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# Characterizing Low-Cost Housing Units in a Community in Central Philippines

**Vincent Raymund Y. Alovera**
vryalovera@yahoo.com
La Consolacion College Bacolod

## Abstract

The study focused on the application of the characteristics of low-cost housing. Using a self-made questionnaire administered to 37 residents of LCC-Friendsville Housing Project of La Consolacion College, Bacolod City, Philippines, the prevailing conditions of the housing units were assessed in the areas of green materials, water efficiency, energy efficiency and air ventilation, and the method of construction. The frequency and percentage distribution were used in analyzing the research data. All housing units used the corrugated galvanized iron roof, the majority of ceilings, partitions, and doors were made of plywood while concrete was used on the exterior walls and floors. Majority of the households used water from the local water utility company for their household needs except for drinking which was procured from the water refilling stations. Most of the households preferred rainwater in flushing the toilet, watering the plants and cleaning the house. Moreover, the number of electric fans, incandescent bulbs and fluorescent lights used had contributed to the energy consumption in the households surveyed. Recommendations were advanced for renovation, repairs, and maintenance to shift design to green architecture gradually.

**Keywords:** *green architecture, low-cost housing, descriptive research, Philippines*

## INTRODUCTION

The Philippines, located near the equator, is susceptible to natural disasters and global climate change which have a growing impact on lives of the Filipinos in a number of ways including costly infrastructure (Bankoff, 2003) such as housing rehabilitation/restoration. The national government, through the Department of Social Welfare and Development funds, shelter units for disaster victims through its shelter assistance which is one of the interventions to the devastating disasters, both human-made and natural, that hit the country and left many families with totally or partially damaged houses (Reliefweb, 2009).

Housing differs in its type, size and design and housing quality can be evaluated in terms of its physical characteristics, facilities (Mohit, Ibrahim, & Rashid, 2010) and climate change resilience (Seelig, 2011). Global climate change is one of the most significant environmental issues in recent years (National Research Council, 1999). Climate scientists inferred that the pace of global warming was most rapid during the last century and had identified the increase of greenhouse gases in the atmosphere as the dominant factor in the observed rise in global temperatures (Hughes, Mann, & Bradley, 1999). The buildings are the leading source of global demand for energy and materials that produce by-product greenhouse gases and are responsible for half of all greenhouse gas emissions worldwide. Thus, the Architecture 2030 challenges the global architecture and building community that new buildings, developments, and major renovations shall be designed to meet the greenhouse gas-emitting, energy consumption performance standard of 70% below the regional (or country) average/median for that building type (Mazria, 2003).

Green architecture is an approach to building that minimizes harmful effects on human health and the environment (Tabb & Deviren, 2013). Green architecture usually symbolizes the sustainability of modern cities (Huseynov, 2011). It attempts to safeguard air, water, and earth by choosing eco-friendly building materials and construction practices (Gospodini, Brebbia, & Tiezzi, 2008). With green architecture as a byword, homebuyers have become concerned about such matters as energy consumption, renewable materials, water usage and indoor air quality(Pratt, 2012).

Planning of sustainable cities serves as a fundamental catalyst for change, improving the quality of the built environments, and upgrading conditions for the development of green architecture (Huseynov, 2011). Various studies suggest physical and mental health problems related to the built environment, including human-modified places such as homes (Srinivasan, O'Fallon, & Dearry, 2003).

In the Philippines and in most cities in Asian countries, residential buildings are characterized with high-rise and high density, thus, achieving comfortable and healthy indoor environment with minimized energy consumption becomes a very challenging engineering and societal issue (Niu, 2004). Climate change and sick building syndrome associated with the common usage of air-conditioning, authorities have recognized the necessity of finding strategies that can offer a more sustainable design in line with satisfactory indoor thermal comfort (Nadarajan & Kirubakaran, 2017). Provision of natural ventilation is a challenge in the design of new buildings since it is difficult to control (Liping & Hien, 2007).

It is on this premise that the characteristics of the built environment, specifically the low-cost housing units, in a community in Central Philippines was examined.

## Framework

The green building design process begins with an intimate understanding of the site in all its beauties and complexities (Ragheb, El-Shimy, & Ragheb, 2016). A design offers sustainable construction if it addresses the five central elements of green building design, namely, sustainable site design, water conservation and quality, energy and environment, indoor environmental quality, and conservation of materials and resources (Walker, 2009; Ragheb, A., El-Shimy, H., and Ragheb, G., 2016).

