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# Development of Affordable and Disaster-Resistant Housing Initiative

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**Abstract***: This research document introduces a blueprint for a housing project in Sison, Surigao del Norte, aiming to achieve both cost-effectiveness and resilience against hazards. The financial burden of rebuilding homes post natural disasters has long weighed heavily on low-income households, often leading to the compromise of crucial disaster-resistant construction practices. The subsequent project design incorporates a range of methods and factors, encompassing environmental assessments, housing adaptability, interior arrangements, structural considerations, and cluster units that offer a convenient approach to reconfiguring existing housing layouts and types. The obtained results affirm the project's robustness against natural perils like earthquakes and storms. Additionally, the designed project aligns with the stipulated requirements of the Housing and Land Use Regulatory Board (HLURB). It's noteworthy that the designs were not only economically viable but also resilient to hazards, making the project financially feasible.*

**Keywords:** affordable, disaster resistant, housing, resiliience

## I. INTRODUCTION

Ranked among the world's most susceptible nations to natural disasters like floods, earthquakes, and typhoons, the Philippines stands as a forefront runner in the pursuit of disaster resilience. With a considerable segment of its populace dwelling in makeshift dwellings within slum regions, the demand for homes capable of withstanding calamities is of utmost urgency. The provision of homes fortified against disasters and the establishment of sustainable novel communities for families affected by Typhoon Yolanda (internationally known as Haiyan) remains a paramount objective for the government, aligning with the "build back better" principle.SinforosoPagunsan, the General Manager of the National Housing Authority (NHA), conveyed that the NHA is executing numerous strategies to guarantee that permanent resettlement sites possess the ability to endure calamities as potent as Yolanda, a storm that etched its name as the most formidable in documented history to make landfall [1, 2, 3].

Low-cost and hazard-resilient housing refers to the capacity of communities to recover, adapt constructively to, or flourish in the face of evolving circumstances or adversities, encompassing both disasters and climate fluctuations. This approach ensures the preservation of the inhabitants' quality of life, promotes sustainable development, robust systems, and the prudent management of resources for the well-being of present and future generations. The attributes of this constructed environment, as gauged by its strength, safety, and utility, significantly influence the overall quality of life and economic progress of a society, as well as the competitiveness of its industrial and service sector [4, 5, 6].

Residential structures constitute a substantial 70 percent of land usage within most urban areas and play a pivotal role in shaping the urban landscape. The Philippine Working Group on Disaster Risk Resilience maintains its dedicated efforts in addressing the critical matters surrounding secure housing and settlements. Presently, the vulnerability of a typical household to even moderate storms remains apparent. However, implementing straightforward techniques can offer a remedy. Elevating foundations, a feature lacking in many homes, through the utilization of compressed soil, stone, and cement, serves to mitigate flood risks. Moreover, it's widely recognized that those who can least afford necessary improvements often experience the most severe impacts from natural disasters and other disruptions. The challenge lies in retrofitting existing structures to be energy-efficient or resilient, a task more intricate than achieving these objectives with new constructions [7, 8, 9].

A hazard serves as the catalyst for potential harm or a circumstance that amplifies the likelihood of detriment in an insured risk scenario, affecting individuals, assets, and even the surrounding environment. On the 13th of February, 2018, Tropical Storm Basyang (Sanba) touched down in Cortes, Surigao del Sur, precisely at 9:15 am on a Tuesday. In this context, the town of Sison confronted predominant risks during the storm's landfall, predominantly centered around the repercussions of flooding. This led to substantial damage to homes and the livelihoods of local farmers [10, 11, 12]. This study specifically focuses on enhancing the adaptive capacity of residences in the event of natural calamities. The significance of resilient housing becomes especially pronounced when contemplating post-disaster responses and relocation efforts. Shelter is an elemental necessity for humanity, and the majority of dwellings in Sison, Surigao del Norte, Philippines consistently experience damage from various disasters. Improving the construction standards represents a viable remedy. It's worth noting that often, it's not earthquakes themselves that claim lives, but rather the collapse of inadequately constructed houses. If we prioritize constructing residences that account for potential hazards, we can significantly enhance the survivability and well-being of communities in high-risk areas [13, 14, 15].

