Relations Between Pro-Environmental Behavior and The Physical Characteristics of Vertical Housing

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Abstract. Residential buildings consume a lot of energy and can cause environmental damage, especially in the post-occupation and operating phase. In order to minimize environmental damage, the green building concept was chosen as a solution that can minimize the causes of environmental damage. Pro-environmental behavior of residents is suspected to be influenced by the occupants environment, which is the physical characteristics that exist in the vertical housing. This study aims to analyze the correlation of physical characteristic in a residential building with the value of pro-environmental behavior, especially on student vertical housing. Based on purposive sampling (non-random/non-probability sampling), correlation analysis shows that the physical characteristic has a high correlation with a significant value of <0.05 towards pro-environmental behavior. The physical characteristics of vertical housing define into three categories, which are site characteristics, building characteristics, and residential unit characteristics. On site characteristics, the highest significant value is at site accessibility, building density, and vegetation distribution. In building characteristics, the highest significance value is in building blocks, distribution systems, building floor area, and the number of residential units. While the characteristics of the residential unit, the highest significance value is found in the occupancy unit area and the existence of the bathroom.

1. Introduction
Total energy consumption in Indonesia in 2015 based on data from the Ministry of Energy and Mineral Resources was 31% in the residential sector. This energy consumption is dominated by electricity that consume 71% energy consumption. Energy demand in this sector is also expected to increase by around 5.8% until 2050 [1]. This proves that in its operations, residential buildings consume large amounts of energy as well as cause environmental problems. In order to minimize environmental damage, the green building concept was chosen as a solution that can minimize the causes of environmental damage [2]. The behavioral aspects of the green concept have now become an important concern besides the physical aspects. This aspect of behavior known as pro-environmental behavior can influence the physical building performance [3]. Pro-environmental behavior is a way of analyzing the building performance of residential phase. This behavior are the interaction between residents and buildings, which shows the green concept, namely energy efficiency and environmental sustainability support. By identifying the influencing factors of pro-environmental behavior, it is known how to improve this pro-environmental behavior. The application of the green building concept is expected to influence pro-environmental behavior.
This study aims to identify the pro-environmental behavior patterns and to identify the physical factors that influence the pro-environmental behavior in vertical residential buildings. So that the conclusion will be obtained recommendations for the building physical characteristics that can increase pro-environmental behavior of residents.

Physical characteristics in this study are factual conditions of vertical housing. In accordance with literature studies [4-6] physical settings can be divided based on the scale of the building space. Spatial scale is divided into residential unit attributes, building attributes, and site attributes. Physical characteristics of the site namely site distance, land area, building orientation, green space, topography, and land density. The physical characteristics of the building namely the building block, building distribution, the number of building floors, the floor area, the number of residential units, and the supporting facilities. While the physical characteristics of the residential unit are the unit area, the layout unit, the position of the openings, the ratio of openings, the existence of the bathroom, and the presence of electronic furniture. Based on the classification of behavioral categories in various literatures

2. Research Methodology

The correlation analysis was used as assessment instrument in this study to recognize the relations of pro-environmental behavior and the building physical characteristics in vertical housing. Respondents were selected by purposive sampling, there were 285 respondents. Purposive sampling is a method that choosing the specific objectives as a sample [7]. The occupants pro-environmental behavior was assessed using a five-scale Likert questionnaire and was divided into two categories: curtailment behavior and investment behavior. Meanwhile, Data collection on building physical characteristics based on research instruments by observing residential buildings supported by structured interviews. Qualitative data processing on each variable (site characteristics, building characteristics, and unit characteristics) to obtain physical characteristics in case studies. The overall analysis aims to determine the relationship structure of occupant pro-environmental behavior variables with the physical characteristics of the building so that it will get a significant characteristic in increasing the value of residents' pro-environmental behavior.

3. Case Study

The case study in this research is a vertical residential building in Bandung, with student occupants: Asrama UPI, Rusunawa UNPAS, and Rusunawa Sangkuriang ITB.