Green and climate responsive buildings The design and construction of the building should be based on Bioclimatic Design or Climatic Responsiveness, use of local material and technology, and community participation as far as practicable. The main criteria that make architecture green are the use of material and constructional technology that is indigenous (Shrestha, Subedi, Yatabe, & Prakash Bhandary, 2011).

Architects are learning to balance the application of the principles of green architecture in designing buildings and houses with the clients' requirements, needs, and finances. With the majority of the country's population belonging to low and middle-income earners (Ericta, 2013), building construction and future maintenance costs are prime considerations. Hence, low-cost housing projects are widely accepted with a challenge to designers to incorporate green building design.

This study may lead to an efficient energy and water system that may be integrated into households and shall then be a core for low-cost housing developments for the improvement of the living conditions of the low-income earners by providing them green building design using environment-friendly materials.

The renewal of the housing may be based on the sustainable renovation principle for the quality of housing in functional, technological and environmental perspective. The variety of space, typology of individual housing units and the low-energy renovation principle including new technologies, structural elements and materials may be introduced (Sitar & Krajnc, 2008).

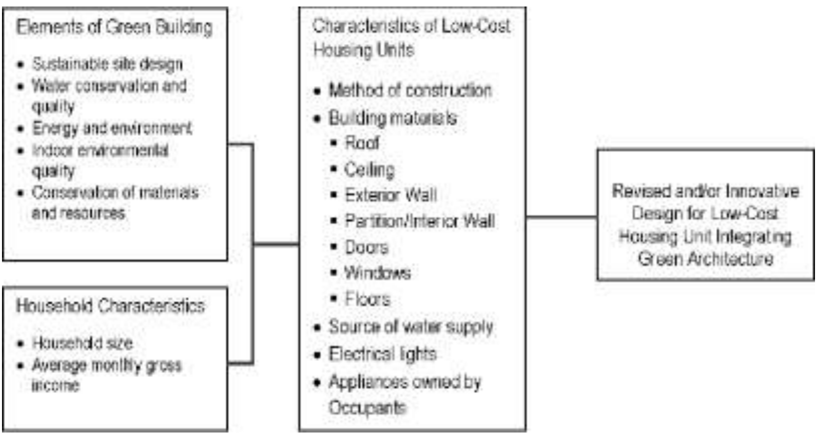


Figure 1. Schematic Diagram of the Framework of the Study

## Objective of the Study

The main purpose of the study was to characterize the low-cost housing units in a community and compare it with those of a green building. Results will be used as a basis for a proposed renovation and repair/maintenance or new design of a low-cost housing unit.

## METHODOLOGY

This study utilized the descriptive research. A researcher-made survey questionnaire was utilized to gather the data among 37 purposively selected heads of the families in a housing project in Negros Island in Central Philippines. The data gathered from the respondents were analyzed using frequency and percentage. A checklist was used to compare the characteristics of the housing units with the principles of green architecture which include the areas of green materials, water efficiency, energy efficiency, and air ventilation were applied in designing a low-cost housing unit.

## RESULTS AND DISCUSSION

Majority of the respondents are married with an average household size of five. The above finding is higher than 4.4 reported 2012 average household size of the city (Philippine Statistics Authority, 2013) and the 2010 average household size of the country which is 4.6 (Ericta, 2012). This result implies that the low-cost housing unit can be occupied by four to five persons. As to average monthly gross income of the family, five or 14% belong to the below average (PhP12,000 and below) group while 32 or 86% belong to the above average group. This report is contrary to the report of the Philippine Statistics Authority that the average monthly gross income of the Filipino family was P19,583.33 (Ericta, 2013). This finding means that the families acquired low-cost housing but other basic needs were sacrificed. Moreover, a study on the performance evaluation of residential buildings in public housing estates in Nigeria revealed contradicting results where a majority (53.75%) were middle-income earners while 22.8% and 23.5% claimed to be low and high-income earners, respectively (Ibem, Opoko, Adeboye, & Amole, 2013). Also, an assessment of facilities and material specification of residential buildings in Nigeria revealed that the majority of the respondents are middle-income earners which implies that the income level of the users of residential buildings could not afford them high-quality buildings (Odediran, Morakinyo, & Adeyinka, 2013).

