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The Impact of Smart Buildings on Optimizing Energy Consumption and Preventing Energy Loss

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Abstract

Optimizing energy consumption becomes crucial as the Earth's available resources for its inhabitants are limited and depleting. Therefore, efforts to provide solutions for smart building implementation are essential. This paper aims to offer strategies for incorporating smart technologies in buildings to optimize energy consumption. The necessity of this endeavor arises from the limited and depleting resources on Earth. The objective of this study is to examine the impact of smart buildings on optimizing energy consumption and preventing energy loss.

Keywords:- Smart Buildings, Energy Consumption Optimization, Energy Loss

Introduction

Energy conservation, especially in the realm of sustainable development, has become a critical issue globally, characterized by population growth, increased consumption, and uneven distribution of resources (Touminia et al., 2020). The world's situation at the beginning of the 21st century underscores an unsustainable development trend, notably in the sectors of energy-intensive industries, administrative sectors, transport, and residential areas (Gerji Mahlabani, 2010, p. 92). The energy sector's significant role in daily life continues to grow, necessitating continuous monitoring and efficient management to curb excessive consumption.

Purpose of the Study

This study aims to investigate the impact of smart buildings on optimizing energy consumption and preventing energy wastage.

Theoretical Foundations

Optimizing energy consumption has emerged as a primary global and national strategy to mitigate environmental impacts and revise energy consumption patterns. Recent years have seen an annual global energy consumption growth of 1-2% and 5-8% in Iran, with buildings consuming approximately 30-35% of total energy in the country (Kazemi, 2013). Governmental bodies and energy planners have prioritized energy optimization policies through structural studies and building energy audits (Danza et al., 2020).

Formulating an educational model for architects to reduce energy consumption remains fundamental. Given architecture's influential role in environmental preservation and resource

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optimization, targeted education can significantly enhance architects' abilities to manage and improve environmental conditions (Ho et al., 2019).

Energy Management

Effective energy management is crucial in today's era, where depleting energy reserves and escalating costs of fossil fuels necessitate efficient energy use strategies (Touminia et al., 2020). For instance, standard-compliant heating systems alone cannot effectively manage energy consumption if buildings continue to overheat without automatic shutdown mechanisms, leading to unnecessary energy waste (Ho et al., 2019).

Research Methodology

This study employs a mixed-methods approach, combining fieldwork and library research. Initially, qualitative data was extracted from literature and research sources. Subsequently, questionnaires and interviews were conducted in the field. Finally, an educational model was evaluated through pre- and post-comparisons within the sample community.

Population, Sampling Method, and Sample Size

The study population comprises all qualified architectural graduates registered with the Building Engineering Organization in Bushehr Province, totaling 308 members, of whom 190 hold design codes. Using Cochran's formula, a sample size of 127 participants was randomly selected for the study

Methods and Tools for Data Analysis

1. Data Collection

2. Selection of Target Population, Sample, and Statistical

3. Questionnaire Preparation

4. Validity and Reliability of the Questionnaire

5. Data Analysis

After gathering the data and determining the target population, the validity and reliability of the questionnaire will first be assessed. Validity will be examined using the Lohshe method, and reliability will be confirmed through the Cronbach's alpha method. (Initially, it must be proven that all data are normally distributed, and the Kolmogorov-Smirnov test will be used to confirm the normal distribution of the data.) After necessary tests to prove the normality of the data and confirm its reliability, samples are selected and questionnaires distributed. (Validity and reliability allow us to distribute the questionnaire and then proceed to its analysis.)

For data analysis, content analysis, correlation analysis, and factor analysis methods will be employed**.**

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First Hypothesis

In the initial stage, relevant information and data will be extracted from theses, books, and articles on similar topics. Using content analysis, factors and indicators will be identified.

Second Hypothesis

The findings from the first hypothesis will undergo factor analysis. Based on the results, influential factors relevant to theoretical and practical domains will be identified, determining educational domains, main objectives, operational processes, lesson descriptions, etc.

Methods of Data Analysis

Statistical methods used in this research can be categorized into inferential and descriptive statistics. Descriptive statistical methods such as frequency distribution tables and bar charts were used to examine and describe respondents' characteristics, and measures such as mean and standard deviation were used to describe research variables. Confirmatory factor analysis and structural equation modeling (SEM) will be utilized for model testing and hypothesis examination. AMOS software will be used for SEM, and SPSS software will be used for regression analysis.

