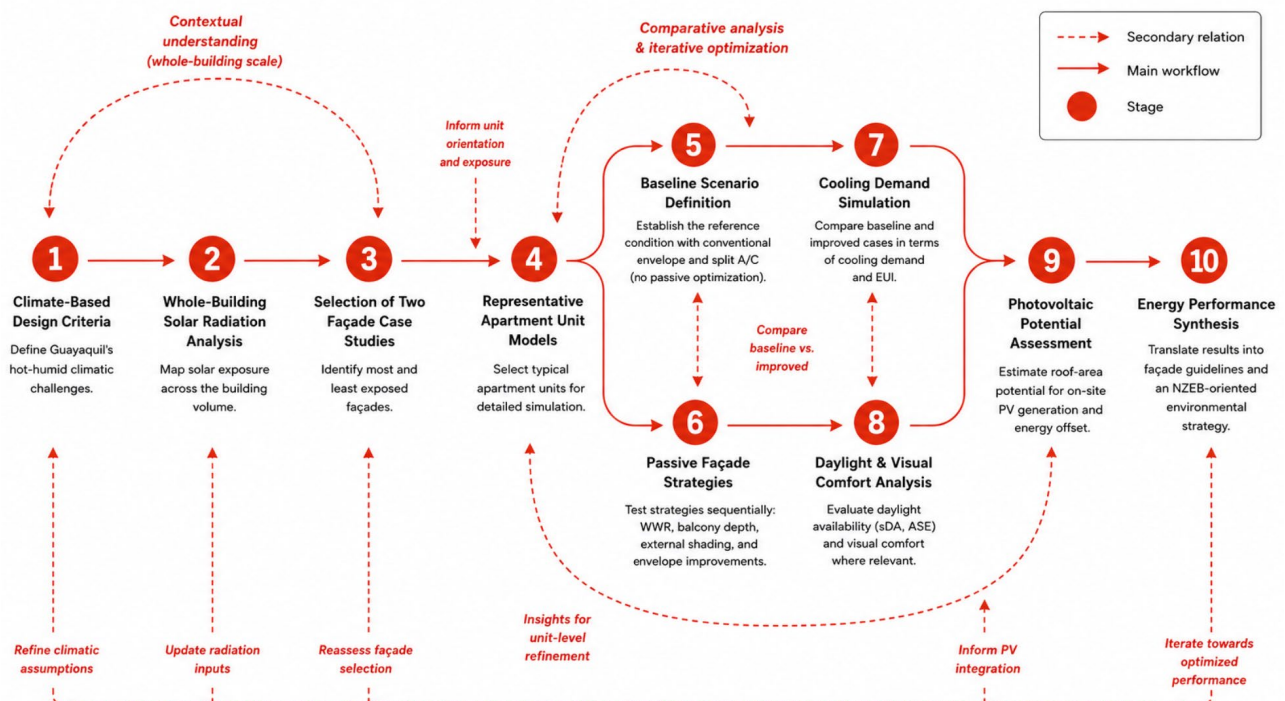


Figure 124. Energy and daylight assessment workflow. (Author, 2026).

7.2 ENERGY FOCUS AND SCOPE OF THE ANALYSIS

Due to the large scale and mixed-use complexity of the project, the energy analysis does not aim to develop a full detailed simulation of the entire building and its mechanical systems. Instead, it focuses on an architecturally relevant objective: reducing cooling demand within the residential component through passive design optimization. This focus responds directly to the climatic condition of Guayaquil, where cooling demand represents one of the main drivers of building energy consumption.

The residential component is selected as the primary field of analysis because apartment units represent spaces of prolonged and recurrent occupancy, where cooling demand remains significant under Guayaquil's hot-humid climate. For this reason, improvements in façade design, solar protection, and envelope performance can contribute directly to reducing operational cooling loads.

Within this framework, the energy strategy is understood not as an isolated technical layer, but as a design-driven process. The project investigates how architectural decisions—such as façade orientation, shading devices, balconies, operable openings, façade depth, and intermediate climatic spaces—can improve indoor conditions while reducing the intensity and frequency of air-conditioning use.

The objective is not to eliminate mechanical cooling entirely, since this would be unrealistic in the hot-humid climate of Guayaquil. Rather, the aim is to reduce its operational intensity through passive design strategies applied to the residential envelope. In this sense, the façade becomes a key element of the energy strategy, as it directly influences solar gains, daylight access, ventilation potential, and indoor thermal conditions.

7.3 SIMULATION TOOLS AND MODEL ASSUMPTIONS

The environmental assessment is developed using Rhinoceros 3D as the main geometric modelling platform and ClimateStudio as the simulation interface for solar radiation, daylight, and energy-related analyses. The model is simplified according to the scope of each stage of the study.

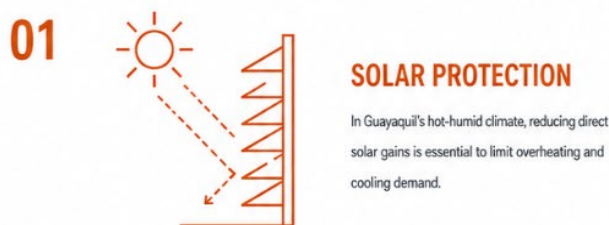
For the whole-building solar radiation analysis, the simulation considers the main building volume and a horizontal ground plane in order to evaluate comparative façade exposure. For the detailed energy and daylight evaluation, representative apartment units are used instead of a full-building simulation, allowing the analysis to focus on the relationship between façade orientation, glazing, shading, and indoor environmental performance.

For energy simulations, the baseline HVAC configuration represents conventional split air-conditioning systems commonly used in residential buildings in Ecuador, enabling the study to assess reductions in cooling dependence through passive architectural strategies rather than the elimination of mechanical conditioning.

7.4 CLIMATE-BASED DESIGN CRITERIA

The environmental design of the project is defined by Guayaquil's equatorial and hot-humid climatic condition. Located near the Equator, the city experiences relatively stable annual temperatures and limited seasonal variation, which means that the building does not require a design logic based on heat retention or winter solar gains. Instead, the main environmental challenge is to reduce excessive solar heat gains, limit indoor overheating, and decrease the dependence on mechanical cooling within the residential units (Johansson et al., 2018; WeatherSpark, n.d.).

According to the Ecuadorian Construction Standard NEC-HS-EE, Guayaquil is classified as a “humid very hot” location, corresponding to climatic zone 1. This classification reinforces the need for an envelope strategy oriented toward cooling demand reduction, solar control and indoor comfort, rather than heat conservation (Ministerio de Desarrollo Urbano y Vivienda [MIDUVI], 2018). In this context, the façade becomes a critical environmental interface: it must protect the interior from direct solar radiation while still allowing daylight, ventilation and visual connection with the exterior.



Based on this climatic condition, the project defines five main climate-based design criteria: solar protection, natural ventilation, controlled glazing, daylight access, and intermediate climatic spaces. These criteria are translated into architectural strategies such as external shading devices, recessed openings, balconies, layered façades, operable windows, vegetation buffers and controlled window-to-wall ratios. Together, these strategies allow the residential envelope to operate as a climatic filter, reducing air-conditioning dependence while preserving spatial quality, daylight availability and visual comfort.

Figure 125. Climate-based design criteria guiding the environmental response of the project. (Author, 2026).

7.5 BUILDING RADIATION ANALYSIS

The solar radiation analysis is developed at the whole-building scale in order to understand how the proposed volume is exposed to incident solar radiation throughout the year. Since the surrounding buildings are located at a considerable distance from the plot, they are not expected to produce significant shading effects on the project and are therefore not included in the simulation model. This allows the analysis to focus on the direct relationship between building geometry, orientation and the solar exposure of the residential envelope.

For this reason, the simulation model is simplified to the main building volume and a horizontal ground plane. This simplification avoids unnecessary geometric complexity while maintaining the essential conditions required to evaluate façade exposure. The objective of the analysis is to identify the façades that receive the highest and lowest levels of solar radiation. These contrasting conditions will then be used to select two representative façade case studies for the detailed energy and daylight assessment of the residential units.

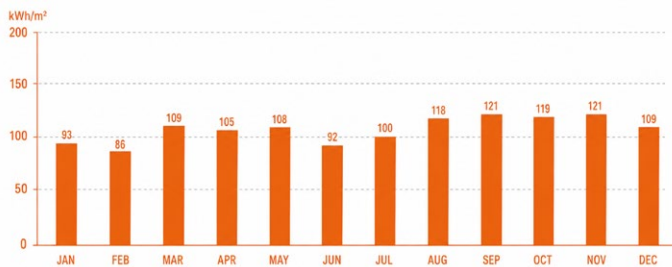


Figure 126. Monthly solar exposure distribution. (Author, 2026).

The monthly solar exposure distribution shows that solar radiation remains relatively constant throughout the year, with values ranging approximately between 86 and 121 kWh/m² per month. The highest levels are observed between August and November, while the lowest values occur in February and June. This confirms that, in Guayaquil, solar exposure is not a seasonal issue but a continuous environmental condition.

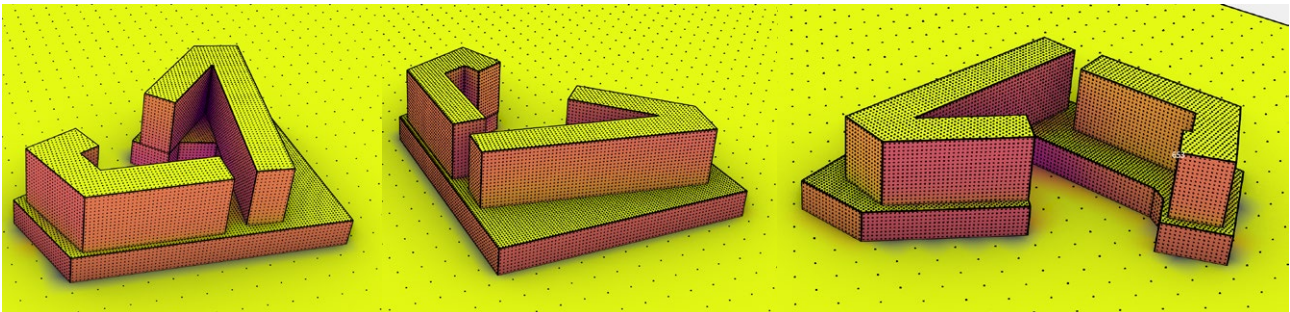
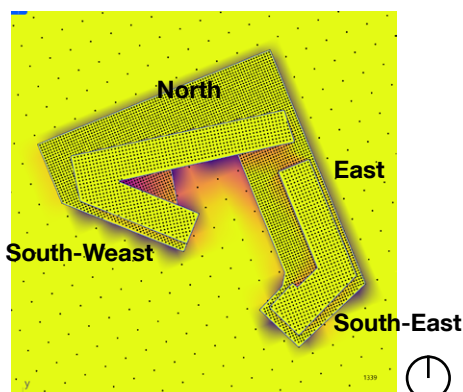


Figure 127. Simplified building model used for whole-building solar radiation analysis. (Author, 2026).

analazing facade



The objective of the analysis is to identify the façades that receive the highest and lowest levels of solar radiation. Following this whole-building reading, each façade is analysed individually in order to compare its solar exposure and define the two representative façade case studies for the detailed energy and daylight assessment of the residential units.

Figure 128. Orientation-based façade classification used for solar exposure assessment. (Author, 2026).

East façade

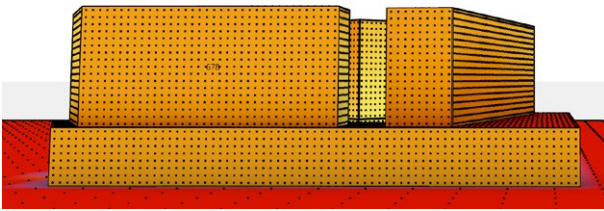


Figure 129. Annual solar radiation analysis of the East façade. (Author, 2026).

South-East façade

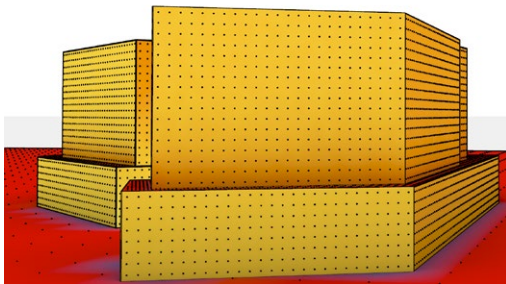


Figure 130. Annual solar radiation analysis of the South-East façade. (Author, 2026).

South-West façade

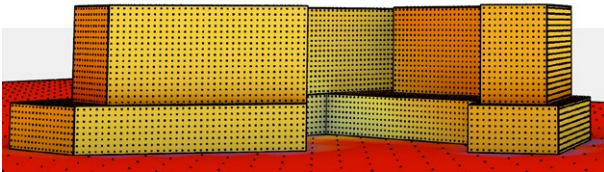


Figure 131. Annual solar radiation analysis of the South-West façade. (Author, 2026).

North façade

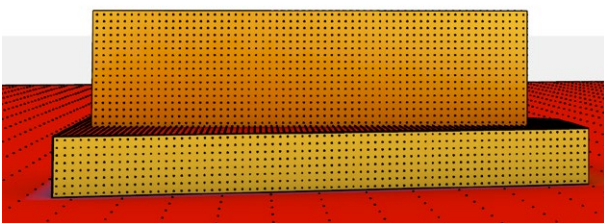


Figure 132. Annual solar radiation analysis of the North façade. (Author, 2026).

The East façade records an average annual solar exposure of **approximately 669 kWh/m²·yr**. This value indicates a significant but not extreme exposure condition, mainly associated with morning solar radiation. It remains relevant for the façade analysis because it can still contribute to indoor heat gains and cooling demand in the residential units.

The South-East façade shows an average annual solar exposure of **approximately 613 kWh/m²·yr**. This is one of the lower values among the analysed orientations, suggesting a comparatively less exposed condition. However, the exposure remains relevant within Guayaquil's hot-humid climate and still requires solar control strategies.