## Assessment of the Prevailing Condition of the Existing Housing Units

The material used on the roof of the housing units was corrugated galvanized iron (G.I.) sheets which may be influenced by the fact that when the housing project was constructed in 1999, the most common roofing material utilized in low-cost housing projects was corrugated G.I. sheets. Similarly, roofs of cyclone resistant housing in Myanmar are made of corrugated iron (UN-Habitat, 2012). At certain places, galvanized iron proved to be more durable than aluminum (Natesan, Venkatachari, & Palaniswamy, 2006). Also, the galvanized steel was found to be the most suitable for rainwater harvesting applications, with the resulting physical and chemical water quality parameters (Lee, Bak, & Han, 2012; Mendez Klenzendorf, Alfshar, Simmons, Berrett, Kinney, and Kirisits, 2011). However, single story houses covered by metal sheet roofing are significantly affected by heat flow through the roof (Chou, Chen, & Nguyen, 2013). Also, the school buildings in a community in Nepal use corrugated galvanized iron roof which makes the classroom hotter than outside during summer while their traditional dwellings with thick thatched roof often covered with the foliage of creeper plants are many times cooler (Shrestha, Subedi, Yatabe, Prakash-Bhandary, 2011). A new design for metal sheet roofing structure may be considered to improve the total thermal resistance by absorbing the downward heat flow made by incident solar radiation to the room and then releasing it back to the environment by means of the naturally favored external convection especially during the nocturnal cycle (Chou, Chen and Nguyen, 2013).

For the exterior wall, 92% used concrete on the exterior wall, and only one or 3% utilized both concrete and bamboo. With this, the introduction of green cement has gained the attention of cement manufacturers. Thus, the use of locally available minerals, recycled materials and (industry, agriculture and domestic) waste may be suitable for blending with ordinary Portland cement as a substitute, or in some cases, replacement, binders (Imbabi, Carrigan, & McKenna, 2012) are now considered. Moreover, partial replacement of Portland cement by rice husk ash (RHA) to enable the use of green coconut husk fiber as reinforcement for the cementitious matrix (Pereira, Savastano, Paya, Santos, Borrachero, Monzo and Soriano, 2013) may also be an option.

As to the ceiling of the housing units, 23 or 62% used plywood, one or 3% combined plywood with hardiflex and another one or 3% used the native bamboo material with basketry design. For the partitions or interior walls of the housing units, 22 or 58% utilized plywood, one or 3% hardiflex, one combined concrete and plywood, one used amacan (local bamboo weave), and another one does not have interior walls or partitions at all. Bamboo can play a role as a non-supporting or finishing material (van der Lugt, van den Dobbelsteen, & Janssen, 2006). One of the reasons why plywood was used in the partitions is that they were familiar with the construction material; they were hesitant to use other materials like hardiflex for they have not tested it in their previous housing unit (Researcher's conversation with the respondents). For other possible partition wall materials, inserting plywood into the sandwich material could reduce the heat transfer content, especially the sandwich material inserted with Chinese plywood which yielded the most efficient insulation and could save more energy than that with regular walls (Reengwaree, Premanond, & Torsakul, 2013).

Table1. Construction Materials used in the Housing Units

| Housing Unit Component | Construction Materials | f | % |
|---|---|---|---|
| ROOF | Corrugated Galvanized Iron | 37 | 100 |
| CEILING | Plywood | 23 | 62 |
| | Hardiflex | 3 | 8 |
| | Plywood and Hardiflex | 1 | 3 |
| | None | 9 | 24 |
| | Amacan | 1 | 3 |
| | Total | 37 | 100 |
| EXTERIOR WALL | Concrete | 34 | 92 |
| | Concrete & Plywood | 2 | 5 |
| | Concrete & Bamboo | 1 | 3 |
| | Total | 37 | 100 |
| PARTITIONS/ INTERIOR WALLS | Concrete | 11 | 30 |
| | Hardiflex | 1 | 3 |
| | Plywood | 22 | 58 |
| | Concrete and Plywood | 1 | 3 |
| | Amacan | 1 | 3 |
| | None | 1 | 3 |
| | Total | 37 | 100 |
| DOORS | Solidwood/Panel | 7 | 19 |
| | Plywood | 28 | 75 |
| | Solidwood/Panel and Plywood | 1 | 3 |
| | Solidwood/Panel, Glass and Plywood | 1 | 3 |
| | Total | 37 | 100 |
| WINDOWS | Jalousie | 34 | 92 |
| | Steel Casement | 1 | 3 |
| | Sliding &Jalousie | 2 | 5 |
| | Total | 37 | 100 |
| 56FLOOR | Tiles | 14 | 38 |
| | Plain Cement | 21 | 56 |
| | Vinyl | 1 | 3 |
| | Tiles & Plain Cement | 1 | 3 |
| | Total | 37 | 100 |