Confirmatory Factor Analysis

Confirmatory and exploratory factor analysis models represent two different approaches in constructing measurement models. Confirmatory models establish solid theoretical and empirical foundations for the observed indicator relationships, whereas exploratory models lack an initial idea of which observed variables relate to which latent variables, expecting these latent variables to be identified after quantitative data analysis. Although statistical software allows both types of analyses, confirmatory factor analysis models serve as the primary basis, as used in the current study to examine the validity and reliability of questionnaire structures.

Structural Equation Modeling

In this research, structural equation modeling is used for fitting measurement models derived from confirmatory factor analysis and structural models. A structural equation model combines path models (structural relationships) and confirmatory factor models (measurement relationships). In path models, researchers aim to explain phenomena with univariate and bivariate relationships based on collected data, while variables in the path model are of the observed type. In confirmatory factor models, researchers define latent constructs based on a set of indicators. Overall, a structural equation model typically integrates measurement and structural models, assessing relationships between latent and observed variables.

Conclusion:

In evaluating the measurement component of the model, researchers should examine relationships between latent and observed variables (indicators). Issues of validity concern whether indicators measure what researchers intend to measure, while reliability concerns how accurately indicators measure the intended subject. Therefore, before any measurement,

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researchers must ensure the quality of measurement tools, and evaluating the measurement component of the model should precede the evaluation of the structural component.

Regression Analysis

In cases where two or more variables significantly affect the dependent variable, multiple regression is used to predict the dependent variable. In multiple regression, the assumption of linearity in the relationship between variables holds, and its equation is defined as follows:

Regression analysis helps determine which independent variables have a significant impact on the dependent variable. It also identifies whether their effects are positive or negative, and finally compares the impact of independent variables on each other.

Finally, the pattern of educational architects to optimize energy consumption in mid-level residential buildings in hot and humid areas was obtained. This pattern was evaluated through empirical research (using both pre-assumption and post-assumption populations) and examining the results of the statistical population before and after the training period.

Research findings:

- The height of the building from ground level is one of the determining factors in the amount of wind pressure on the building and therefore the use of wind in natural ventilation. Buildings taller than surrounding trees and nearby buildings have better conditions for natural ventilation compared to other buildings. Tall towers, higher than nearby short buildings, not only benefit from suitable ventilation conditions but also play a significant role in improving the ventilation conditions of neighboring buildings. However, these buildings are exposed to severe wind and rain in winter, so measures must be taken to prevent rainwater from penetrating into the walls.

- Generally, in humid areas, due to the importance of creating shades, the orientation of the building should be determined according to the desired direction of wind flow to maximize the use of wind currents in creating shades in indoor spaces. However, the choice of building direction considering solar radiation and the energy derived from it in various directions is also of great importance. The larger the windows, the greater the importance of selecting the building direction based on solar radiation. Buildings should provide the possibility of creating shades in all rooms in humid areas. Therefore, buildings that include apartments with an external level, especially in the suction area (facing away from the sun), are not suitable for these areas.

- Excessive window size beyond the minimum specified size, to the extent that it effectively protects against solar radiation, is not very important. Even with small windows placed in a suitable location based on wind flow, shades can be created inside the building. However, if it is not possible to create shades, large windows will have a significant impact on indoor air cooling during the afternoon. However, creating effective shades for these windows, especially on eastern or western walls, is difficult.

- To create smart ventilation inside the rooms, the main airflow should be directed to the area where people reside.

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Avoiding the prediction of large windows, especially on the northern facades, the use of double-glazed glass or sometimes triple-glazed glass, the use of movable networks behind the windows as thermal insulation, and the use of thermal insulation sheets inside the open windows, the use of various types of movable network curtains, and the valve behind the window to prevent heat loss from the inside of the building, and the facade of the southern building at least in an angle of 3 degrees from each side in a period of 3 degrees or less.