The South-West façade presents variable annual solar exposure values, ranging from **approximately 659 kWh/m²·yr**. This variation is influenced by the irregular geometry of the building, setbacks and self-shading conditions. Therefore, this façade shows how exposure depends not only on orientation, but also on the building's massing configuration.

The North façade presents the highest average annual solar exposure, with **approximately 694 kWh/m²·yr**. Although the difference with the other façades is not extreme, this orientation represents the most exposed condition in the analysis. It is therefore considered the critical façade for testing solar protection and cooling demand reduction strategies.

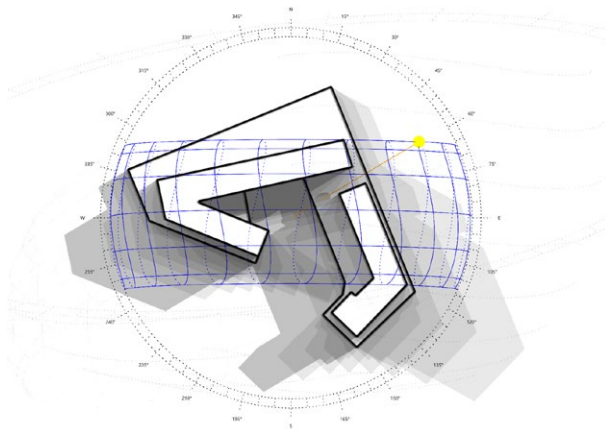
The façade-specific results show that annual solar exposure does not vary drastically between orientations. Although the North façade presents the highest value, with approximately 694 kWh/m²·yr, the East, South-West and South-East façades remain within a relatively close exposure range. This indicates that, in Guayaquil's equatorial context, solar radiation affects the residential envelope as a continuous condition rather than as a strongly orientation-dependent phenomenon.

7.6 SELECTION OF TWO FAÇADE CASE STUDIES

Although the annual solar exposure analysis provides a useful quantitative overview, it is not sufficient on its own to determine the façade case studies. The results show that the annual radiation values between the different orientations remain relatively close, suggesting that solar exposure in Guayaquil is a continuous condition affecting the whole residential envelope. Therefore, the selection of the case studies requires a more detailed interpretation of how radiation reaches each façade, when it occurs during the day, and how it relates to the apartment layout.

Solar Incidence Patterns

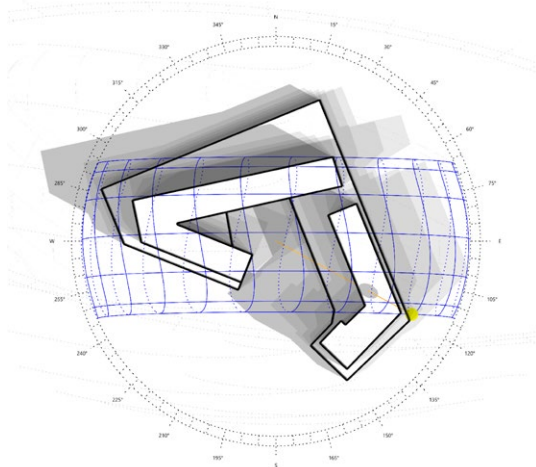
Summer solstice



During this solstice condition, the solar path produces a differentiated exposure across the building envelope, increasing radiation on specific façade orientations according to the sun's position. East- and west-facing façades remain affected by low-angle solar radiation during the morning and afternoon, making them relevant for evaluating direct solar gains and shading needs.

Figure 133. Solar incidence pattern during the summer solstice. (Author, 2026).

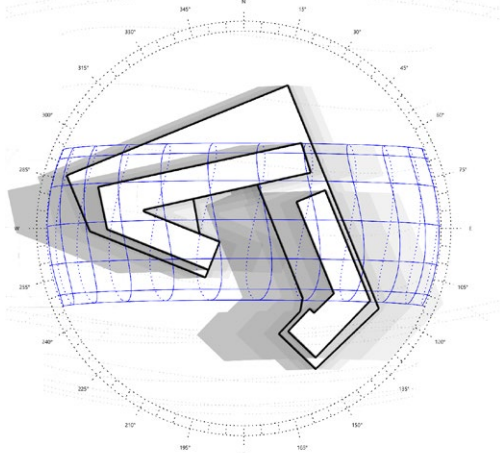
Winter solstice



During the opposite solstice condition, the sun path shifts, modifying the distribution of solar incidence across the envelope. This seasonal variation helps identify how different façade orientations respond to changing solar angles and whether shading strategies should be adapted according to orientation and time of day.

Figure 134. Solar incidence pattern during the winter solstice. (Author, 2026).

Equinox



During the equinox, solar incidence is more balanced, as the sun follows a more central east-to-west path. This condition provides an intermediate reading of façade exposure and helps reveal which parts of the building remain continuously affected by solar radiation under neutral seasonal conditions.

Figure 135. Solar incidence pattern during the equinox. (Author, 2026).

The first criterion is the type of solar exposure. East and West-oriented façades are generally more affected by direct low-angle solar radiation during the morning and afternoon, respectively. These conditions can be particularly critical because horizontal shading alone may not be sufficient to block direct sun penetration. In contrast, the North façade receives solar radiation in a more continuous way throughout the day and year, often with a different angle of incidence. This makes it relevant for testing a façade strategy based on more permanent filtering elements, such as balconies, layered envelopes and controlled glazing.

Apartment relevance

The second criterion is apartment relevance. Since the objective of the analysis is to evaluate the impact of façade design on residential comfort, the selected façades must correspond to comparable apartment configurations. For this reason, the case studies are chosen from apartment units with similar spatial layouts on different orientations. This allows the following simulations to compare how the same apartment typology responds to different solar conditions, and how shading strategies need to change according to façade exposure.



Figure 136. Selection of representative apartment units for the comparison of façade orientations and solar exposure conditions. (Author, 2026).

In this sense, the façade selection is based on a combined reading of annual radiation values, solar incidence patterns, façade orientation and apartment typology. The objective is not only to identify the façade with the highest numerical exposure, but to compare representative conditions that can inform different passive design responses. This approach allows the study to test how shading, glazing control, balcony depth and façade layering can be adapted to each orientation while maintaining comparable residential conditions.

7.6.1 REPRESENTATIVE APARTMENT UNIT MODELS

The East and North façades are selected as the two representative case studies for the detailed energy and daylight assessment. The East façade represents a condition of direct low-angle morning radiation, making it relevant for testing strategies such as vertical filtering, recessed openings and controlled glazing. The North façade, instead, presents a more continuous solar incidence pattern and one of the highest annual exposure values, making it suitable for testing permanent filtering strategies such as balcony depth, layered envelopes and shading devices.

Both façades also allow the use of comparable apartment units with the same spatial configuration. This ensures that the following simulations compare how the same residential typology responds to different solar conditions, rather than comparing different apartment layouts. Following the selection, the next step is to define the representative apartment units used for the detailed energy and daylight simulations.

For simulation purposes, the apartment model is simplified while preserving the elements that directly affect environmental performance. The main spatial layout, façade orientation, room depth, glazed openings and window-to-wall ratio are maintained in order to ensure a consistent comparison between the East and North cases.

Parameter	Modelling decision
Selected façades	East façade and North façade
Unit type	Same apartment typology
Purpose	Compare different solar exposure patterns
Maintained elements	Layout, façade orientation, glazing, balcony, room depth
Simplified elements	Furniture, minor partitions, non-essential details
Main outputs	Cooling demand and daylight performance

Figure 138. Main parameters and modelling decisions for the representative apartment unit case studies. (Author, 2026).

This approach provides a controlled basis for testing how different façade strategies should respond to distinct solar conditions while maintaining comparable residential layouts.

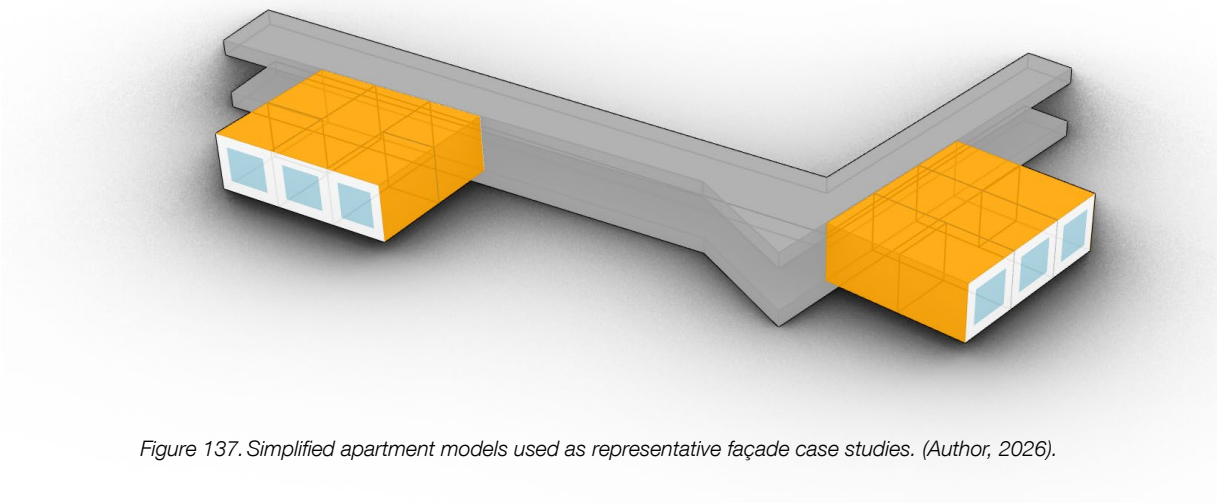


Figure 137. Simplified apartment models used as representative façade case studies. (Author, 2026).

7.7 BASELINE MODEL

Baseline Parameters

The baseline simulation is defined through a set of simplified parameters and schedules that describe the residential use of the selected apartment units. Since the objective of the analysis is to compare the environmental behaviour of the East and North façades, the same operational assumptions are applied to both models. These include occupancy, lighting, equipment loads and ventilation assumptions based on standard residential templates derived from ASHRAE.

These assumptions provide a standardized reference condition for evaluating the impact of passive architectural strategies on cooling demand and indoor environmental performance in Guayaquil's hot-humid climate.

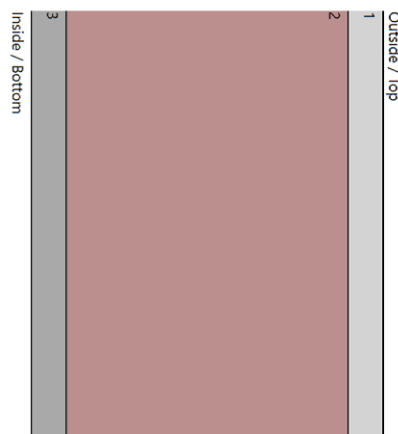
Heating		OFF
Cooling		ON
Cooling System Type	Conventional Split AC Units	Represents common residential cooling systems used in Ecuador
Cooling COP	3	Typical efficiency value for conventional split systems
Energy Source	Electricity	Standard electrical cooling system
Cooling Setpoint	25	Scheduled residential cooling setpoint bases on ashrae
Humidity Control		OFF
People		ON
People Density	0.028 P/m ²	Approx. 1 person per 35 m ²
Metabolic Rate	1.2 met	Light residential activity
Clothing Model	Dynamic Clothing Model ASHRAE55	Adaptive clothing assumption
Equipment		ON
Equipment Power Density	6.67 W/m ²	Domestic appliances and plug loads
Lighting		ON
Lighting Power Density	6.458 W/m ²	Residential lighting load
Illuminance Target	500 lux	
Dimming Type	OFF	
Hot Water		OFF
WWR		0.4
Air tightness		0.7

Figure 139. Baseline configuration and internal load assumptions used for the representative residential simulation model. (Author, 2026).

Baseline Envelope and Glazing

The baseline envelope configuration represents conventional residential construction commonly found in Guayaquil, characterized by reinforced concrete and masonry walls, single clear glazing, and the absence of external shading devices. The material selection was based on the construction systems and residential typologies previously analyzed in earlier chapters, identifying the most commonly used envelope solutions in the local context. This reference condition reflects a typical thermally inefficient tropical residential façade with high solar exposure and strong dependence on mechanical cooling systems.

Facade walls



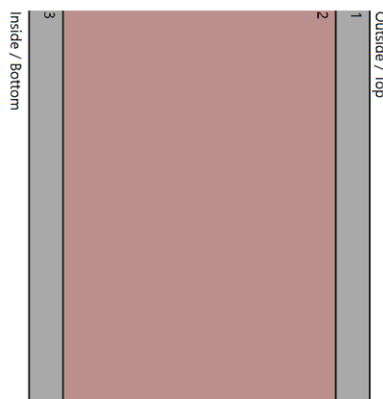
- 1 - Stucco 0.015 [m]
- 2 - Brick 0.12 [m]
- 3 - Plaster 0.015 [m]

Figure 140. Baseline external wall assembly.
(Author, 2026).

U-Value[W/(m²·K)] = 2.935
R-Value[m²K/W] = 0.171
Thermal Capacitance[kJ/K/m²] = 239.302
Embodied Energy[MJ/m²] = 39.9
Embodied Carbon[kgCO₂/m²] = 6.63

The external wall assembly was defined based on conventional residential construction systems commonly found in Guayaquil. The façade consists of an exterior stucco finish, a hollow masonry block layer, and an interior plaster finish. This configuration represents a typical non-insulated tropical envelope characterized by relatively high thermal transfer and strong dependence on mechanical cooling systems.