## II. METHODS

The visualization of the project's concept is presented in Figure 1 below, which offers a flowchart depicting the study's progression. The initial box encompasses the study's input phase, encompassing data collection and information compilation. It was observed by the researchers that individuals affected by flooding tend to construct their homes in a manner similar to those that lack safety measures. Furthermore, the research team carried out on-site inspections to incorporate crucial factors for the study, with evaluations performed by municipal Engineering personnel.During the subsequent processing phase, once all data has been gathered, the researchers proceed to formulate plans and perspectives using drawing software, perform structural analyses utilizing dedicated software, and estimate associated costs. Following these sequential stages, the culmination is the output—a reflection of decisions made during the course of the process.

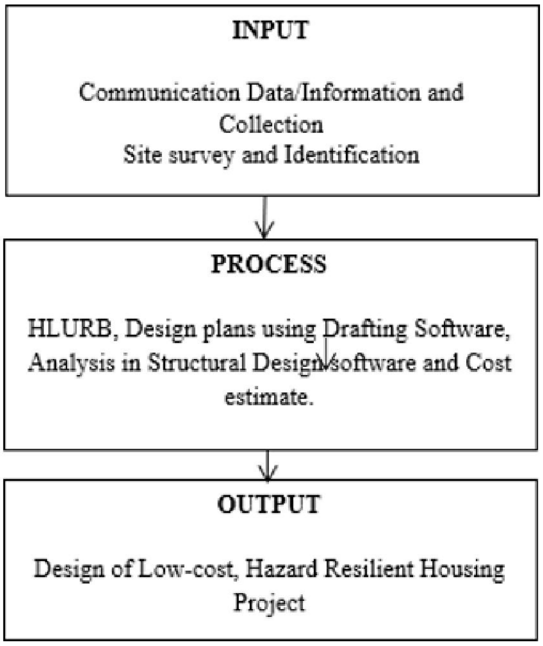


**Figure 1.**Flowchart of the Study

The diagram in Figure 2, illustrates the various factors that play a role in the formulation of a housing project's design. Within housing projects, the chosen housing type is a cluster unit. This configuration offers a pragmatic approach to reconfiguring existing spaces, consolidating the area that would have been interspersed between individual houses into a more expansive, efficiently utilized lot. The utilization of shared walls within cluster units contributes to decreased material usage, thereby leading to cost savings. As new housing plans are developed, it's imperative to anticipate future growth and remain attentive to the evolving needs of the community. A well-crafted housing plan should not only

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provide adequate living space for current residents but also allow room for expansion. Simultaneously, this growth should not encroach upon roads, open areas, and communal spaces. Maximizing the environment's potential involves careful considerations of building design, shape, and orientation.

The incorporation of adaptability within building design tends to optimize space and resources utilization over the entire lifespan of a structure. Sustainability often hinges on enhancing the flexibility and adaptability of systems. When it comes to interior layouts, the allocation of rooms within the housing plan can vary. These layouts should offer concise, essential information about the rooms and their dimensions. During the plot assessment phase, factors like the connection to fundamental services such as drainage, electricity, and water should be evaluated.Turning to structural design, stability assessments are crucial to prevent overturning, sliding, or buckling of the structure or its components under various loads. Ensuring structural strength to safely withstand load-induced stresses is vital. Serviceability considerations come into play to ensure satisfactory performance under typical load conditions, encompassing the provision of adequate stiffness and reinforcements to manage deflection, crack widths, and vibrations within acceptable thresholds. Lastly, impermeability and durability are integral components to guarantee the structure's longevity and functionality.