- Expansion and extension of the poles in the direction of the east west axis allocated to the south-facing spaces of the living area and the establishment of low-importance areas in the eastern and western parts of the building organizing the axis in such a way that the possibility of penetration of the sun into the internal spaces is provided with the greenhouse, attached to the south part of the building, to prevent the heat in such spaces in the summer season it was necessary to predict building materials with a hypothesis of high thermal heat and dark color surfaces in the sunny side of the living areas to use heavy building materials on the south façade of the building to predict dark colors and rough textures for external surfaces to predict a veranda with outside spaces are exposed to the sun from the eastern and western sides of the building organizing the poles in such a way that the possibility of penetration of the sun into the internal spaces is provided with the greenhouse attached to the south part of the building to prevent the heat in such spaces in the summer season it was necessary to predict the use of heavy building materials and thermal insulators in a piece of the outer walls to predict the use of heavy and thermal insulation in a piece of the outer walls

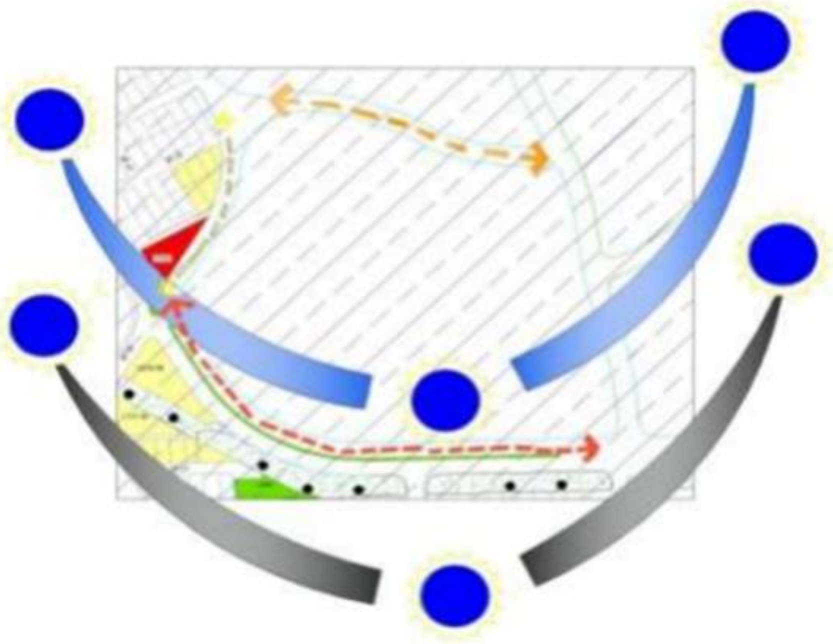

Figure 1_3"The solar position on site: south in winter, gray in summer."

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Coefficient of Expansion

As an example, the meaning of a coefficient of 10 in these units is that with an increase in temperature of 10 degrees Celsius, the length of a material increases by one millimeter. Based on this, an iron beam that is 100 feet long at a temperature of 32 degrees Fahrenheit will be half an inch longer at a temperature of 100 degrees Fahrenheit. It should be noted that wooden beams do not expand in length due to heat, but they do become slightly larger in cross-sectional area. The effect of heat on wood is more pronounced under humid conditions compared to dry heat.

High temperatures in lower latitudes have an undesirable effect on asphalt roofs or tarred roads exposed to the sun, as they can reach temperatures between 130 to 140 degrees Fahrenheit, and in some drier areas, temperatures can reach up to 160 degrees Fahrenheit. This not only increases the internal heat of the building but also leads to the melting and flow of tar on the roof surface, resulting in clogged gutters and drains, necessitating annual asphalt roof maintenance. Similarly, using cement instead of asphalt leads to thermal expansion and contraction, causing cracks in cement roofs and water infiltration, reducing roof insulation, necessitating repeated insulation and costly expenses.

Temperature also affects the efficiency of workers during construction projects. Very high temperatures noticeably slow down manual work in inclement weather and can lead to illness in physically demanding tasks. Low temperatures require more clothing, making manual labor more complicated and challenging. Incidents occurring during periods with temperatures below freezing or excessively hot are more frequent than those in normal conditions. During concrete pouring and plastering, if the freezing agent has already settled, concrete and plaster will be damaged. Frozen ground and soil also delay some construction activities. It should also be noted that wind, snowfall, rain, and even hail slow down or halt construction activities.

Relative humidity in the air is also important for building materials, coatings, building facades, and colors, as metals are generally susceptible to gradual corrosion and rust under high relative humidity conditions. Physical and chemical corrosion of colors also increases rapidly in humid weather, and stone buildings deteriorate more quickly under rapid humidity conditions. Rainfall not only exacerbates moisture-related damage but also has direct physical effects on open surfaces. Heavy rains erode earth and clay buildings, creating runoff and floods that undermine foundations. Such rains dig fresh concrete, erode soil aggregates, and hinder or stop most ground-moving activities. Dams, canals, columns, and bridges must also withstand maximum resistance to heavy rains and the resulting floods.