Interior walls



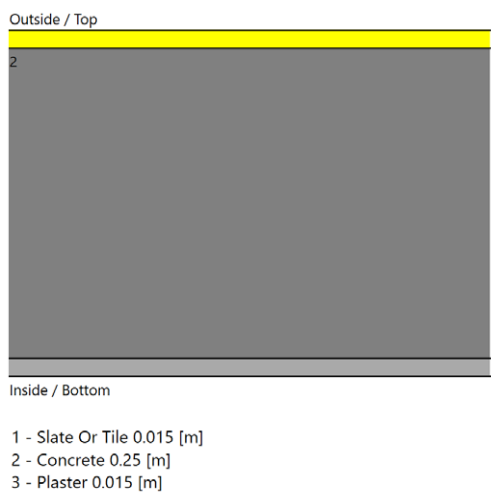
- 1 - Plaster 0.015 [m]
- 2 - Brick 0.12 [m]
- 3 - Plaster 0.015 [m]

Figure 141. Baseline internal wall assembly.
(Author, 2026).

U-Value[W/(m²·K)] = 2.987
R-Value[m²K/W] = 0.165
Thermal Capacitance[kJ/K/m²] = 249.816
Embodied Energy[MJ/m²] = 79.8
Embodied Carbon[kgCO₂/m²] = 13.26

The internal partition walls were simplified using a conventional masonry assembly composed of plaster finishes and hollow block construction. These partitions primarily serve as internal spatial separators and contribute thermal mass to the simulation model while maintaining a construction logic representative of typical residential buildings in Ecuador.

Interior slabs

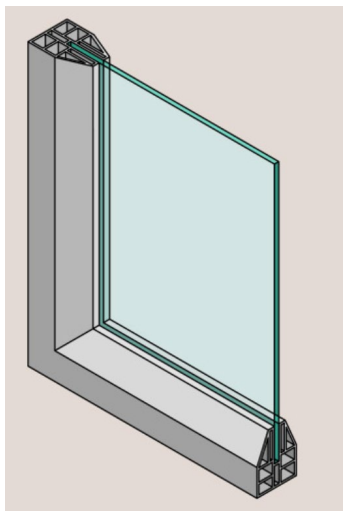


U-Value[W/(m²·K)] = 3.131
R-Value[m²K/W] = 0.149
Thermal Capacitance[kJ/K/m²] = 640.188
Embodied Energy[MJ/m²] = 489.9
Embodied Carbon[kgCO₂/m²] = 66.63

The internal floor slab assembly was defined using a conventional reinforced concrete slab with ceramic tile flooring and interior plaster finishing. Hard floor finishes are widely used due to durability, cost efficiency, and climatic suitability. The assembly contributes significantly to the thermal inertia of the building while maintaining the characteristics of a typical non-insulated tropical residential structure.

Figure 142. Baseline floor slab assembly. (Author, 2026).

Glazing



U-Value[W/(m²·K)] = 5.82
SHGC = 0.818
TVIS = 0.877
Embodied Energy[MJ/m²] = 217.5
Embodied Carbon[kgCO₂/m²] = 13.195

The baseline glazing system consists of conventional single clear glazing commonly used in residential buildings in Guayaquil. The window assembly presents relatively high thermal transmittance and solar heat gain, contributing to increased cooling loads under tropical climatic conditions.

Figure 143. Baseline single clear glazing system. (Author, 2026).

COMPARATION OF TWO SELECTED FACADE

To define the reference case for the optimization phase, a preliminary orientation comparison was conducted using the baseline apartment model. Since the proposed building presents multiple façade exposures, a simplified comparative analysis was performed to identify the orientation associated with the highest cooling demand under Guayaquil’s climatic conditions.

The results showed relatively similar performance between both orientations, which is consistent with the stable solar conditions characteristic of equatorial tropical climates. However, the east-oriented façade consistently presented slightly higher cooling demand, solar heat gains through glazing, and total annual energy use intensity.

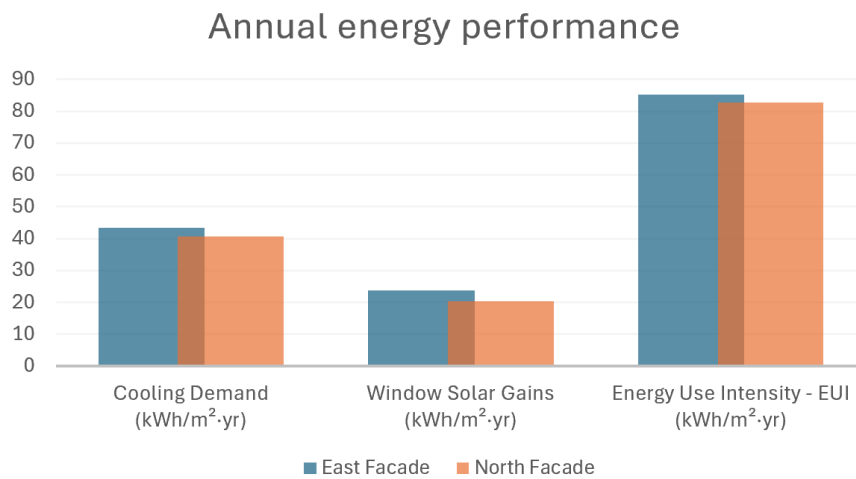


Figure 144. Comparison of annual cooling demand, window solar gains, and total energy use intensity (EUI) for the baseline apartment model under east- and north-facing orientations. (Author, 2026).

The east-facing configuration recorded an annual cooling demand of 43.42 kWh/m²·yr, compared to 40.80 kWh/m²·yr for the north-oriented case. Similarly, window solar gains were higher in the east façade (23.64 kWh/m²·yr) than in the north façade (20.33 kWh/m²·yr), resulting in a total EUI of 85.26 kWh/m²·yr, compared to 82.64 kWh/m²·yr.

Although the differences remained moderate, **the east-oriented apartment was identified as the critical baseline case**. Consequently, this orientation was selected for the subsequent optimization phase, where passive façade strategies aimed at reducing cooling demand were evaluated.

7.8 PASSIVE FAÇADE OPTIMIZATION SCENARIOS

Following the identification of the east-oriented apartment as the critical baseline case, the subsequent simulation phase focused on evaluating passive façade strategies capable of reducing cooling demand under Guayaquil's hot-humid climatic conditions. Since the preliminary orientation comparison demonstrated only moderate differences between exposures, the optimization process shifted toward architectural variables with greater influence on thermal performance.

The selected scenarios were defined according to both environmental performance criteria and the architectural logic of the project, particularly its reinterpretation of tropical passive design principles. Rather than relying solely on mechanical cooling systems, the analysis investigates how architectural design decisions can directly mitigate solar heat gains, improve daylight performance, and reduce operational energy demand.

Four optimization scenarios were established.

The optimization phase evaluates four passive façade strategies aimed at reducing cooling demand and improving environmental performance under Guayaquil's hot-humid climate: variations in window-to-wall ratio (WWR) to assess the balance between daylight and solar gains, balcony depth as passive climatic buffers inspired by tropical intermediate spaces, external solar shading systems to mitigate direct solar exposure, and an improved envelope configuration comparing the conventional baseline construction with a more thermally efficient façade solution.

The objective of this phase is to identify the passive interventions with the greatest impact on cooling reduction and overall façade performance. Based on the comparative results, the most effective strategies will be integrated into a final optimized façade configuration for comparison against the original baseline model.

Window to Wall ratio

The first optimization scenario evaluates the influence of the window-to-wall ratio (WWR) on both thermal performance and daylight availability. Since façade openness directly affects solar heat gains, cooling demand, and indoor daylight quality, three glazing proportions were tested under identical simulation conditions. The objective of this analysis is to identify an appropriate balance between environmental performance and façade transparency for residential use in Guayaquil's tropical climate.

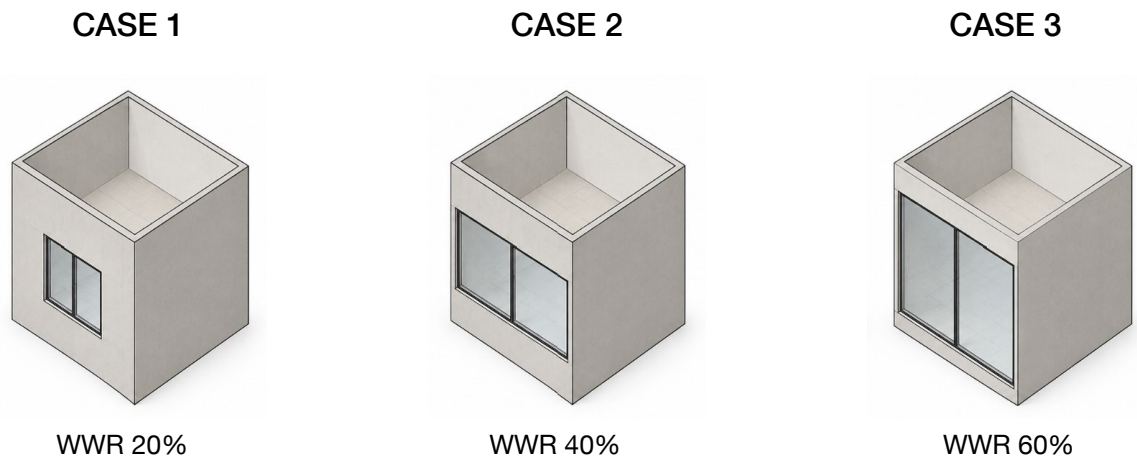


Figure 145. Window-to-wall ratio (WWR) scenarios evaluated during the façade optimization process. (Author, 2026).

Three WWR scenarios are evaluated under identical simulation conditions to assess the influence of façade transparency on cooling demand and solar heat gains. As expected, increasing glazing proportion leads to higher solar exposure and a progressive rise in cooling energy consumption.

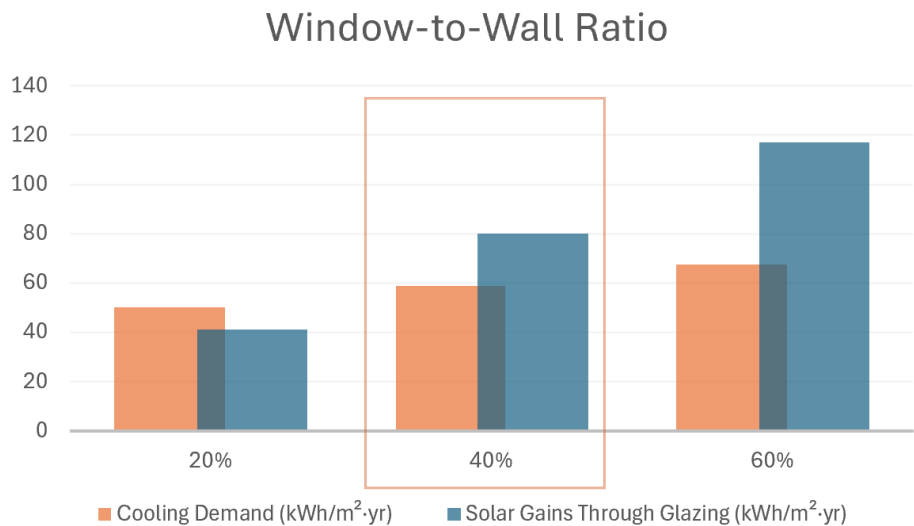


Figure 146. Comparative thermal performance of WWR scenarios under baseline conditions. (Author, 2026).

The results confirm a direct relationship between façade openness and cooling demand. While the 20% WWR scenario achieves the best thermal performance, it limits daylight access and façade permeability. In contrast, the 60% WWR configuration increases solar gains and cooling demand. Therefore, the 40% WWR scenario was selected as the most balanced solution between thermal performance, daylight availability, and architectural openness.

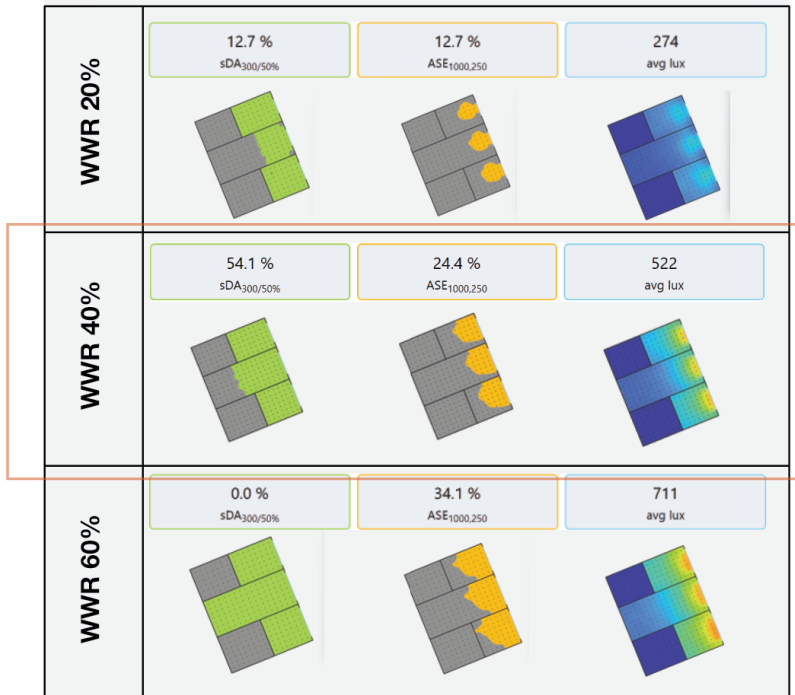


Figure 147. Comparative daylight performance of the three WWR scenarios under identical simulation conditions. (Author, 2026).

Daylight simulations reveal a clear trade-off between façade openness and visual performance. Increasing WWR improves daylight penetration, raising spatial daylight autonomy (sDA) from 12.7% in the 20% WWR scenario to 82.0% in the 60% configuration. However, greater transparency also increases solar exposure, as reflected in higher ASE values and thermal penalties. The 40% WWR case provides the most balanced performance, combining acceptable daylight availability with controlled cooling demand, and was therefore selected for the subsequent optimization stages.

Results

The combined thermal and daylight analysis confirms that façade openness significantly influences both energy demand and indoor environmental quality. While lower WWR reduces cooling loads, excessive reduction compromises daylight access. Conversely, higher glazing ratios improve daylight performance but increase solar heat gains. Based on this comparative assessment, the 40% WWR configuration was identified as the most balanced design solution.