As to the door of the housing units, 75% used plywood, one or 3% combined the solid wood/panel and plywood, and one combined the solid wood/panel, glass, and plywood. When contemplating the renovation of a house, the owner together with the designer may consider the sustainable renovation principle for the quality of sustainable housing in functional, technological and environmental aspects and fit the new structural elements such as windows, doors, balconies, and windbreaks (Sitar & Krajnc, 2008).

Ninety-two percent (92%) of the respondents used jalousie windows and one used steel casement. This condition may be influenced by the fact that the original window in the housing units was jalousie. Among them, only three or 9% said that they have louvers in their housing units and five or 14% used decorative blocks for additional ventilation. Some respondents installed sliding window when they renovated or extended their housing units. Respondents might not have fully recognized the importance of occupant window-opening behavior on a home's air change rate and the consequent need to incorporate this factor when estimating human exposure to indoor air pollutants (Howard-Reed, Wallace, & Ott, 2002). Optimum window to wall ratio 0.24 can improve indoor thermal comfort for full-day ventilation, and 600mm horizontal shading devices are needed for each orientation to improve thermal comfort (Liping & Hien, 2007).

Fig. 1. Jalousie windows

Fig. 2. Cement Flooring

Fig 3. Cement Exterior Wall and G.I. Sheets Roofing

Furthermore, results revealed that more than half of the respondents did not change or upgrade the floor of their housing units but utilized the original floor which is plain cement, one or 3% used vinyl, and another one or 3% combined tiles and plain cement. Their decisions may have been influenced by the results of a study which revealed that PVC flooring is associated with human uptake of phthalates in infants. Thus, environmental factors such as building materials should be considered when designing indoor environment (Carlstedt, Jönsson, & Bornehag, 2013). Similarly, in Nigeria, residential buildings were constructed with conventional building materials derived mainly from cement, timber, glass, steel and aluminum products (Ibem, Opoko, Adeboye and Amole, 2013).

The majority (75%) of the households get water supply from the local water utility company. This water supply is used for various household activities including but not limited to kitchen activities, toilet, and bathroom activities, cleaning the house, washing the car, watering the plants. On the other hand, six or 16% utilized deep well with an electric motor pump in their household activities while three or 8% of the respondents do not have any other source of water except shallow well or hand pump. Only six or 16% of the respondents utilized rainwater in their household activities. All households get their drinking water from the nearby water refilling stations. The average volume of water consumed per month was 16 cubic meters with an average monthly bill of P 340.00. Majority of the respondents were looking for ways and alternative water sources to reduce their monthly water bill. Two households used concrete for the gutter, four utilized PVC or plastic pipe, and no household used the plain galvanized iron sheet for the gutter. Their decision may be influenced by the fact that galvanized iron sheet is prone to corrosion especially that the housing project is located near the sea. When the downspout of the housing units was examined, four used PVC or plastic pipe while two utilized plain galvanized iron sheets. Looking at the water tank of the housing units, only two utilized rainwater using PVC or plastic water tank. The others do not have a permanent water tank to collect and store the rainwater. Architects and developers may consider water conservation measures and provide facilities for rainwater collection (Edwards & Turrent, 2002).