Snowfall and its accumulation require relatively high resistance of structures. In buildings in mountainous areas and high latitudes, roofs must be strong enough to withstand heavy snow loads. The density and accumulation of snow on other horizontal surfaces create an extraordinary weight that requires the construction of additional and supplementary barriers to prevent their fall. Increased potential for ice on towers, bridges, and cables also surpasses safety limits in design. Buildings heavily laden with ice and snow are more vulnerable to other weather factors such as wind.

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Wind also exerts direct pressure and force on all buildings and structures in its path, so the maximum wind speed and expected pressure must be considered in the design of buildings, towers, and bridges. In this regard, weather-based calculations and structural engineering tests are helpful.

Design and shape:

In terms of the effect of weather on the shape and design of buildings, the following should be considered in planning:

1: Light and brightness of the interior of the building

2: Thermal balance inside the building

3: The time and location of the ports against rain and snow in the freezer

4: The shape of the ports in relation to the reduction and disposal of wind erosion

If the building and structure are well-designed against climatic elements and their shape and plan provide the above, not only will the coefficient of safety and structural resistance be high, but also the comfort and well-being of the building's inhabitants will be ensured from a human bioclimatic perspective.

The shape of the building and the light and brightness:

The most important factors affecting the light of the building are:

A: Geographic width and the position of the sun, which also affect the angle of radiation and the direction of radiation.

B: The length of the radiation and the intensity of the radiation depend on the number of sunlight hours per day and the intensity of radiation on factors such as height, cloud amount, weather-oriented sand in the air (suspended dust) and contamination. The urban texture and direction of the alleys. The streets and highways, which, of course, a compression and dense texture and narrow pathways are reducing daylight and vice versa. D: The density and compression of housing are dependent on their area. In fact, in the fields and small pieces of space, and therefore the small building area is reduced**.**

Therefore, designers, architects, urban planners, and city planners should consider the above-mentioned factors based on the geographical location of their desired city and provide appropriate lighting for building projects. For example, to direct sufficient light and heat into buildings located at higher latitudes, it is necessary to have a widespread and non-dense urban fabric with open and non-compacted residences, a large number of windows with increased height, and to avoid balconies and awnings.

Architectural form and thermal balance:

Creating suitable heat and air conditioning in the interior of a building is another architectural issue that will not be easy. Because this issue relates to human comfort or discomfort and the

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concepts of heat or cold are more due to the natural feeling of humans and their physiological conditions.

A person with light clothing and resting at 23 degrees Celsius is in equilibrium, but at the same time, if undressed, must work or exercise. , even To age in? even<|end_of_action|><|start_of_action|> Drag 63 821 331 865<|end_of_action|><|start_of_action|> Type balance the temperature and, and Reduce costs. the walls of As well, glazed façades Prevent summer maximum winter. of the façade building building, For areas, solar shading installed northern façade. the summer season, north-facing façades optimal.Therefore, designers, architects, urban planners, and city planners should consider the above-mentioned factors based on the geographical location of their desired city and provide appropriate lighting for building projects. For example, to direct sufficient light and heat into buildings located at higher latitudes, it is necessary to have a widespread and non-dense urban fabric with open and non-compacted residences, a large number of windows with increased height, and to avoid balconies and awnings.

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Sure, here is the translation of your text into English:

A: Significant Effects of Wind on Buildings:

The major effects of wind on buildings can be categorized into several general aspects:

- Buildings with a round shape, such as those with domed ceilings, reduce wind resistance and durability compared to angular structures.

- Tall and high-rise buildings with short horizontal dimensions are more susceptible to overturning or complete bending in their upper parts.

- Buildings with open sides or wind-catching shapes tend to capture wind and increase wind forces.

- Protrusions or projections of buildings, shelters, tall walls, parapets, balconies, and unstable walls contribute to all-round wind-induced tensions.

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- Signs, symbols, chimneys, antennas, penthouses, and other rooftop equipment also undergo wind-induced effects.

B: Comfort and Convenience Coefficients in Buildings:

It is self-evident that in architecture, planning, and building design, if we carefully consider the aforementioned factors, suitable living conditions are established, providing residents with necessary comfort and convenience. Nevertheless, today's buildings must be constructed in the smallest possible space to meet human comfort needs in all seasons. To achieve this goal, efforts should be made to utilize solar energy and natural resources instead of fossil fuels and heating devices in winter, while maximizing shade, wind, and other climatic cool features in summer

First, we examine the general climate factors affecting site design, then we address specific items of our website accordingly.