Balcony / facade depth

The second optimization scenario evaluates the effect of balcony depth as a passive self-shading strategy on the selected façade. Since horizontal projections directly influence solar exposure, heat gains, and indoor daylight penetration, this analysis investigates the effectiveness of façade-integrated shading in reducing cooling demand while maintaining architectural feasibility and visual comfort within Guayaquil's hot-humid climate.

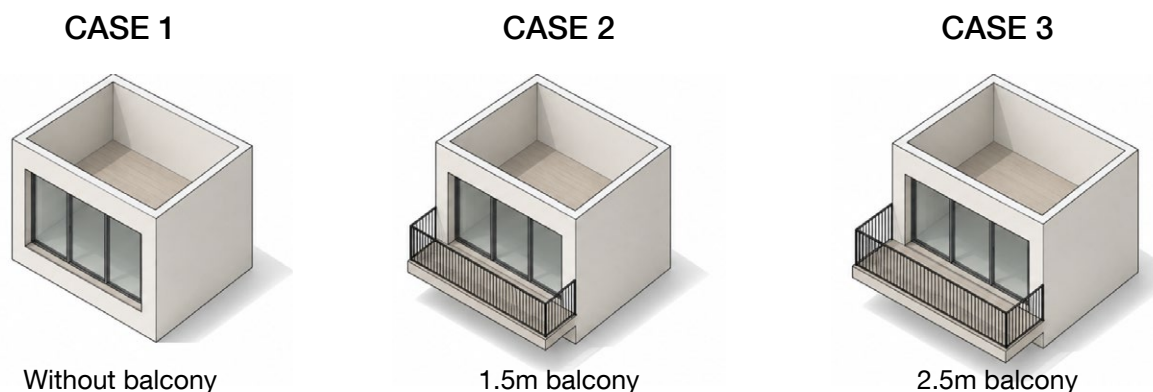


Figure 148. Balcony depth scenarios evaluated as integrated shading strategies for the residential façade. (Author, 2026).

This comparison assesses the impact of balcony depth on thermal performance, evaluating how increased façade self-shading reduces solar heat gains and cooling demand.

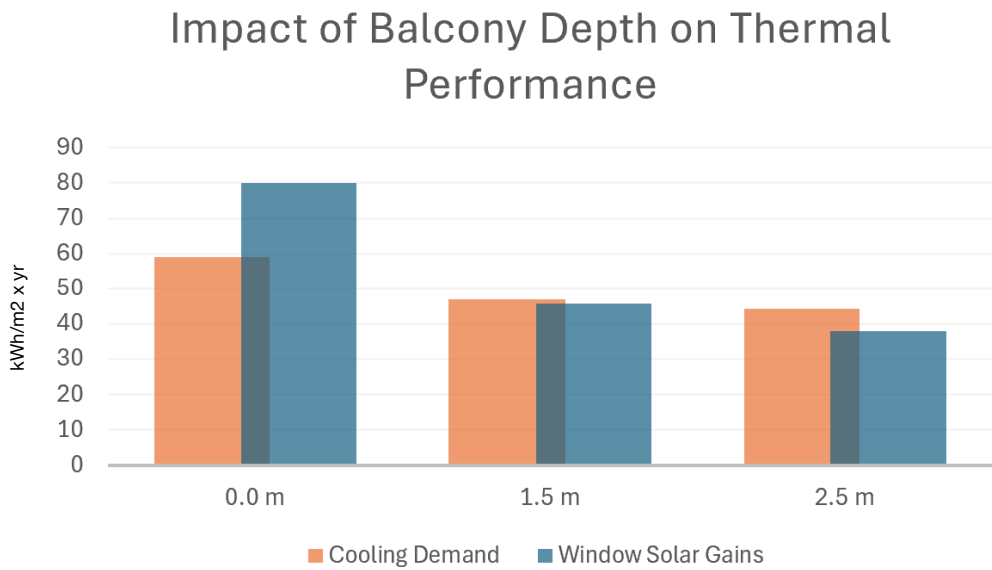


Figure 149. Comparative thermal performance of balconies scenarios under baseline conditions. (Author, 2026).

Results

The results demonstrate that balcony projections significantly improve thermal performance by reducing direct solar gains through glazing. The greatest performance improvement occurs between the no-balcony case and the 1.5 m projection, while deeper shading provides smaller incremental benefits. Considering both energy performance and architectural practicality, the 1.5 m balcony depth was selected for the next optimization stage.

Solar shading device

The third optimization scenario evaluates the impact of external façade shading as an additional passive solar protection strategy for the selected east-facing façade. Building on the previously optimized balcony depth, this analysis investigates how façade-integrated shading elements can further reduce direct solar exposure and cooling demand. Inspired by traditional climatic filtering devices, the tested configurations explore the relationship between solar protection, façade permeability, and thermal performance in Guayaquil’s hot-hu-mid climate.

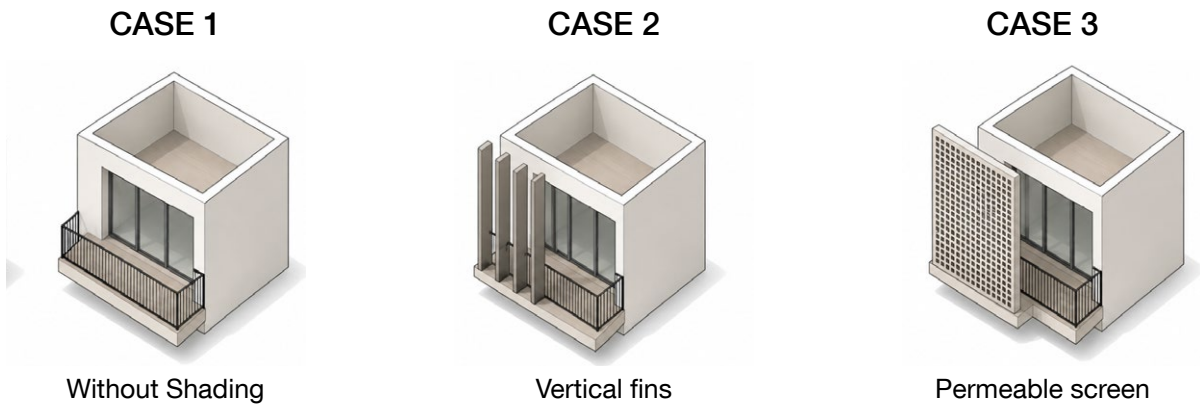


Figure 150. Solar shading device scenarios evaluated as integrated shading strategies for the residential façade. (Author, 2026).

The thermal comparison evaluates the effectiveness of each external shading strategy in reducing direct solar heat gains through glazing and lowering cooling demand. All scenarios were simulated under identical conditions, modifying only the façade shading configuration.

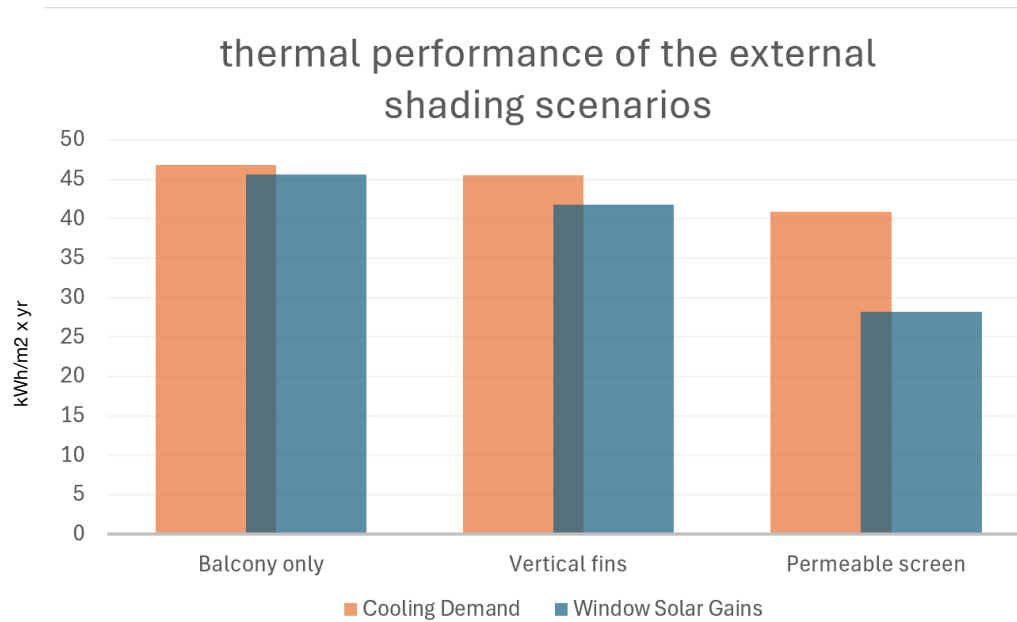


Figure 151. Comparative thermal performance of external shading device scenarios under baseline conditions. (Author, 2026).

The results demonstrate that external shading devices significantly improve thermal performance compared to the balcony-only reference case. While vertical fins provide a modest reduction in solar gains and cooling demand, the permeable screen achieves the strongest performance improvement, reducing cooling demand from 38.62 to 36.40 kWh/m²-yr and window solar gains from 15.31 to 11.36 kWh/m²-yr. This confirms the effectiveness of a continuous permeable filtering façade in mitigating solar exposure on east-facing residential façades in Guayaquil’s tropical climate.

Conclusion

Based on the comparative analysis, the permeable screen configuration was selected for the subsequent optimization stage. Beyond its superior thermal performance, this strategy aligns with the architectural concept of the project by reinterpreting traditional climatic filtering devices as a contemporary passive façade system.

Envelope optimization

After defining the main passive geometric strategies, the final optimization stage focuses on improving the thermal performance of the building envelope through material-based interventions. In hot-humid climates such as Guayaquil, reducing solar gains through passive design alone may not be sufficient to minimize cooling demand, as conductive heat transfer through opaque surfaces and glazing continues to contribute significantly to internal thermal loads. Therefore, this final assessment evaluates feasible envelope upgrades as a complementary strategy to enhance the overall thermal efficiency of the façade. To isolate the specific impact of material performance and obtain a clearer comparison, this analysis was conducted using the simplified reference shoebox model without balcony projections or additional external shading devices, ensuring that performance variations are directly attributable to envelope modifications alone.

The proposed improvements focus on two key façade components: the opaque wall assembly and the glazing system. For the wall, the baseline conventional concrete block construction is upgraded through the incorporation of an external thermal insulation layer, improving resistance to conductive heat transfer while maintaining a construction logic compatible with local building practices. Simultaneously, the glazing system is enhanced through improved thermal and solar performance properties, aiming to further reduce heat transmission and solar gains while preserving façade transparency.

Opaque wall assembly

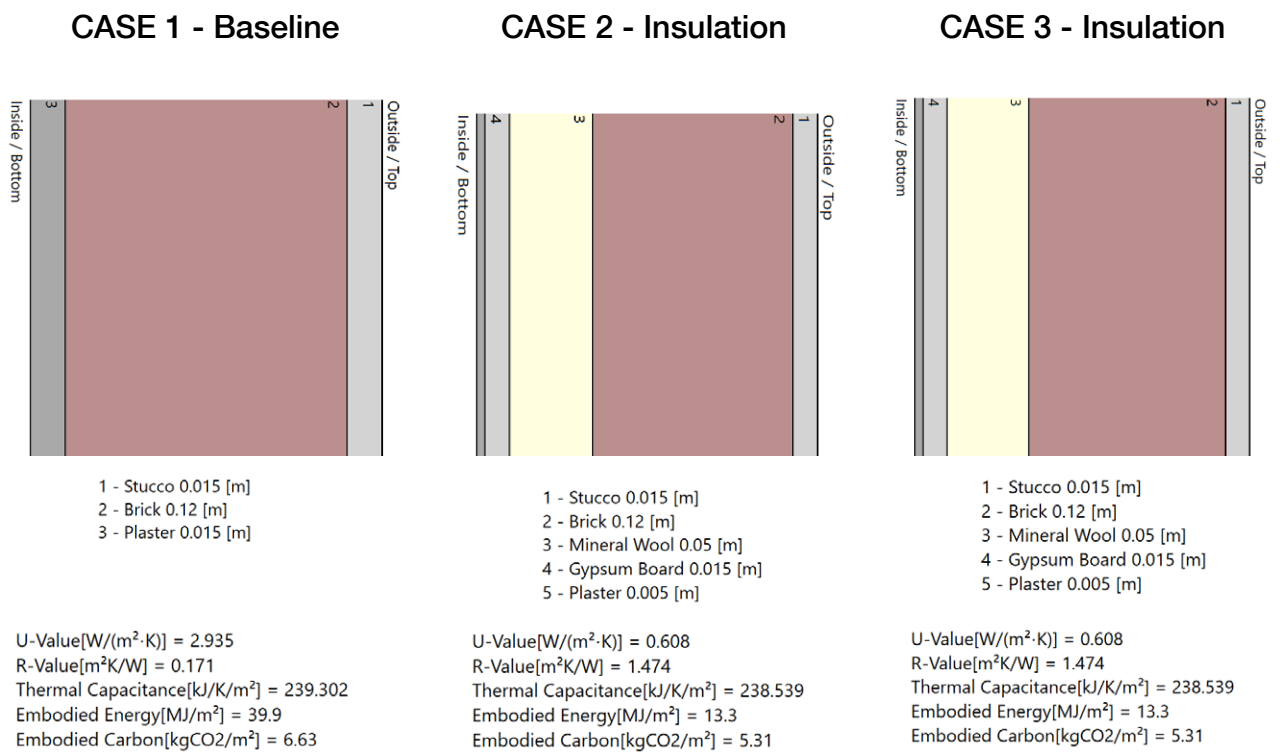


Figure 152. Opaque wall assemblies evaluated during the envelope optimization process. (Author, 2026).

