The application of modular architecture on apartment buildings

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Abstract. Housing crisis become one of the world problems, where many people cannot afford a decent shelter. This problem is mostly experienced by young people, where young people have a middle-level income, so they feel it difficult to get suitable housing for them and their needs. Research using descriptive methods with literature study approach. The study is aimed to provide affordable housing for young people with developing financial condition. The aspect to be considered is about how the application and method of modular architecture can provide affordable housing for young people in the form of vertical housing or apartment. This study will discuss about a comparison between modular and conventional construction and the impact of applying modular architecture to apartments to produce affordable apartment units. The results of this study discuss about how the influence of modular architecture to provide an affordable apartment.

Keywords: affordable housing, apartment, modular architecture, prefabricated architecture.

1. Introduction
This study is based on one of the United Nations: Sustainable Development Goals that focuses on a sustainable future. The material taken is Sustainable Development Goals number 11 which discusses about sustainable cities and communities aimed to make cities inclusive, safe, resilient, and sustainable. The discussion focused on sub-number 11.1, especially regarding ensure access for all to affordable housing [1].

The housing crisis is one of the world's major problems according to the United Nations which must be resolved. It is noted that the reduction in land proportion to the amount of development and development in various parts of the world has an impact on the high price of land and occupancy. The high price of housing does not only affect low-income groups, but also affects young people and the next generation.

Most young people choose to live and work in big cities with big hopes for their future. However, the high cost of living in big cities that is not comparable with the income earned is the problems for young people, one of the other problems is in choosing and owning a place to live. Young people's income is classified as middle-level income which impacts that young people cannot get social housing with too high income, but they also cannot afford to live in public housing with a small income [2].
Jakarta is the capital and economic center of Indonesia, where the city is one of the cities of choice for young people to try their luck. With the large population immigration from other region to this city, Jakarta has a high population level that is comparable with the number of housing needs. With a limited area and intense economic competition, the price of land in Jakarta can be considered very high, even reaching Rp. 200 Million - Rp. 250 Million [3]. With the high price of land having an impact on high housing prices, some people in Jakarta choose to live in the interior of the city and even in slums. This makes it difficult for the city government to organize and develop the city of Jakarta. Young people who are critical and care about the future, knowing this, young people choose to avoid settling in slums and hoping to find a more suitable and suitable place to live.

Apartments are one solution to the small amount and high price of existing land. However, most apartments in Jakarta are targeted at middle and upper markets, which is not suitable for the economic conditions of young people. Apartments with conventional construction methods have significant construction costs so they cannot reach the middle market segment. Then an apartment building solution with a modular architectural system is obtained in order to achieve affordability and middle-class market segments.

In reaching the middle class market segment, the cost of materials and construction of apartments must be cut. Modular architecture is one way to achieve the target of these middle class apartments. Modular architecture is an architectural construction system in which the building is based on modules that are already in the form of a volumetric room complete with some components such as toilets, kitchens, doors and windows. Modular architecture is a classification of prefabricated architecture created in the form of volumetric space. With manufacturing done outside the site and on a large scale, this can reduce the time and cost of construction of apartments around 30%-70% [4].

Not only from the manufacture that is done outside the site and on a large scale, but also the use of materials that are more efficient and flexible. In order to get an affordable apartment unit price, a modular architectural approach to the apartment will be used. The modular drafting system is adapted to the basic size standards obtained from SNI 03-2855-1992 and the modular architecture criteria obtained from the Modular for Architects (2017) book, by Harry W. Parker.

Essentially, this paper presents the initial study and it contains the study of: (1) a comparison between modular and conventional construction, (2) the effect of the use of modular architecture on apartment unit prices, (3) the application of modular architecture to apartments to produce affordable apartment units.

2. The methodology
2.1. The method of study
The diagram below shows the method used in the study (see figure 1). This study is a literature review of the impact of the use of modular architecture on the affordability of residential prices. From this study the results obtained in the form of the concept of applying modular architecture to the apartment following the most efficient module size for use in designing modular apartments.
3. Result and Discussion
The modular construction is more effective when applied to large scale projects. Not only is it due to cutting costs, but it also has advantages in checking stable quality, using less labor, and work that can be done in parallel. However, the use of modular systems is not recommended for use on small scale projects such as houses. The use of modular architecture in small scale projects will indeed make development faster but can have an impact on the high cost of customization and the small number of modules to be used.

The application of modular architecture to large scale projects such as apartments has the greatest impact on the period of construction required. Development can be done more quickly by relying on parallel development, when the land is processed to be built, the module is also in the process of making it at the factory [6]. The construction time can be reduced by 70% and makes the apartment can start operations faster.

The timeline comparison between conventional and modular construction. Modular construction is carried out in parallel at 2 different locations, on the site and at the factory. With this parallel distribution of construction, construction can be completed faster without any process having to wait for other processes.

Not only does it affect the speed of construction, repeated use of modules can also cut costs used in making modules. The following chart will show a comparison between the prices of each module and the repetition or variations of modules used in the project [7].
From the graph in Figure 5 we get a comparison of costs / modular units with repetition and the modular variations used. In Figure 5 a) the results obtained in the form of modular unit prices can be cheaper with more and more repetitions of modules in the building. Figure 5 b) shows the price of modular units can increase with the increasing number of variations used in buildings. Whereas in Figure 5 c) the use of a number of modular variations increases but the price of the modular unit is maintained at the specified cost margin. This can affect the use of materials, the quality of the materials used, and the size of the module to get the variation of modules according to the specified price margins [7].

The graph in Figure 6 contains information about spending on development costs in accordance with the construction timeline. In Figure 6 a) expenditures for conventional construction systems will increase sharply upon building completion, one of which can occur during the finishing process. Besides increasing during the finishing process, expenditure can also increase in accordance with the occurrence of failures and errors in conventional construction processes. Whereas in Figure 6 b) expenditure on modular construction systems can be considered more stable, where the increase does not occur significantly. An increase in expenditure on modular construction can occur when transporting the module to the site according to the module size, site location, and terrain of the site location. Failures and errors that occur during module construction during the construction process are
the responsibility of the module manufacturing plant, which means that the costs of such errors will not be charged to the project itself [7].

The three things mentioned can affect the price of apartment units. The price of apartment units for both sale and rent can be influenced by a number of basic factors such as the material used, the quality of the material, and the size of the unit. In apartments with a modular approach, variations and repetitions of modules, speed of construction, and materials used can affect the high or low price of apartment units. The less variety, the more repetitions, and the faster the construction, the price of apartment units can be more affordable. Whereas on the contrary, the more variations, the less repetition, and the slower construction can make apartment unit prices higher than apartment units with conventional construction systems.

4. Conclusion
Applying the right modular architecture to the apartment can cut the budget and the construction costs of the apartment. Making modules that are done offsite can make work done in parallel which will make the construction time can be completed faster. Modular construction also has minimal maintenance costs compared to conventional construction on large-scale projects. With lower costs and faster processing time, the apartment can start operations faster, which then has an impact on the duration of the rental unit in the first year can be longer. From these factors, the use of modular architecture in apartments can make apartment rental prices more affordable.

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