Row	Effective Items	Description
1	Solar Position	Ideal for sunlight capture from the south and southeast in cold climates.
2	Suitable Wind	Winds from the south and southwest are favorable for solar orientation. Undesirable winds from the northeast should be mitigated with measures such as increasing block height.
3	Noise	Due to proximity to a major noisy street, design considerations for effective soundproofing are crucial.

Row	Effective Items	Description
4	Skyline	The width of the street allows for high-rise construction up to 9 stories, considering the new urban fabric and adjacent buildings.
5	Site Context	Attention to surrounding environment, addressing site slope and channels.
6	Topography Consideration	Importance of block layout and landscaping.
7	Entries	Control in optimal visibility with separate emergency exits.
8	Pedestrian Entry and Pathway	Control in optimal visibility with separate emergency exits.

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9	Pedestrian Entry and Pathway	Maximum separation between pedestrian and bicycle paths for safety.
10	Vehicle Entry and Pathway	Ensuring maximum pedestrian safety.
11	Hierarchy	Access levels for blocks, pedestrians, and emergency access in natural disaster scenarios.
12	Block Entries	Ensuring emergency access to all blocks
13	Emergency access	Emergency access to all blocks in terms of natural disasters.
14	Public space	Neighborhood unit and community center.
15	Block Uniformity	Avoiding block hierarchies for inappropriate sightlines relative to each other.
16	Sun Shadow	Minimizing shading on blocks.
17	Adequate Visibility	Suitable visibility considerations.
18	Component Coordination	Coordination between components.
19	Site Utilization	Maximizing the use of the entire site.
20	Earthquake Consideration	Attention to earthquake-prone region considerations.

Summary and Conclusion:

Community life requires physical structures that cater to various needs. These include parking for homeowners, visitors, and service vehicles such as trucks, designated spaces for garbage collection, open spaces for socializing, relaxation, and outdoor sports, attention to greenery and landscape for children's play areas, reception spaces for postal services and package deliveries, areas for maintenance and inspection of public utilities like water, sewage, and gas pipelines. Designing a complex involves analyzing and complying with regional constraints and amenities such as postal services, terrain slope, soil type, and resistance, green spaces, roadways, and existing networks. It also involves considering climatic and geographical factors, aligning communication networks, determining routes based on the shape and location of the area, predicting hierarchical communication functions, and selecting appropriate water management systems aligned with spatial designs. Dividing the land into neighborhoods and selecting an appropriate scale and necessary density, predicting suitable shapes and proportions

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between residential service communication spaces and other filled and empty spaces, observing spatial order and clarity, orientation, and adjusting nodes, signs, and spatial road layouts in the complex.

Location of building construction on a large width and complexes:

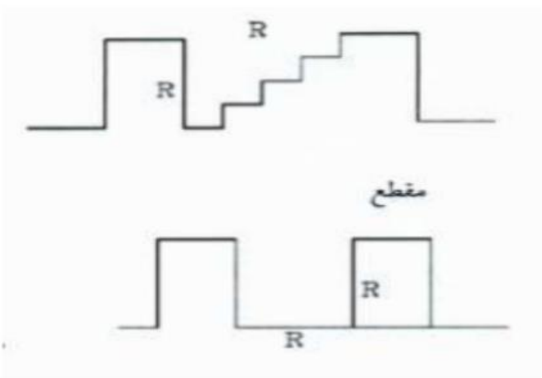
For areas larger than 15 square meters and where building complexes are constructed, building construction regulations are as follows, respecting the relevant regulations of roads and open spaces: In building complexes, building construction can definitely be in separate forms, except in sections where their width is less than the width of the northern section. The distance of the building from the northern edge of the land is three meters if the width of the buildings is not greater than the width of the northern sections, and otherwise, it is half the height.

Minimum open space:

For compliance with the above conditions, floors must have minimum open spaces in the following proportions: up to two floors, 4%; three floors, 45%; four floors, 5%; five floors, 55%; six floors, 6%. An additional 2% open space is added for each additional floor, with a maximum of 8%. Note 1: Pilots are not considered for calculating floor open space. Note 2: An additional 5% of open space is deducted for each extra passageway. Note 3: Rectification of open space violations is only possible through demolition, excluding fines in Commission Article 1. Furthermore, in the northern and southern floors where buildings are constructed separately, 10% of the required open space area is reduced, but the minimum open space should not be less than 40%.