A preliminary comparison of three wall assemblies was conducted to identify the most effective opaque envelope strategy. The baseline masonry wall was evaluated against two insulated alternatives with varying mineral wool thicknesses, isolating the effect of wall thermal resistance before the final envelope optimization.

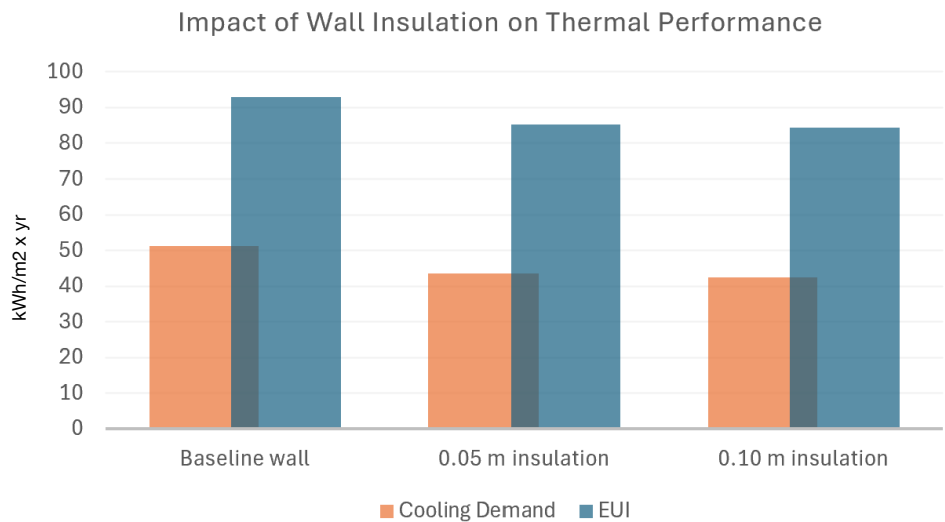
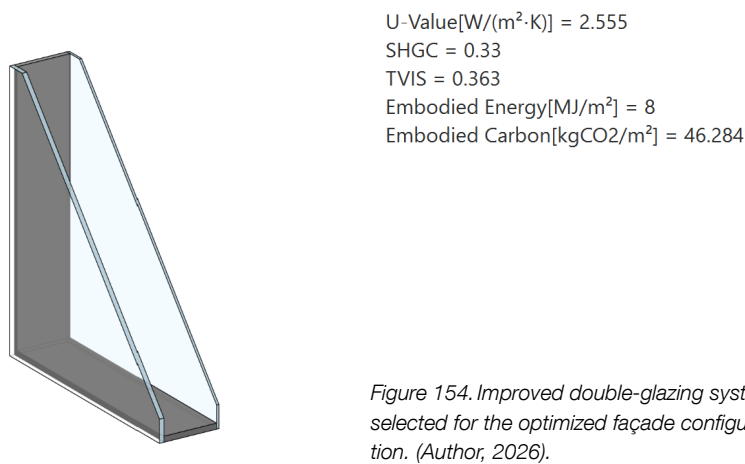


Figure 153. Impact of wall insulation thickness on cooling demand and annual energy use intensity (EUI). (Author, 2026).

The introduction of thermal insulation significantly improves envelope performance, reducing cooling demand from 51.2 to 43.5 kWh/m²·yr with a 50 mm mineral wool layer. Increasing insulation thickness to 100 mm provides only marginal additional improvement, indicating diminishing thermal returns beyond the first insulation upgrade. Therefore, the 50 mm configuration was selected as the most balanced solution between thermal efficiency and material practicality.

Improved glazing system

An improved double-glazing system with enhanced solar-control properties was selected as a realistic upgrade compatible with contemporary residential construction practices and commercially available glazing technologies in Ecuador.



The optimized envelope significantly improves thermal performance compared to the baseline case. Cooling demand decreases by 25.7%, total EUI is reduced by 14.2%, and window solar gains drop by 36.0%. These findings confirm the importance of combining passive façade design with improved material performance to achieve greater cooling efficiency in Guayaquil’s climate.

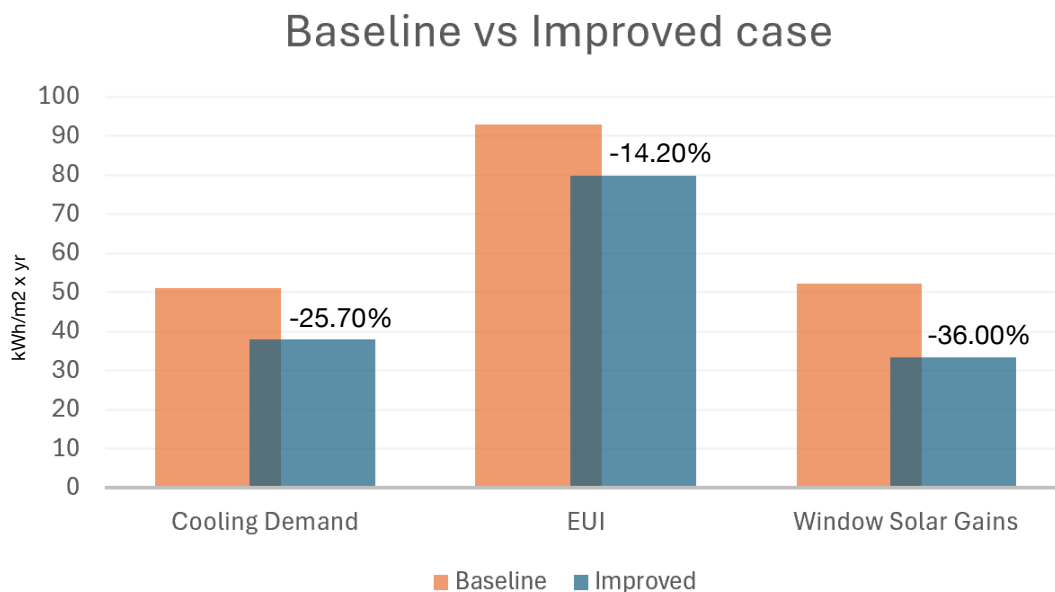


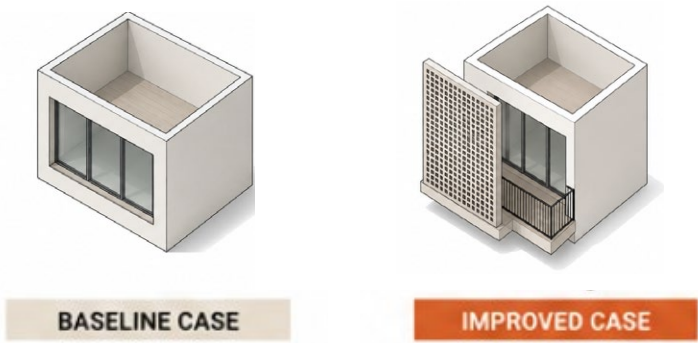
Figure 155. Comparative performance of the baseline and improved façade configurations. (Author, 2026).

7.9 OPTIMIZED FAÇADE CONFIGURATION

After evaluating each passive and material-based strategy in isolation to clearly identify its individual contribution, the most effective solutions were selected and integrated into a final optimized façade configuration. This final assessment measures the cumulative impact of the full optimization process by comparing the original baseline condition with the final combined proposal, incorporating the selected façade transparency, passive shading strategies, and envelope performance improvements.

	BASELINE CASE	IMPROVED CASE
 WALL-TO-WALL RATIO	40% WWR	40% WWR
 BALCONY	No balcony	1.5 m balcony
 EXTERNAL SHADING	No external shading	Permeable screen
 ENVELOPE ASSEMBLY	Conventional wall assembly	50 mm rock wool insulated dry-lined wall
 GLAZING	Single glazing	Improved double glazing

Figure 156. Summary of the baseline and optimized façade configurations. (Author, 2026).



The final optimized configuration demonstrates that the combination of architectural and material strategies produces a greater impact than individual improvements alone. While the baseline case represents a conventional façade approach commonly found in residential buildings, the improved scenario integrates passive solar control, intermediate outdoor spaces, and enhanced envelope properties to reduce heat gains and improve overall energy efficiency. The following comparison summarizes the cumulative performance benefits achieved through the design optimization process.

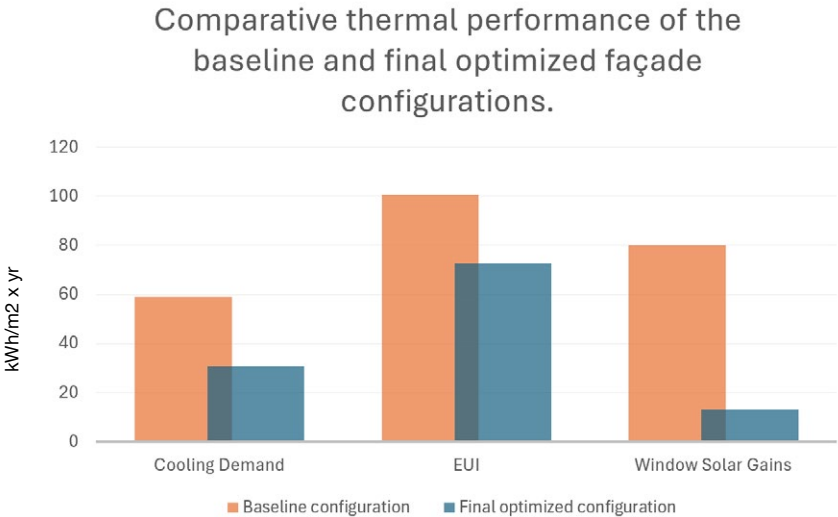


Figure 157. Comparative thermal performance of the baseline and final optimized façade configurations. (Author, 2026).

The integrated optimized façade demonstrates the cumulative effectiveness of the sequential design strategy. Compared to the baseline condition, the final optimized configuration reduces cooling demand by 47.9%, lowers total energy use intensity by 28.0%, and decreases window solar gains by 83.8%. These results confirm that combining passive geometric strategies with targeted envelope improvements produces substantially greater thermal benefits than isolated interventions alone.



Figure 158. Overall reduction in cooling demand and annual EUI achieved through the optimized façade design. (Author, 2026).

The final comparison confirms the effectiveness of a climate-responsive façade design approach for residential buildings in Guayaquil's hot-humid climate. By integrating optimized façade transparency, passive self-shading, permeable external solar protection, and improved envelope performance, the proposed design significantly reduces thermal loads and dependence on mechanical cooling. Rather than relying solely on active systems, the results demonstrate the potential of architectural design decisions to drive substantial operational energy reductions through context-appropriate passive strategies.

7.10 FINAL PERFORMANCE EVALUATION

The passive strategies previously evaluated at prototype scale were translated into a simplified full-building energy model to assess their cumulative impact at the architectural scale. Rather than reproducing every detailed design component, the improved scenario incorporated the equivalent thermal and solar performance of the proposed envelope enhancements, glazing improvements, and shading strategies. This approach enabled a realistic comparison between the baseline and optimized building configurations while maintaining a level of complexity appropriate for early-stage design evaluation.

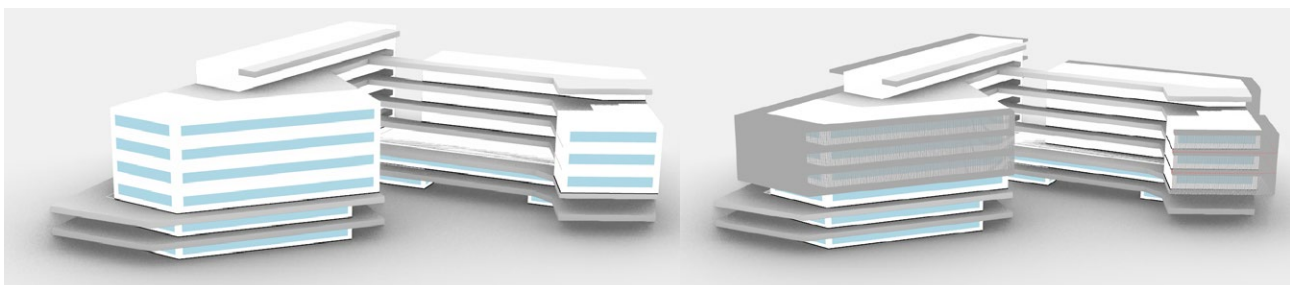


Figure 159. Simplified whole-building energy models used for the baseline and improved performance assessment. (Author, 2026).

The improved scenario integrates the passive architectural and envelope optimization strategies previously evaluated at prototype scale. These include façade thermal enhancement, improved glazing performance, and solar control strategies aimed at reducing heat gains and cooling dependence, while maintaining the same operational assumptions and HVAC configuration as the baseline model.

To evaluate the cumulative impact of the passive design strategies at building scale, a simplified full-building energy model was developed and compared against the conventional baseline scenario.

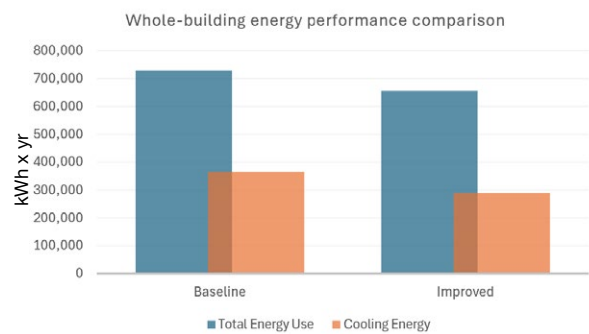


Figure 160. Comparison of total annual energy use and cooling energy demand for the baseline and improved building models. (Author, 2026).

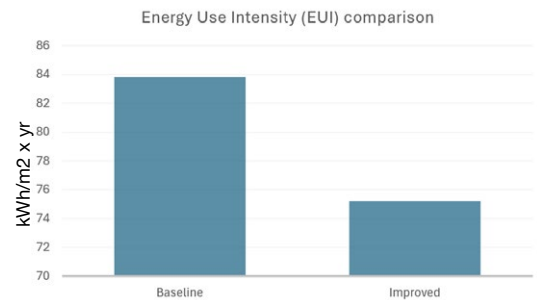


Figure 161. Annual Energy Use Intensity (EUI) comparison between the baseline and improved building scenarios. (Author, 2026).