Most of the respondents (84%) do not utilize rainwater in their daily activities. The housing units do not have a gutter and other appurtenances to collect and convey rainwater. Thus, most of the occupants did not utilize rainwater. Most of the respondents (73%) are in favor of using rainwater in their household activities. Among them, 22 or 81% prefer to use it in flushing the toilet, 19 or 70% in watering the plants, 15 or 56% in cleaning the house and only three or 11% want to use it in taking a bath. The main reason why respondents prefer to utilize rainwater is that they want to reduce the monthly water consumption and monthly water bill. They can use rainwater in flushing the toilet, watering the plants, and cleaning the house. On the other hand, 10 or 27% of the respondents are not in favor of utilizing rainwater for their household activities. Among them, one or 10% prefer deep well with motor pump, two or 20% prefer shallow well, and seven or 70% prefer to use water from the local water utility company instead of rainwater. For those who prefer to use house pump, their water use will consume significant energy (Cheng, 2002). In response to increasing water demand, water conservation incentives for the residential customers may be implemented by the local government (Lee, Tansel, & Balbin, 2011).

Some (35%) have three electric fans, 11 or 30% have two units while three or 8% have only one electric fan which consumes an average of 25.25 Kwh/month with an average monthly electric bill of P227.25. Most (24) have two to three electric fans which consume an average of 30.44 Kwh/month with an average monthly electric bill of

P273.95. Some respondents (27%) have four to seven electric fans which consume an average of 49.10 Kwh/month with an average monthly electric bill of P442.00. This practice implies that respondents with more electric fans have a higher average monthly electric bill for the said appliance. This result may be attributed to some housing units do not have ceiling or homeowners did not plan out the orientation, location, and size of the window when they renovated or extended their house. Air ventilation in their housing unit was insufficient. Thus, they spent a lot for the use of electric fans. When the number of air conditioning (AC) units was examined, it was found out that six or 16% have only one air-conditioning unit and two or 5% have two air-conditioning units. Improving the thermal insulation of the building envelope and introduction of the use of renewable energy sources (RES) leads to energy savings and also increases the indoor comfort (Gagliano, Nocera, Patania, & Capizzi, 2013). An experiment to evaluate the consumers' willingness to pay for energy-saving measures such as air renewal ventilation systems and insulation of windows and facades) was conducted in Switzerland's residential buildings. The results suggest that the benefits (thermal comfort, air quality, and noise protection) of the energy-saving attributes are significantly valued by the consumers (Banfi, Farsi, Filippini, & Jakob, 2008).

Eleven or 30% used both Compact Fluorescent Lamp (CFL) and Fluorescent Lamp (FL) in their housing units, eight or 22% used CFL, Incandescent Bulb (IB) and FL, one or 3% utilized IB, and another one or 3% combined both IB and FL. This practice implies that more than half of the respondents still used both IB and FL in their housing units. When the type of electric lights was examined, it was observed that six or 16% of the respondents who are using compact fluorescent lights consume an average of 5.65 Kwh/month with an average monthly electric bill of P 50.85. On the other hand, one or

3% use the incandescent bulb which consumes an average of 11.25 Kwh/month with an average monthly electric bill of P 101.25. Energy consumption in the residential and tertiary sectors is usually high. Thus, energy conservation measures may be developed for newly constructed buildings and buildings under refurbishment (Chwieduk, 2003). Retrofits of inefficient lighting in the residential sector is a strategy that can save a significant amount of energy and consumers money (Mahlia, Said, Masjuki, & Tamjis, 2005)

## CONCLUSIONS

The condition of the housing units reveals that green architecture was not considered in the design and construction process of the project. It was evident that the housing project thrives in a community that still has a long way to go to attain sustainability as it has not incorporated the innovations and developments of green architecture. There are lots of opportunities for improvement in the housing project. Some steps need to be taken to upgrade the residential buildings to green architecture-compliant status. It is necessary for architects to engage in relevant design practice that encourages the incorporation of alternative sources of energy such as solar panels into the retrofitting of existing residential buildings and in the design and construction of new housing projects.

An eco-friendly community can be attained if the owners and designers can agree. The following can be done to incorporate green architecture in the renovation, repair or maintenance of the housing units: the use of environmentally desirable building materials and specifications including but not limited to green roofs and walls; use of traditional building materials to meet code-required standards for health and safety; and the use of solar power, wind catcher, cross ventilation, shading device, and rainwater catchment.

The present condition also offers opportunities to educate the homeowners on innovations, technologies and building materials that could enhance the sustainable building process with the end in mind of reducing the impact of the housing units on the surrounding environment by using energy and water resources more efficiently. Through this way, the health and well-being of the household members are protected.