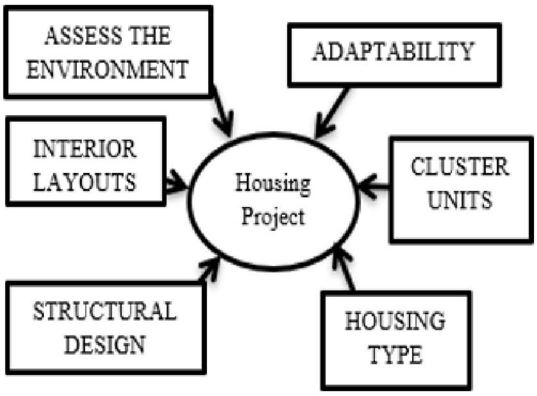


**Figure 2.**Factors considered in Housing Project

**2.1 Project Setting**

The project site is at Poblacion, Sison, Surigao del Norte, Philippines. The lot area of the housing is approximately three (3) hectares as shown in the Figure 3 below.


**Figure 3.** Location of the Project

**2.2 Instruments**

This study employs a selection of computer software applications as tools for conducting the research.

- *Drafting Software* is a computer-aided program used for creating blueprints encompassing various domains such as architecture, bridges, and computer chips, among others.
- *Graphic Software*, provided by Google, facilitates both 3D and 2D modeling with a reputation for user-friendly functionality. This software finds utility in architectural, film, and game design, transitioning designs from two dimensions to three through a patented method of pushing and pulling.

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- *Structural Design Software* stands as one of the globally prevalent structural analysis and design software solutions. It offers a spectrum of analysis methods ranging from traditional static analysis to contemporary techniques such as p-delta analysis, geometric non-linear analysis, Pushover analysis (Static-Non Linear Analysis), and buckling analysis. Additionally, it encompasses diverse dynamic analysis approaches spanning time history analysis to response spectrum analysis.
- *Microsoft Office*, encompassing Microsoft Excel, Microsoft Word, and Microsoft Project, serves as a pivotal tool in facilitating this research. These applications expedite the generation of reports, construction estimates, PERT-CPM analyses, and related tasks, resulting in efficient documentation and data input. Particularly noteworthy, Microsoft Project aids researchers in estimating costs and establishing a comprehensive work breakdown structure. It additionally offers scheduling capabilities, serving as a foundation for tracking construction progress in terms of adherence to schedule timelines.

## III. RESULTS AND DISCUSSION

Sison emerges as a progressive municipality within Surigao City, Philippines aspiring to achieve greater strides in terms of both livelihood and tourism. Among the forthcoming initiatives is a housing project tailored for the municipality's workforce, a pivotal endeavor poised to reverberate as a cornerstone of Sison's development. In collaboration with the Local Government Unit of Sison, the researchers have secured a designated plot measuring 2.6 hectares for the project's implementation. Their task was to devise an economical and resilient housing structure.Sison stands as one of the city's municipalities that remains susceptible to natural hazards such as earthquakes, floods, and landslides. In light of these potential threats, the researchers formulated a housing design that not only prioritizes affordability but also incorporates resilience to these hazards, all while ensuring the safety of prospective residents.Figure 4 visually demonstrates the proximity of the project's location to the nearest active fault line, estimated to be approximately 8 km away, utilizing the Faultfinder application.