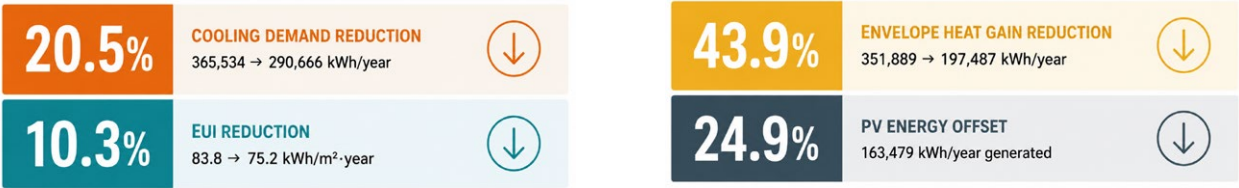


Figure 162. Summary of whole-building performance improvements achieved through passive optimization and photovoltaic integration. (Author, 2026).

This phase demonstrates that passive architectural optimization alone can substantially reduce operational cooling demand, establishing the foundation for subsequent renewable energy compensation strategies.

7.11 PHOTOVOLTAIC (PV) ACTIVE STRATEGY

Following the reduction of operational energy demand through passive and envelope-based optimization strategies, an active renewable energy strategy was introduced to further reduce the building’s dependence on grid electricity. Within the Net Zero Energy Building (NZEB) framework, renewable energy systems are generally understood as a complementary strategy implemented after demand minimization, rather than as a substitute for efficient architectural design (Sartori et al., 2012).

Photovoltaic (PV) integration was selected as the most viable on-site renewable strategy due to Guayaquil’s favorable solar resource availability and the accessible roof surfaces of the proposed building. However, rather than pursuing complete energy autonomy, this study evaluates the realistic contribution of rooftop photovoltaic generation in offsetting the residual operational electricity demand of a dense mixed-use building.

The photovoltaic system was integrated exclusively on the building’s available rooftop surfaces, where solar exposure is highest and installation feasibility is most realistic within the project’s architectural constraints. A total usable photovoltaic area of 933.2 m² was identified across the roof surfaces selected for panel installation.

Given the density of the proposed mixed-use building and the limited horizontal surface availability typical of compact urban typologies, rooftop PV generation was prioritized over façade-integrated photovoltaic systems at this stage in order to maintain a realistic and technically feasible renewable strategy.

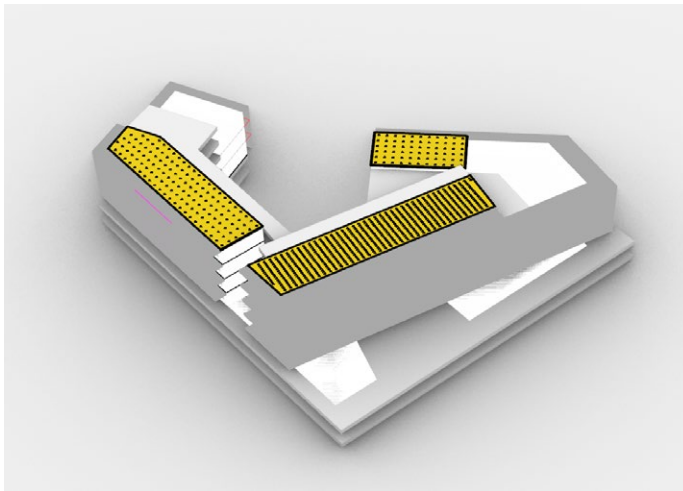


Figure 163. Rooftop surfaces considered for photovoltaic integration. (Author, 2026).

Photovoltaic performance was estimated using PVGIS, developed by the European Commission's Joint Research Centre, for a grid-connected rooftop system in Guayaquil (European Commission, 2026). The system uses crystalline silicon technology, widely applied in rooftop PV installations (Fraunhofer ISE, 2024), with an installed capacity of 196 kWp based on the available roof area.

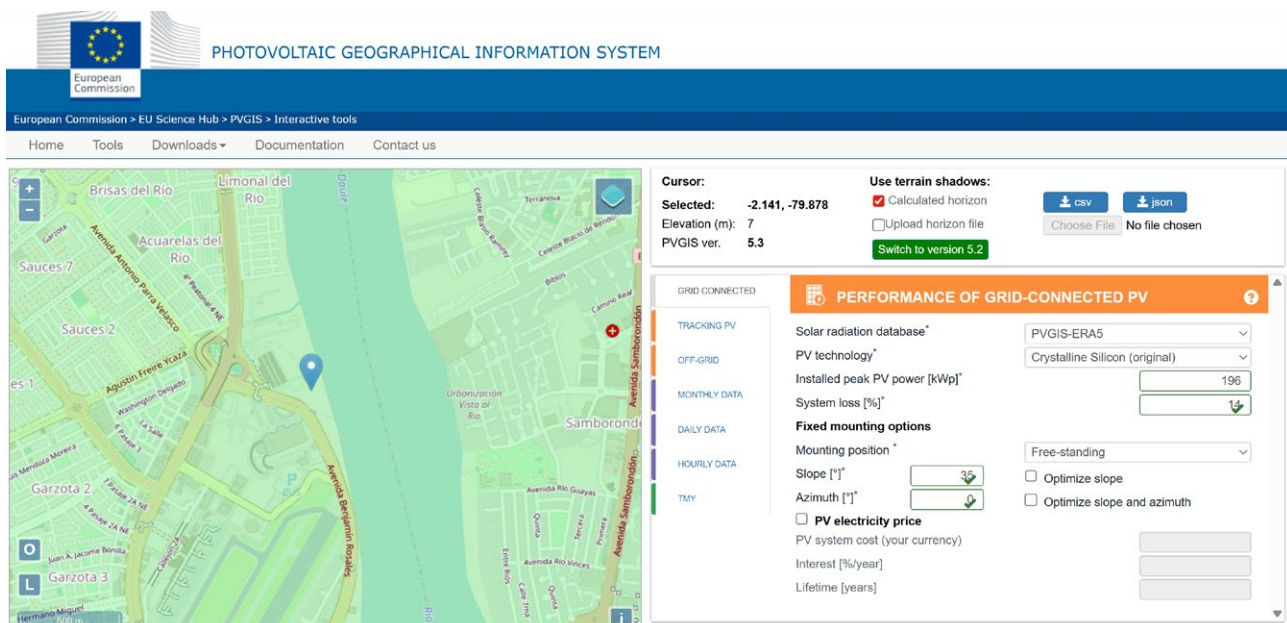


Figure 165. PVGIS simulation interface used to assess solar resource availability and photovoltaic generation potential for the project site in Guayaquil. (Source: PVGIS, 2026).

Solar resource availability was assessed through PVGIS using Guayaquil's climatic data. Results indicate a relatively stable solar production profile throughout the year, consistent with the tropical climate conditions of the site.

The simulation reports a yearly in-plane irradiation of 1129.44 kWh/m², confirming the viability of rooftop photovoltaic integration for the proposed building.

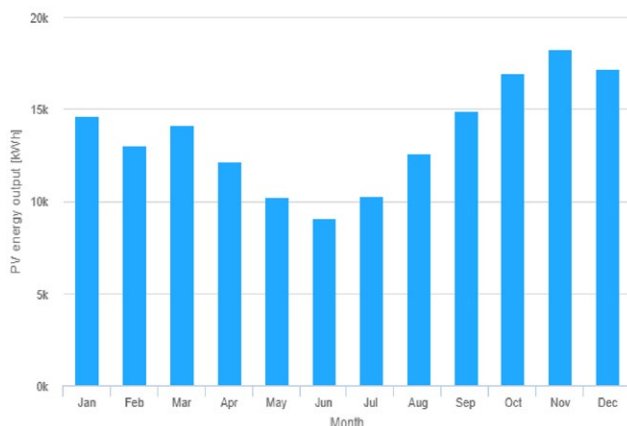


Figure 164. Monthly PV electricity generation estimated through PVGIS for the proposed rooftop system. (European Commission PVGIS / Author elaboration). (Author, 2026).

The photovoltaic contribution was evaluated against the optimized building scenario previously developed through passive design strategies.

When compared to the improved building’s annual operational electricity demand (655,221 kWh/year), the rooftop PV system offsets approximately 24.9% of the total demand.

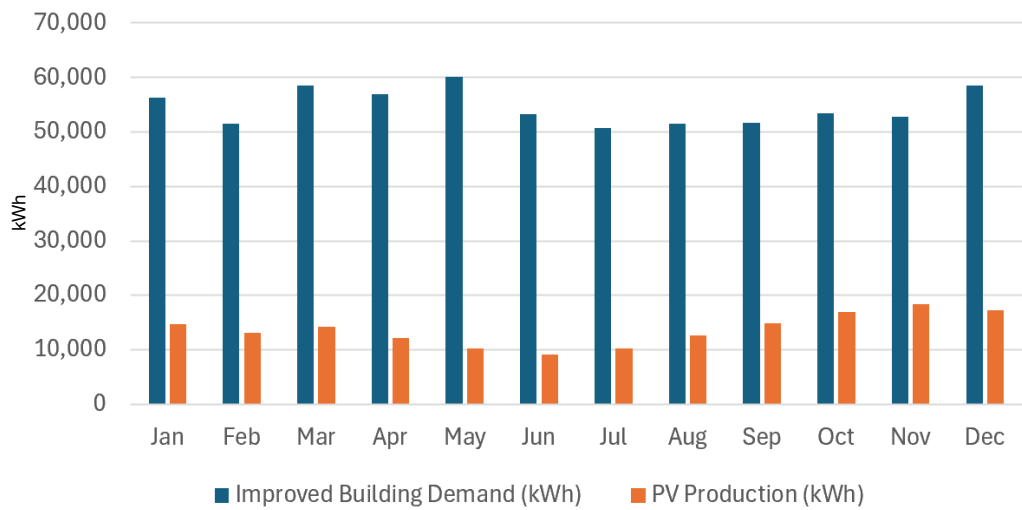


Figure 166. Photovoltaic contribution to operational demand. (Author, 2026).

This demonstrates that while rooftop photovoltaic integration significantly reduces dependence on external electricity supply, the available roof area alone remains insufficient to fully compensate the operational energy demand of a high-density mixed-use building.

7.12 FINAL COMBINED ENERGY IMPACT

When photovoltaic generation is combined with the passive architectural optimization strategies previously implemented, the project achieves a significantly greater reduction in annual operational demand.

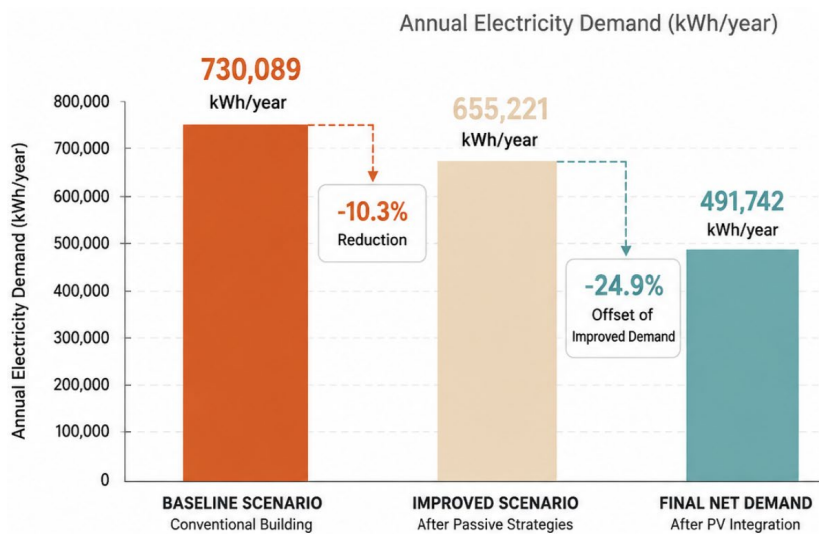


Figure 167. Annual electricity demand comparison between the baseline, passive optimization, and final net-demand scenarios after photovoltaic integration. (Author, 2026).

When photovoltaic generation is combined with the passive architectural optimization strategies previously implemented, the project achieves a significantly greater reduction in annual operational demand.