Distance between two building blocks and other open spaces and sheds:

(a) The distance between two building blocks is equal to the height of a building located on the southeast and southwest sides, which can also be stepped or sloped. However, this distance should not be less than half the height of the northern building. In the figure below, the courtyard depth on the first floor is equal to the height of the first floor, and on the second floor, it is equal to t he height from the second floor to the last



"**Figure 1.4: Spacing of blocks considering daylighting issues.**"

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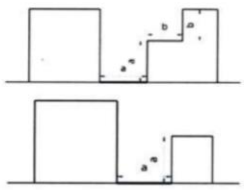
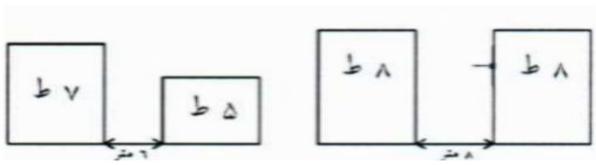
The distance between two buildings, where their main facades face each other without any gap, varies in different configurations when constructing on plots with more than one building block. Placement of buildings considers directions such as south, north, east, and west. The distance will be equal to the height of the southern building. If there are height variations (breaks) in the buildings, the distance between them is calculated based on the height of the southern building at each break point.



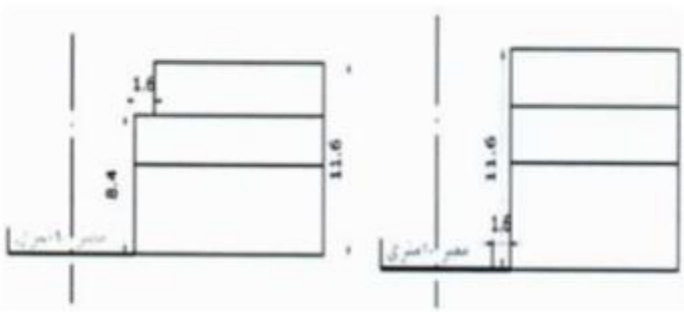
"Figure 2.4 : Spacing of blocks considering daylighting issues with respect to block articulation."



"Figure 3.4: Block spacing considering daylighting issues as a function of distance per number of floors."

Types of setbacks for buildings:

- Setback for maintaining the height-to-width ratio of the thoroughfare can be continuous for the entire height or only for additional height.



" Figure 4.4 The distance of the block from the thoroughfare."

Setback from the courtyard can also be continuous or stepped. For example, a 10-story building without a pilot with a height of 34 meters can be constructed with a setback of 17 meters by creating a deep courtyard. Another example is constructing up to 6 floors with a courtyard

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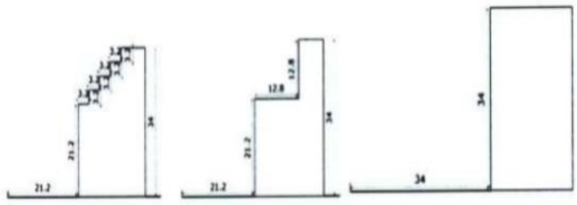
depth of 6.10 meters, followed by a setback of 6.4 meters in the form of a terrace on the roof of the sixth floor for the next 4 floors.



"Figure 5.4: Step setback with one setback and setback with one bay."

1. The total area of residential units shall not exceed 120% of the land area.

2. The gross land area per residential unit shall be at least 100 square meters.

3. The area of the smallest residential unit shall not be less than 80 square meters.

4. The maximum permissible occupancy on the ground floor is 35% of the total land area. Areas such as guard rooms, greenhouses, showers, dressing rooms, sanitary facilities, pools, and covered recreational spaces for children are not included in this limit.

5. The construction of parking spaces equivalent to at least 75% of the number of residential units is mandatory.

6. The minimum net parking area per vehicle shall be 5.12 square meters.

7. The minimum width of access roads to parking areas shall be 5.5 meters.

8. The total occupied area of residential building floors, plus the area occupied by driveways to parking lots, shall not exceed 60% of the total land area when parking lots are located in open areas. For the interior design of spaces, an introduction to the areas and spaces is first provided, followed by detailed standards and dimensions.

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