3.1. Asrama UPI (Indonesia University of Education)

Built around 2010, this building located in Jalan Setiabudi no 229 Bandung that inside the campus area of UPI. In this research, male dormitory and female dormitory buildings are used as case studies. These two building is a twin building with 4 floors. This building has 136 units with 272 residents. The entire floor used as a residential area with common room such as canteen, photocopy and multipurpose room.

3.2. Rusunawa UNPAS (Pasundan University)

This dormitory is located in Jalan Setiabudi no.193 Bandung, inside the Pasundan University campus IV. This building used as female students dormitory. Rusunawa UNPAS is one block building with 5 floors. This building consist of 96 residential units. Rusunawa UNPAS has 96 residential units with 384 residents. Rusunawa has a common area such as library, laundry, and cafeteria.

3.3. Rusunawa Sangkuriang ITB (Bandung Institute of Technology)

Rusunawa Sangkuriang ITB located at Jalan Sangkuriang Dalam no. 55 Bandung and managed by UPT Asrama ITB. This building has 196 residential units with 384 people. This one twin block building with five building floors, have 60 residential units that located on the second to fifth floor. Service and public areas are available on the first floor with multipurpose area.
4. Result & Discussion

4.1. Pro-Environmental Behavior

Pro-environmental behavior in this study is divided into two categories: curtailment behavior and investment behavior [8, 9, 10]. The curtailment behavior manifested in behavior that minimize the intensity of energy consumption (such as reducing shower duration, decreasing the use of air conditioning, etc.). Meanwhile, investment behavior is a behavior that increase quality of a dwelling in order to create energy efficiency (such as replacing old glass with double glass) or the behavior in purchasing energy-efficient furniture to reduce energy use.

This part of the analysis has previously been carried out in previous studies that have been disclosed by Syahriyah [11]. The analysis shown that residents has pro-environmental behavior in their residential environment. The average of pro-environmental behavior shown with 2.85 points in all case study. The pro-environmental behavior as seen on Figure 1, has a medium value of 2.80 points in Asrama UPI, 2.76 points in Rusunawa UNPAS, and 3.01 points in Rusunawa ITB. This analysis shows that all residents have the same pro-environmental behavior pattern.

Furthermore, based on the category of pro-environmental behavior, the value of the curtailment behavior (3.28 point) has a higher value than investment behavior (2.43 point). This analysis shown that occupants tend to minimalize the intensity of energy consumption in pro-environmental behavior, rather than making investment by purchasing energy-efficient furniture in reducing energy use.

![Figure 1. Pro-environmental behavior values of three case study.](image)

4.2. Relationship between Physical Characteristics and Pro-Environmental Behavior

This relationship is done by analyzing the relationship of pro-environmental behavior with data on the physical characteristics of buildings. This analysis is done through correlation analysis and ANOVA analysis. The results of the analysis with a high significance value (<0.05) will be as a recommendations to increase the residents pro-environmental behavior. The results of the analysis indicate that there is a relationship between physical characteristics and the pro-environmental behavior, both on the characteristics of the site, buildings, and residential units.
Table 1. Significance value of physical characteristics and pro-environmental behavior