7.13 ARCHITECTURAL DETAIL DRAWINGS

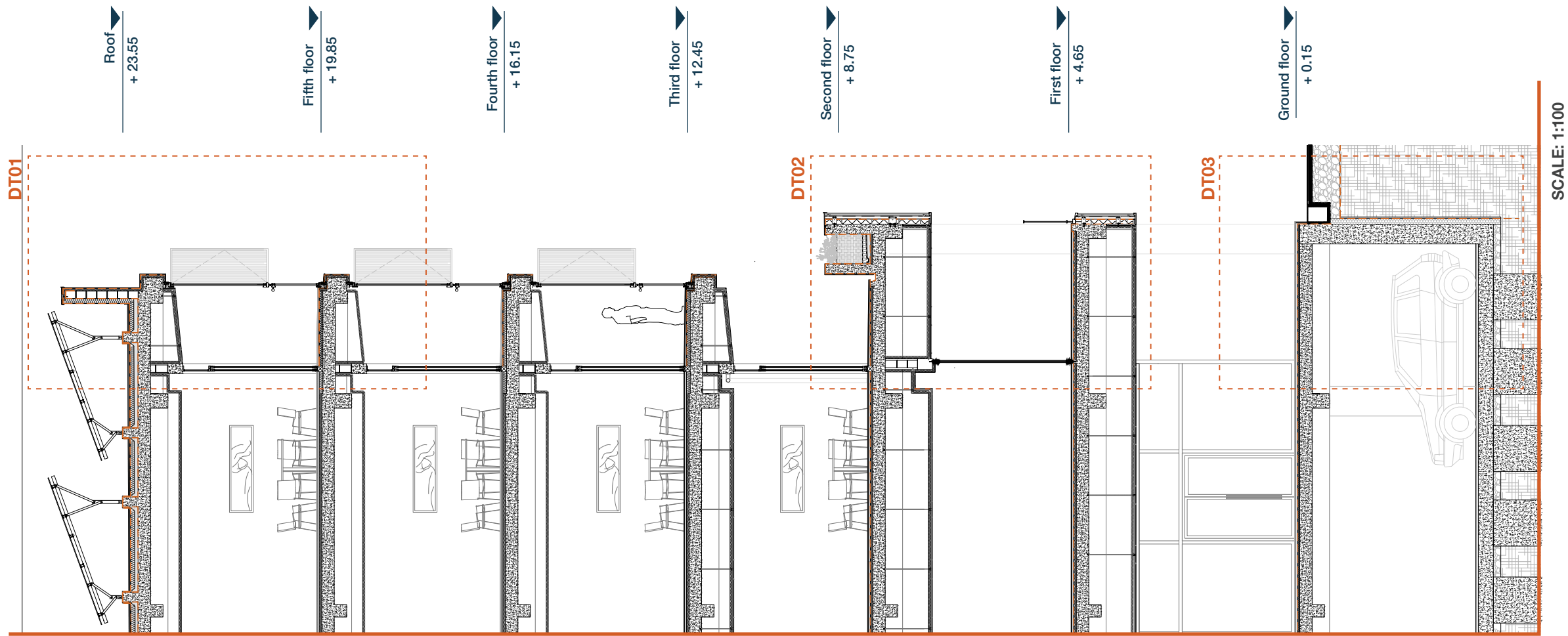


Figure 168. Representative façade section and material composition of the final optimized building envelope. (Author, 2026).

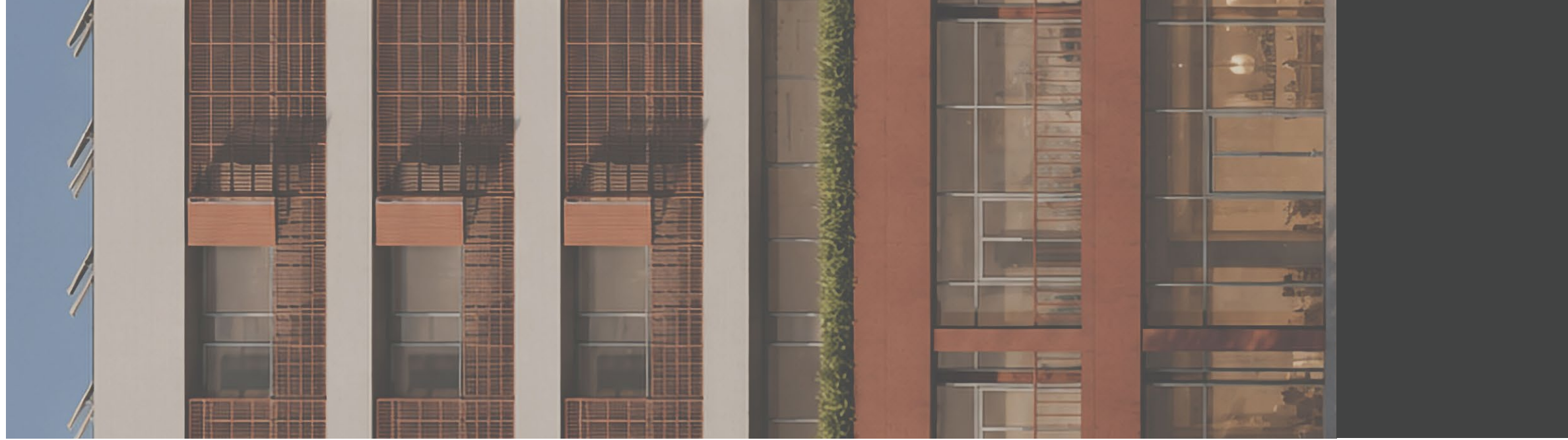
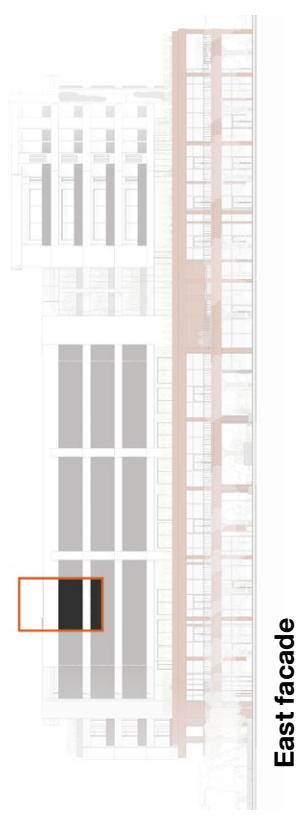
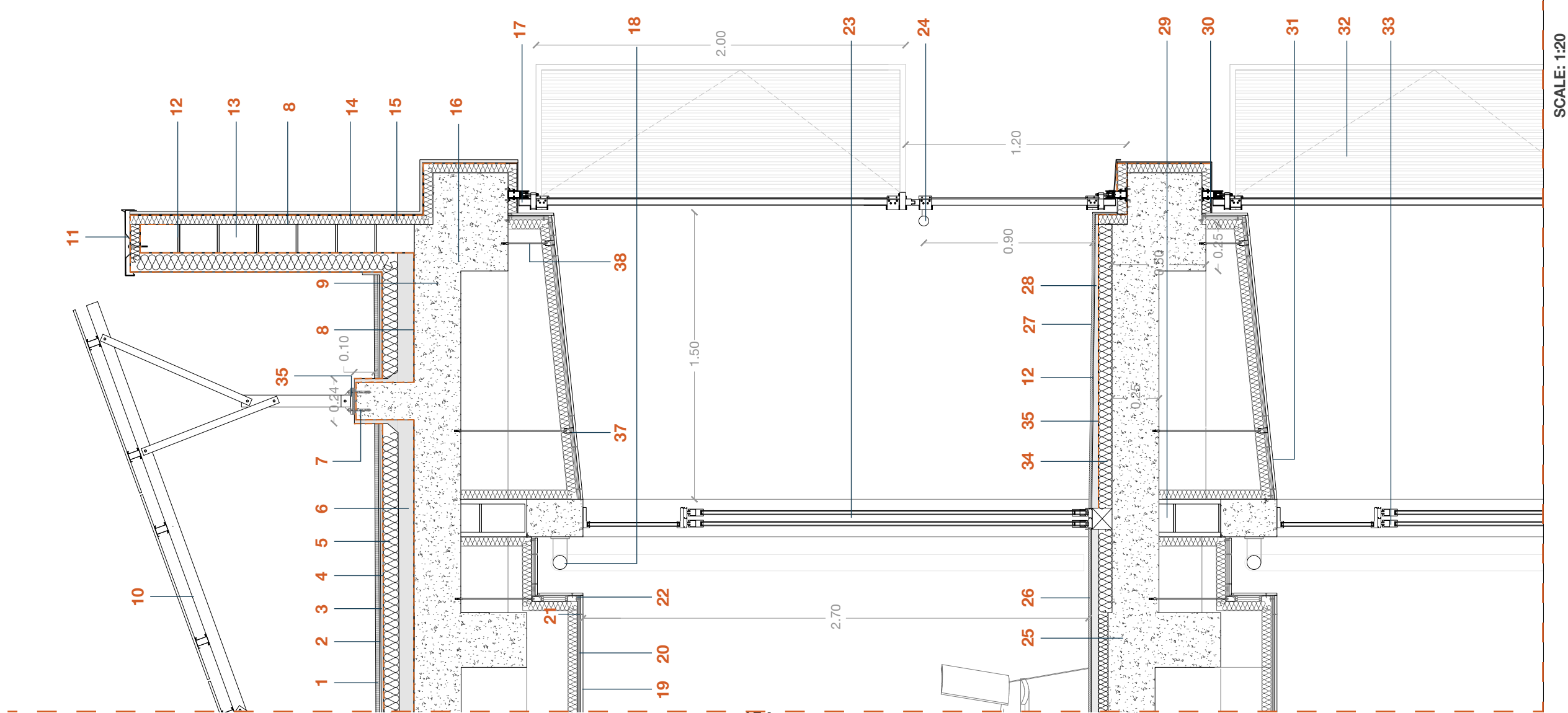


Figure 169. Representative façade render. (Author, 2026).

DT01 - Residential facade



East facade

- 1 Exterior porcelain paving tiles, 600 × 600 mm, 20 mm
- 2 Cementitious adhesive mortar bed, 8 mm
- 3 Cementitious levelling screed
- 4 Bituminous waterproof membrane, 4 mm
- 5 XPS rigid thermal insulation board, 80 mm
- 6 Cement screed with 2% slope to drainage
- 7 Stainless Steel Anchor Bolt with Nut and Washer
- 8 Vapour control layer
- 9 Reinforced concrete roof slab, as per structural design
- 10 Monocrystalline photovoltaic panel array mounted
- 11 Aluminium coping flashing
- 12 Cementitious mortar bedding layer
- 13 Hollow clay brick masonry wall, 150 mm
- 14 Cement plaster finish
- 15 Exterior acrylic weather-resistant paint finish
- 16 Reinforced concrete perimeter beam
- 17 Folding façade support frame in powder-coated aluminium
- 18 Concealed curtain recess / integrated curtain pocket
- 19 Interior gypsum board lining
- 20 Secondary omega channel ceiling framing
- 21 Self-Drilling Drywall Screw
- 22 C-channel ceiling framing system
- 23 Aluminium double-glazed sliding window system with integrated insect screen
- 24 Stainless steel structural support handrail
- 25 Reinforced concrete beam
- 26 Interior porcelain floor tiles, 600 × 600 mm, 10–12 mm
- 27 Exterior porcelain paving finish, 600 × 600 mm, 20 mm
- 28 Cement screed with 2% slope to drainage
- 29 Hollow clay brick masonry wall, 150 mm
- 30 Folding façade screen support structure in powder-coated aluminium frame
- 31 Exterior gypsum board lining resisting to humidity
- 32 Operable folding façade shading panels
- 33 Fixed thermally broken aluminium double-glazed glazing panel
- 34 XPS rigid thermal insulation board, 40 mm
- 35 Bituminous waterproofing membrane
- 36 Galvanized Steel Photovoltaic Support Frame
- 37 Main C-channel suspended ceiling framing system
- 38 Galvanized steel suspension hanger

Figure 170. DT01 – Residential Roof detail. (Author, 2026).

DT02 - Commercial facade

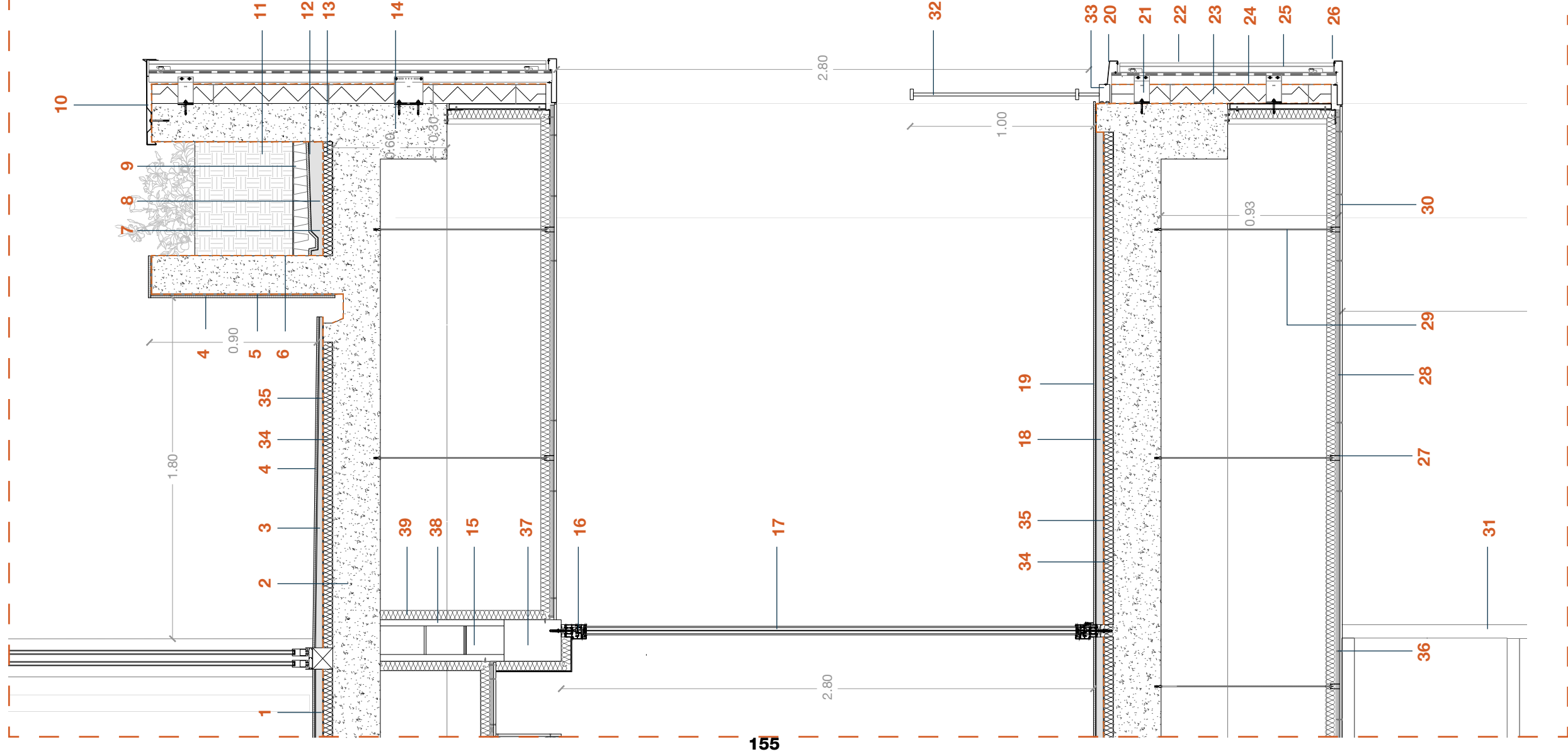
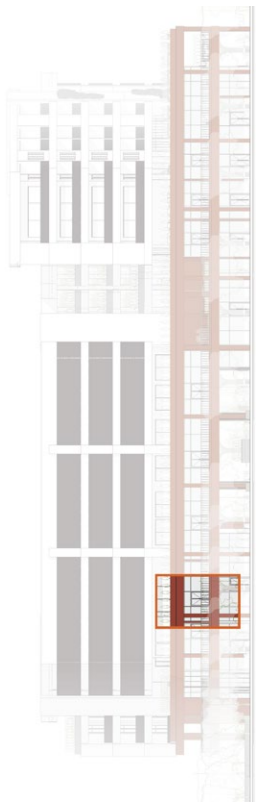


Figure 171. DT02 – Commercial façade detail. (Author, 2026).