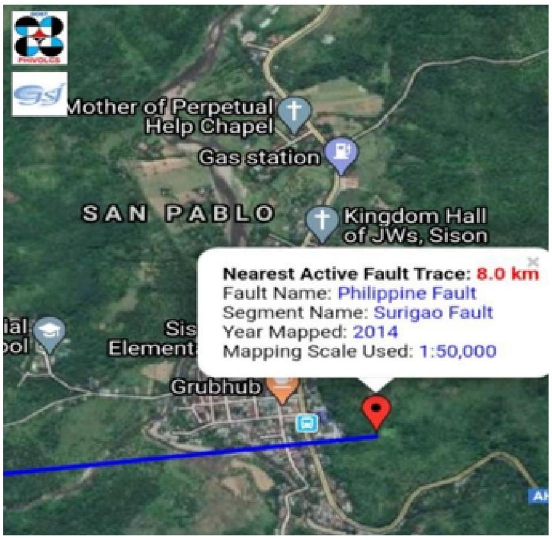


**Figure 4**. Location of Nearest Active Fault

**Figure 5**. Location of Nearest Active Fault

Displayed in Figure 5 is the wind speed map extracted from the 2015 edition of the National Structural Code of the Philippines (NSCP). This map illustrates a fundamental wind speed of 310 km/h in close proximity to the project site.
Displayed in Figure 6 below structural analysis of the disaster-resistant housing project. The design of the structural elements is based on the standard of the National Structural Code of the Philippines and the National Building Code of the Philippines. The structural elements are now analyze based on the results of the structural software used.

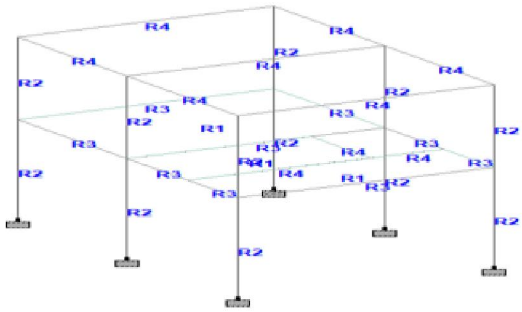

**Figure 6**. Structural Analysis of the Project

### 3.1 Design Criteria

The following are the design criteria that the researchers have considered in designing the structures:

- The code and references where it undertakes the National Building Code of the Philippines-NSCP 2015 and the Building Codes Requirements for Reinforce Concrete-ACI 318.
- The method used in designing the structures is Working Stress Design.
- For the minimum lot area, parks and playgrounds allocation, road right-of-way, width of planting strips and sidewalks, and setbacks, is based in Revised Implementing Rules and Regulations for BP 220 from the Housing and Land Use Regulatory Board (HLURB).

TABLE 1: MINIMUM LOT AREA

| Type of Housing | Economic (sq.m.) | Socialized (sq.m.) |
|---|---|---|
| a. Single detached | 72 | 64 |
| b. Duplex/single attached | 54 | 48 |
| c. Row houses | 36 | 28 |

TABLE 2: PARKS AND PLAYGROUND ALLOCATION

| ECONOMIC HOUSING | | SOCIALIZED HOUSING | |
|---|---|---|---|
| Density (No. of lots/DU* per hectare) | Allocation (% of gross area for PP**) | Density (No. of lots/DU* per hectare) | Allocation (% of gross area for PP**) |
| 150 and below | 3.5 % | 150 and below | 3.5 % |
| 151 – 160 | 4 % | 151 – 160 | 4 % |
| 161 – 175 | 5 % | 161 – 175 | 5 % |
| 176 – 200 | 6 % | 176 – 200 | 6 % |
| 201 - 225 | 7 % | 201 – 225 | 7 % |
| Above 225 | 9 % | Above 225 | 9 % |

The minimum area requirements, as well as the allocation for parks and playgrounds, are depicted in the preceding Tables 1 and 2. These essential data serve as the foundation for crafting a disaster-resistant housing design that remains both cost-effective and tailored to the needs of residents within disaster-prone regions.
The minimum road right of way requirements, are shown below in tables 3 and 4. To consider the safety of the occupants minimum road right of way requirement should be used in the design of the project.