## DESIGN CRITERIA FOR A PROPOSED NEW DESIGN

The following design criteria consist of the type of materials and systems that were utilized for each aspect of the study:

Green materials which were renewable, organic, recyclable, non-toxic and reusable were used in the low-cost housing. Formaldehyde-bearing materials, pressure treated wood, and synthetic materials were avoided. Also, various components of the house will be selected based on the guidelines on the energy-conserving design of buildings prepared by the Department of Energy (Department of Energy, 2007).

A low-cost house is considered water efficient if water consumption is reduced and the quality of water is preserved. This design can be done by integrating rainwater harvesting system where rainwater is used for cleaning, car washing and watering the plants to lessen water consumption. In compliance to the National Plumbing Code of the Philippines regarding rainwater systems, downspout or conductor pipes shall be made of iron, copper, PVC or galvanized sheet metal (Republic of the Philippines, 1999).

A low-cost house is considered energy efficient if daylight is maximized and natural air is utilized for ventilation instead of depending on the unnatural or electric lighting. Thus, the type, location, and size of windows in the house are important factors to be considered. Another factor to be considered in the aspect of energy efficiency is the proper selection of electrical fixtures and appliances which consume less energy or electricity.

Air ventilation can be measured by the type, location, and size of window that is used. The design criteria are based from the National Building Code of the Philippines which states that rooms for human habitable use should have a window or windows with a total free area of openings equal to at least 10% of the floor area of the room. Non-habitable rooms such as bathrooms and storage shall be provided with windows with an area not less than 5% of its floor area.

**Design, Plan, Preparation, and Fabrication.** The information regarding the profile of the respondents from a housing project in Central Philippines was used as baseline data in the design of a low-cost housing unit. Likewise, the assessment of the prevailing condition and the method of construction of the said housing project were carefully examined to come up with a design for low-cost housing unit applying the concept of green architecture.

A complete set of architectural plans was prepared to illustrate the entire concept of the low-cost housing unit. The variables mentioned in the objectives of the study such as green materials, water efficiency, energy efficiency and air ventilation were presented in these drawings. The drawings were composed of the floor plan/s, elevations, sections, perspective, plumbing layout plan, electrical layout plan and architectural details. Technical specification was also prepared to explain the type, color, brand names and instructions for mounting of materials and various components in the low-cost housing unit. Moreover, detailed estimate was included to confirm that the cost of the housing unit is within the range of a low-cost house.

A prototype or scale model, based on the architectural plans, was fabricated to show the entirety of the housing unit. It showcased all parts of the house such as roof, ceiling, walls, doors, windows, floor, architectural features, and finishes.

**Evaluation Procedure.** The design of the low-cost housing unit applying the concept of green architecture was evaluated based on the design criteria set by the government authorities who were responsible for the design of residentail buildings. The design criteria for green materials and air ventilation were taken from the Guidelines on Energy Conserving Design of Buildings prepared by the Department of Energy and National Building Code of the Philippines, respectively. On the other hand, the design criteria for water efficiency was based on the National Plumbing Code while for energy efficiency, the criteria were taken from the Philippine Electrical Code.

**Parameters for Analysis.** The study comprised green architecture and the four areas such as green materials, water efficiency, energy efficiency, and air ventilation. In the aspect of green materials; organic, non-synthetic, recyclable, non-toxic, reusable, and construction materials that were available in the market and with high resistance to heat were adequately selected. For water efficiency, the constraint was on the utilization of rainwater and selection of the plumbing fixtures. On the other hand, energy efficiency focused on the use of both natural air and daylight. It also involved the type, and size of windows including the proper selection of electrical lights which consume less energy. In the aspect of air ventilation, the focus was on the utilization of natural air including the type, location, and size of windows including the use of architectural features which provides additional ventilation in the house.

**Cost Analysis.** The design of the prototype low-cost housing unit was based on the Revised Minimum Design Standards of Batas Pambansa 220 (BP 220) for economic housing. Cost of economic housing units under this category ranges from P 400,000.00 to P 1,250,000.00. By this, the estimated cost of the prototype housing unit ranges from P 607,500.00 to P 675,000.00. It includes all material and labor costs for the fabrication, construction and installation of roof, exterior walls, partitions, ceiling, doors, windows, stair and other parts of the house for the completion of the project. Quantity take-off method and square meter method were used in estimating the cost of the housing unit. Total estimated cost of the project was computed based on the current material and labor market costs.

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