SCALE: 1:20

- 1 Interior porcelain floor finish, 600 × 600 mm, 20 mm Reinforced concrete roof slab
- 2 Cementitious screed with 2% slope to drainage
- 3 Exterior porcelain paving finish, 600 × 600 mm, 20 mm
- 4 Cementitious adhesive mortar bed, 8 mm
- 5 Vapour control layer
- 6 SikaPlan® 12 G waterproofing membrane, 1.2 mm
- 7 Sika PP 1800 protection membrane, 1.8 mm
- 8 Non-woven filter geotextile layer
- 9 Aluminium coping flashing with weatherproof termination
- 10 Lightweight planting substrate
- 11 Drainage layer (washed gravel / drainage composite)
- 12 Cementitious screed with 2% slope to drainage
- 13 Reinforced concrete perimeter beam
- 14 Hollow clay brick parapet wall, 150 mm
- 15 Thermally broken aluminium storefront glazing head profile / top transom connection
- 16 Full-height thermally broken aluminium storefront glazing system with double-glazed insulated glass units (IGU)
- 17 Cementitious levelling screed
- 18 Exterior porcelain paving finish, 600 × 600 mm, 20 mm
- 19 Aluminium top closure flashing / façade termination profile
- 20 Adjustable galvanized steel façade anchorage bracket
- 21 powder-coated aluminium rainscreen cladding pane
- 22 Non-combustible mineral wool thermal insulation
- 23 Water-resistant vapour-permeable weather barrier membrane
- 24 Ventilated cavity (drained and back-ventilated zone)
- 25 Aluminium closure flashing at façade-to-ceiling junction
- 26 Main suspended ceiling C-channel framing system
- 27 Secondary omega channel ceiling framing
- 28 Galvanized steel suspension hanger
- 29 Exterior gypsum board ceiling lining
- 30 Thermally broken aluminium curtain wall mullion profile
- 31 Stainless steel structural balustrade support post
- 32 Fixing bracket for hand rail
- 33 XPS rigid thermal insulation board, 100 mm
- 34 Bituminous waterproofing membrane
- 35 Self-Drilling Drywall Screw
- 36 Reinforced concrete lintel beam
- 37 Cement plaster finish
- 38 Rigid thermal insulation board, 50 mm



DT03 - Ground floor

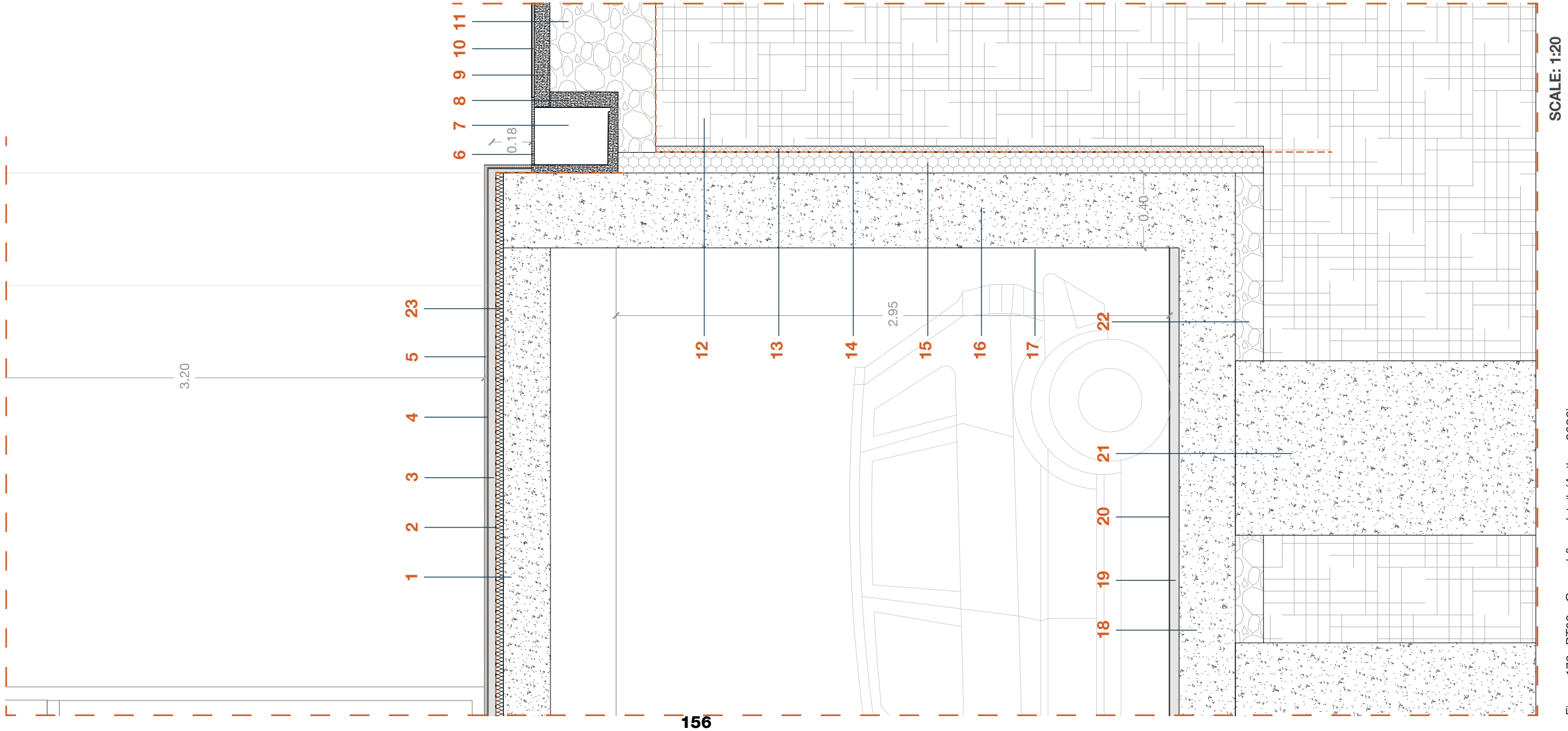
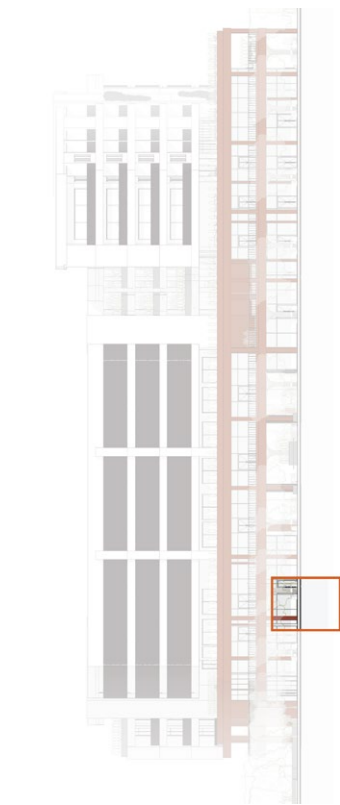


Figure 172. DT03 - Ground-floor detail. (Author, 2026).



- 1 Reinforced concrete podium slab
- 2 Bituminous waterproofing membrane
- 3 Cementitious levelling screed, 8 mm
- 4 Adhesive mortar bed
- 5 Exterior porcelain paving finish, 600 × 600 mm, 15–20 mm
- 6 Galvanized steel drainage grate
- 7 Precast polymer concrete linear drainage channel
- 8 Cast-in-place concrete drainage channel surround
- 9 Lean concrete base layer
- 10 Granite paving finish
- 11 Compacted drainage gravel layer
- 12 Backfill soil / compacted earth
- 13 HDPE drainage board, drainage protection mat
- 14 Bituminous waterproofing membrane
- 15 XPS rigid thermal insulation board
- 16 Reinforced concrete retaining wall, as per structural design
- 17 Interior cement plaster finish with acrylic paint coating
- 18 Reinforced concrete basement floor slab
- 19 Cementitious levelling screed, 8 mm
- 20 Polished concrete floor finish
- 21 Bored reinforced concrete pile foundation
- 22 Compacted gravel sub-base
- 23 XPS rigid thermal insulation board, 40 mm

Chapter 8:

Conclusions & Recommendations

8.1 CONCLUSIONS

This thesis explored how architecture can contribute to the development of more sustainable, climate-responsive, and socially active urban environments within the context of Guayaquil's future urban expansion. Through the integration of urban analysis, architectural design, structural development, and environmental performance assessment, the research proposed a comprehensive design approach capable of responding to the environmental, social, and spatial challenges of contemporary tropical cities.

From an urban perspective, the study identified the former airport area as one of the most strategic development zones within the future growth of Guayaquil. Its proximity to major transportation infrastructures creates the opportunity to establish a new urban centrality within the city. Rather than understanding mobility exclusively as a mechanism of movement, the project explored how transportation infrastructure can support urban life, transforming a transit-oriented area into a place that encourages social interaction, mixed-use development, and long-term urban activity. Through the proposed masterplan, mobility systems, public spaces, landscape strategies, and mixed-use programs were integrated into a coherent urban framework capable of supporting future growth while improving accessibility, environmental quality, and public life.

At the architectural scale, the proposal combines residential, commercial, and communal functions within a mixed-use framework that promotes activity throughout the day while contributing to the vitality of the surrounding district. The design reinterprets key principles of Guayaquil's vernacular architecture—including shaded thresholds, galleries, courtyards, elevated ground floors, and transitional spaces—and translates them into a contemporary vertical typology adapted to current urban conditions. Through the integration of public space, communal areas, and climate-responsive design strategies, the project seeks to balance density, environmental quality, and collective living.

An important aspect of the proposal is the reinterpretation of local architectural knowledge within a contemporary framework. Rather than replicating historical forms, the project adapts environmental and social principles derived from Guayaquil's vernacular architecture to present-day urban conditions. Elements such as galleries, courtyards, shaded transitional spaces, and elevated ground floors were incorporated not as stylistic references, but as strategies that improve environmental performance and strengthen the relationship between architecture and public life. In this way, local identity becomes an active component of the design rather than a purely symbolic element.

From an engineering perspective, the project incorporates a reinforced concrete structural system composed of slabs, beams, columns, shear walls, and deep foundations. Developed in response to the building's mixed-use program, height, and location adjacent to the Guayas River, the structural proposal was verified through a preliminary feasibility assessment that confirmed the compatibility between the architectural and structural systems. The adopted solution provides stability, constructability, and flexibility while supporting the spatial organization of the building and its long-term adaptability.

Environmental performance constituted a central component of the research. Through a process of analysis, testing, and comparison, different massing configurations, façade transparencies, shading systems, balcony dimensions, and envelope compositions were evaluated to understand their impact on building performance.

The final optimized building configuration achieved a 47.9% reduction in cooling demand, a 28.0% reduction in total energy use intensity, and an 83.8% reduction in window solar gains compared to the baseline scenario. These results confirm that architectural decisions related to form, shading, and envelope design can significantly improve environmental performance and reduce dependence on mechanical cooling systems, even within the demanding climatic conditions of Guayaquil. While mechanical cooling remains necessary to maintain thermal comfort throughout the year, its energy demand can be substantially reduced through passive architectural strategies integrated from the earliest stages of design.

Beyond the findings of each individual discipline, the project highlights the benefits of an integrated design approach. Urban planning decisions influenced architectural form, architectural strategies affected structural requirements, and both directly impacted environmental performance. The development of the proposal therefore relied on the continuous interaction between urban, architectural, structural, and environmental considerations, allowing design decisions to be evaluated from multiple perspectives throughout the process.

Finally, this research proposes a framework that may inform future developments in Guayaquil and other tropical cities facing rapid urban growth and increasing environmental challenges. By integrating mixed-use programming, public space activation, structural feasibility, and climate-responsive design, the project contributes to ongoing discussions about how architecture can support more sustainable patterns of urban development. Although developed for the specific context of New Guayaquil, many of the principles explored throughout the thesis can be applied to similar urban conditions where climate, mobility, and future growth play a significant role in shaping the built environment.

Ultimately, the project illustrates how the integration of urban, architectural, structural, and environmental considerations can contribute to the creation of more responsive and resilient urban environments. In the context of New Guayaquil, the proposal presents one possible approach for addressing future urban growth while maintaining a strong relationship with local climate, public life, and architectural identity. More broadly, it highlights the potential of architecture to contribute not only to the performance of individual buildings, but also to the quality and long-term development of the city as a whole.

8.2 RECOMMENDATIONS

As New Guayaquil continues to develop, future projects should continue exploring the integration of climate-responsive design strategies at both the building and urban scales. Particular attention should be given to solar protection, natural ventilation, public space quality, and the creation of mixed-use environments that encourage everyday urban life.

Further development of this proposal could include detailed structural calculations, MEP design, and additional environmental analyses such as embodied carbon and life-cycle assessments. These studies would provide a more comprehensive understanding of the project's long-term performance and support its potential implementation in the future.

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