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TABLE 3: ROAD RIGHT OF WAY

| PROJECT SIZE RANGE (has.) | RIGHT OF WAY (m) | | | | | |
|---|---|---|---|---|---|---|
| | ECONOMIC HOUSING | | | SOCIALIZED HOUSING | | |
| | Major | Collector | Minor | Major | Collector | Minor |
| 2.5 and below | 8 | - | 6.5 | 8 | - | 6.5 |
| Above 2.5 – 5.0 | 10 | - | 6.5 | 10 | - | 6.5 |
| Above 5.0 – 10 | 10 | 8 | 6.5 | 10 | - | 6.5 |
| Above 10 - 15 | 10 | 8 | 6.5 | 10 | 8 | 6.5 |
| Above 15 – 30 | 12 | 8 | 6.5 | 10 | 8 | 6.5 |
| Above 30 | 15 | 10 | 6.5 | 12 | 10 | 6.5 |
| | ROW | Carriageway | | ROW | Carriageway | |
| Motor Court | 6 | 5 | | 6 | 5 | |
| Alley | 2 | - | | - | - | |
| Pathwalk | - | - | | 3 | - | |

| RIGHT-OF-WAY (m) | ECONOMIC HOUSING | | SOCIALIZED HOUSING | |
|---|---|---|---|---|
| | Planting Strip (m) | Sidewalk (m) | Planting Strip (m) | Sidewalk (m) |
| 15 | 1.3 | 1.2 | 1.3 | 1.2 |
| 12 | 0.8 | 1.2 | 0.8 | 1.2 |
| 10 | 0.8 | 1.2 | 0.8 | 1.2 |
| 8 | 0.4 | 0.6 | 0.4 | 0.6 |
| 6.5 | Optional | 0.5 | Optional | 0.5 |

Tables above were all taken from the Revised Implementing Rules and Regulations for BP220from the Housing and Land Use Regulatory Board (2008). The researchers used row houses with minimum lot area of 36 square meters to maximize the number dwelling units.

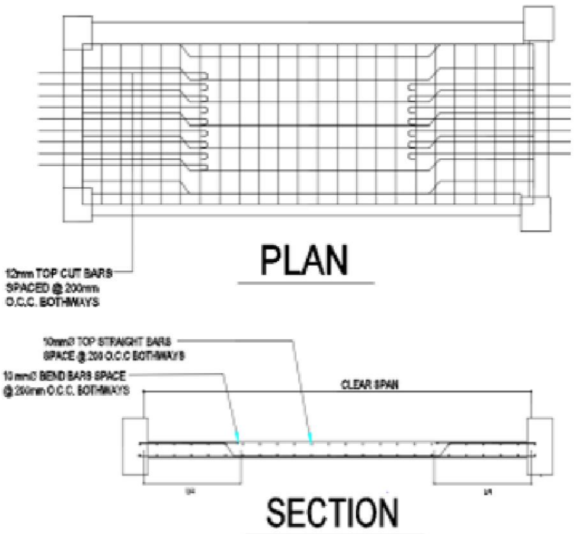


**Figure 7**. Structural Slab Design of the Project

Figure 7 presents the essential design data employed in formulating the slab design. The plans and sections for the slab are visually represented in the Figure above. The slab's thickness measures 200 mm and is reinforced with 10 mm diameter straight bars, alongside bend bars arranged at 200 mm intervals at the center. Notably, both one-way and two-way slabs share identical steel reinforcement bar diameters and spacing. Adhering to the specified steel requirements for the slab in terms of both its longer and shorter spans, the ensuing results were ascertained.

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**Figure 15**. *Section of Beams for One-Storey*

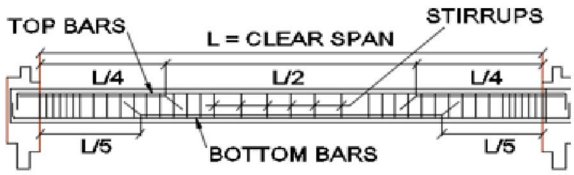


**Figure 8**. Structural Beam Design of the Project

The section details for beams of the structure are depicted in Figure 8. The upper bars symbolize tension bars, while the lower bars represent compression bars. For both the one-storey and two-storey configurations, the beam schedules are outlined. In the design, uniform dimensions are maintained, with a width of 200mm and a depth of 300 mm. Reinforcement involves a 16 mm diameter bar for both the top primary straight bars and bend bars. In the two-storey configuration, distinct dimensions are applied: the girder beam measures 250 mm by 400 mm, the roof beam is sized at 200 mm by 300 mm, and the floor beam maintains dimensions of 200 mm by 300 mm. Similar to the one-storey case, all these beams feature reinforcement with 16 mm diameter bars for both the bend bars and top primary straight bars.