| Physical Characteristics | Pro-Environmental Behavior |
|--------------------------|----------------------------|
|                          | Investment Behavior | Curtailment Behavior |
| Site Characteristics     |                           |                        |
| Site Distance            | Located outside the college area | 0.0002     | <0.0001     |
| Site Topography          | Site elevation is above the activity center | 0.1020 | <0.0001 |
| Site Area                | large footprint area, the value of pro-environmental behavior is higher, especially water conservation | 0.0197 | 0.8688 (0.1468) | (-0.0105) |
| Site Density             | Located in a moderate density area | 0.0011 | <0.0001 |
| Green Space              | green space around the site | 0.0011 | <0.0001 |
| Building Block           | Configure parallel building blocks | 0.0011 | <0.0001 |
| Building Distribution    | Linear building distribution system | 0.0002 | <0.0001 |
| Number of Building Floors| more than 3 residential building floors | 0.0372 | 0.8352 |
| Floor Area               | the area of each building floor gets smaller, the pro-environmental behavior value is higher | 0.0031 | <0.0001 (0.1859) | (-0.2827) |
| Number of Residential Units | the number of floor occupancy is getting smaller, the pro-environmental behavior value is higher | 0.0300 | <0.0001 (0.1368) | (-0.2642) |
| Supporting Facilities    | Lobby, shared space, multipurpose room and laundry room | 0.1956 | 0.0059 |
| Unit Layout              | Equipped with a pantry | 0.1187 | 0.0138 |
| Unit Area                | the occupancy unit area for each occupant is wider, the pro-environmental behavior value of the occupant is higher, especially water conservation | 0.2252 | 0.0002 (0.0767) | (0.2362) |
| Bathroom                 | bathroom inside the residential unit | 0.1020 | <0.0001 |
| Openings Position        | dual aspect | 0.0372 | 0.8352 |
| Electronic Furniture     | (+) entertainment | 0.0280 | 0.3234 |
| (-) others, such as iron |                        |                        |

*The most significant relationship

Based on the analysis, it was found that all aspects of the physical characteristics of the building, namely the design of buildings related to the site, buildings and residential units, had a correlations with the occupant's pro-environmental behavior. Significant relationship seen in the relationship of building physical characteristics to both investment behavior and curtailment behavior. From the results, the characteristics with the highest significance values in each category (sites, buildings and residential units) were selected. This most significant characteristic then becomes the recommendation of the building's physical design criteria related to the influence of occupant pro-environmental behavior (see...
The application of the physical characteristics of the building design can be realized in the initial design of residential buildings, as well as in the physical improvement of buildings. In site characteristics, the highest significant value is seen in the characteristics of site distance, land density, and green space. In building characteristics, the highest significance value is seen in the characteristics of building blocks, building distribution, building floor area, and the number of residential units. While the characteristics of the residential unit, the highest significance value is found in the unit area and the existence of the bathroom. The result shown that there are 2 categories of recommendations for student vertical residential design criteria, related to the occupants pro-environmental behavior, namely support for green building concepts and the creation of behavioral opportunities. Support green building concept is a physical characteristic that shows an effort to create a green building concept in the physical environment. The application of the green building design concept may increase the buildings performance value and pro-environmental behavior of residents. This recommendation is in accordance with Mazar and Zhong [8] that the green building concept can be a moderator in the occupants’ pro-environmental behavior. Meanwhile, the creation of behavioral opportunities is an effective environment for someone to create interpersonal/social spaces that support pro-environmental behavior, with control over certain physical environments. Control of space creates behavioral opportunities and triggers individual behavioral motivation. Behavioral opportunities and occupant motivation are among the factors that influence the formation of pro-environmental behavior [8, 12]. Pro-environmental behavior in vertical housing cannot be separated from the spatial behavior of the individual. As stated by F. Langdon [13] the environmental potential has a high correlation with spatial behavior.

5. Conclusion
The results of vertical housing with a high significance value on the pro-environmental behavior, the physical setting of the vertical housing can create the occupants pro-environmental behavior. Recommendations on the physical setting of this vertical housing can be divided based on the scale of the building space. The spatial scale is in accordance with the literature obtained [4-6], is divided into residential unit attributes, building attributes, and site attributes. There are 2 categories of recommendations for student vertical residential design criteria, related to the occupants pro-environmental behavior, namely support for green building concepts and the creation of behavioral opportunities. The application of the green building design concept may increase the buildings performance value and pro-environmental behavior. This is in line with the statements of Wilkinson et al. [15] and Syahriyah [14] that pro-environmental behavior can be realized with the application of green building concept and can be done by creating housing arrangements that apply several physical criteria to create behavioral opportunities and triggers individual behavioral motivation.

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