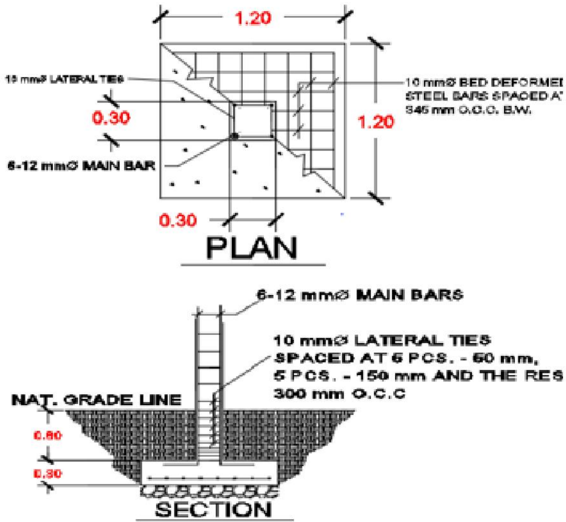


**Figure 9.** Columns and Footings Design of the Project

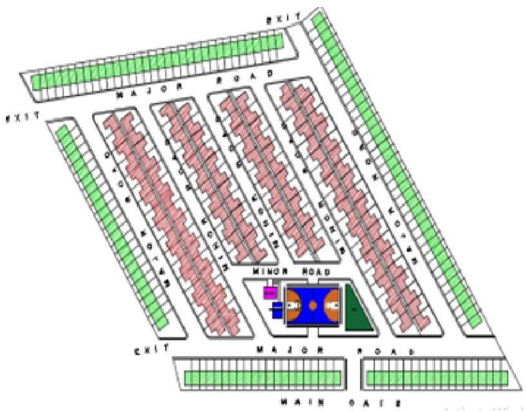


**Figure 9.** Lot Development Plan of the Project

The structural arrangement for the columns and footings of the disaster-resistant, cost-effective housing units is illustrated in Figure 9 above. These designs have been meticulously engineered to ensure safety and resilience against adverse conditions like typhoons and other calamities.

**Figure 10.** Perspective Design of Single Storey Project

**Figure 11.** Perspective Design of Two Storey Project

Figure 9 portrays the site development plan, encompassing a land area of 2.6 hectares. The allocation for parks amounts to 9%, a decision influenced by the presence of more than 225 dwelling units. Additionally, the major road width measures 8 meters, while the minor road width stands at 6 meters. The depicted one-storey row houses in Figure 10 feature unit dimensions of 6.4 meters by 6.7 meters each. On the other hand, the two-storey row houses showcased in Figure 11 have dimensions of 5.7 meters by 3.85 meters.

## IV. CONCLUSIONS AND RECOMMENDATIONS

### 4.1 Conclusions

The residents of Sison confront natural perils such as earthquakes, floods, and landslides.

- The project's design aligns with HLURB's stipulated requisites encompassing park and playground allotment, road right-of-way, and the width of planting strips and sidewalks.
- Design standards outlined by the National Building Code of the Philippines, National Structural Code of the Philippines, and the Housing and Land Use Regulatory Board have been satisfied to guarantee the caliber of the housing initiative.
- Financial viability characterizes the housing project, as the individual house prices remain within the scope of economic housing affordability.

### 4.2 Recommendations

- Explore cost-effective yet durable building materials accessible in Sison to reduce housing expenses.
- Given the site's topography, thorough site inspections were essential.
- Incorporate innovative construction techniques, such as precast, to enhance project construction efficiency.

## V. ACKNOWLEDGMENT

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