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EVALUATION OF ENVIRONMENTAL ENGINEERING AND HYDROLOGY ARCHITECTURE OF EMPLOYEE'S FLOOD RESISTANCE AT PT XYZ, IN A PEATLAND AREA

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Abstract: *Occupancy comfort is an essential factor for the owner. A critical aspect of occupancy is good housing resilience from various elements, from risk management in dealing with natural disasters and maintenance functions, such as the potential for flooding in areas prone to overflow. PT XYZ is a palm oil industry in western Indonesia with employee housing with a high potential for flooding because it is close to a waste treatment site and a river flow. Therefore, the owner of the company has plans to rebuild new housing. The process of building flood-resistant houses must be carried out so as not to cause more significant losses. This paper aims to provide an evaluation to the community, especially company stakeholders, to prioritize the analysis of potential flood risks before building multi-story residential structures in new housing. Observations using the hand drill approach showed that the soil element of 3.63 g/cm*^{3} *peat experienced an increase in water content from 120% (1991) to 230% (2023). Stabilizing the red bricks that had been smoothed at the start of the construction were declared lost, making it prone to flooding and difficult to construct new residential buildings. The hydrological technique with eight experiments shows that the higher the number of gaps that occur, the higher the inundation around settlements, with a function of* $y = 0.2x - 0.01$ *and* $R^2 = 0.9767$*.*

Keywords: Construction; flood; hydrology; peat soil; residential.

Abstrak: Kenyamanan hunian merupakan faktor yang sangat penting bagi pemiliknya. Salah satu aspek yang perlu ada adalah memiliki ketahanan yang baik dari berbagai sisi, baik dari aspek manajemen risiko dalam menghadapi bencana alam maupun fungsi pemeliharaan, seperti potensi banjir di suatu kawasan rawan luapan. PT XYZ merupakan industri kelapa sawit di wilayah Indonesia bagian barat memiliki perumahan karyawan yang memiliki potensi banjir yang tinggi, karena letaknya yang dekat dengan tempat pengolahan limbah, dan aliran sungai. Oleh karena itu, pemilik perusahaan memiliki rencana untuk membangun kembali perumahan baru. Proses pembangunan perumahan yang tahan banjir harus dilakukan agar tidak menimbulkan kerugian yang lebih besar. Tujuan dari penulisan ini adalah untuk memberikan evaluasi kepada masyarakat khususnya stakeholder perusahaan agar mengutamakan analisis potensi resiko banjir sebelum membangun struktur hunian bertingkat di perumahan yang baru. Hasil pengamatan dengan pendekatan bor tangan menunjukkan bahwa unsur tanah gambut sebesar 3,63 gr/cm^3 mengalami peningkatan kadar air dari 120% (1991) menjadi 230% (2023). Stabilisasi batu bata merah yang dihaluskan pada awal konstruksi dinyatakan hilang, sehingga rentan terhadap banjir dan sulit untuk membangun konstruksi tempat tinggal baru. Teknik hidrologi dengan 8 kali percobaan, menunjukkan bahwa semakin tinggi jumlah celah yang terjadi maka semakin tinggi genangan di sekitar hunian, dengan fungsi $y = 0{,}2x - 0.01$ dan $R^2 = 0{,}9767$.

Kata Kunci: Konstruksi; banjir; hidrologi; tanah gambut; perumahan.

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Introduction

The concept of housing in buildings worldwide tends to prioritize comfort and safety. This condition is closely related to long-term factors such as unexpected maintenance and handling costs. The factors in question are disasters and events that threaten and disrupt social activities and can cause loss of life, environmental damage, loss of property, and psychological impact on disaster victims [1]. The development of disaster evaluation, which continues to be carried out by world researchers, also emphasizes that the materials and design systems must be environmentally friendly to balance the harmony of climate and nature. Climatic constraints and building materials define the context where the building exists. Art and architecture settings are always influenced by weather, and the need for energy and resources, even in extreme climatic conditions [2].

One of the disasters that is very detrimental in terms of residential repairs is the incident of flooding. Floods can be caused by increased individual needs to meet the necessities of life, which results in height risk changes in land use or agricultural management status from watershed exploitation. One of the consequences that can arise from a flood disaster is a reduction in the water catchment area (infiltration) in the upstream area and an increase in the value of the coefficient of rainwater runoff [3]. The incident is known to have occurred at the residence of PT XYZ employees, a palm oil industry in the western region of Indonesia.

Residential facilities that were previously declared flood-resistant have yet to function correctly since 2012, which caused the conditions around the housing to become waterlogged during the rainy season. Provision of requests for flood-resistant aspects, motivated by the housing conditions of company employees, which have a high flood potential due to the layout close to the waste treatment process and the overflow of rivers that flow around the residential area. This problem requires the company to build employee housing back around the old residence to maintain the comfort aspect of its workers.

Based on the problems, an evaluation was carried out by reviewing the environmental engineering and hydrology of the flood-resistant employee residential architecture at PT XYZ. Environmental engineering evaluation is a preventive and curative action to address and save all natural processes, such as water, soil, and air. Meanwhile, hydrological analysis is part of civil engineering science in the design of hydraulic buildings. Hydrological data is collected from the rain station post, so it is hoped that the rainfall data obtained will have sufficient accuracy [4].

The detailed process of observing the evaluation aims to provide an evaluation to the community, especially company stakeholders, if they want to build a multi-story residential house structure again in the same area by prioritizing a risk analysis of the strength of the building. Because a house is always related to human activities in supporting the formation of behavior-organizing lifestyles, it can inspire imagination and make a real contribution to the peace, joy, and growth of the people who live in it [5]. This community service activity is also expected to create value for the productivity of the peatlands around the company, both in terms of quality, chemical, physical and biological elements [6]. This observation is also an evaluation for the company to determine activities on peatlands around company-owned areas that have already been used [7].

Method

The method used by researchers in conducting building analysis is a qualitative approach by collecting primary and secondary data. Data collection was carried out by searching for documents or observations, references to journals based on the selection of topic suitability to obtain relevant data. Data analysis formulates and explains problems from the design results, before going into the field, and continues until the research results. The qualitative approach also emphasizes case studies as a form of simulation if a flood disaster actually occurs, because this research was not carried out at the same time, but based on comparisons at different times (Figure 1).

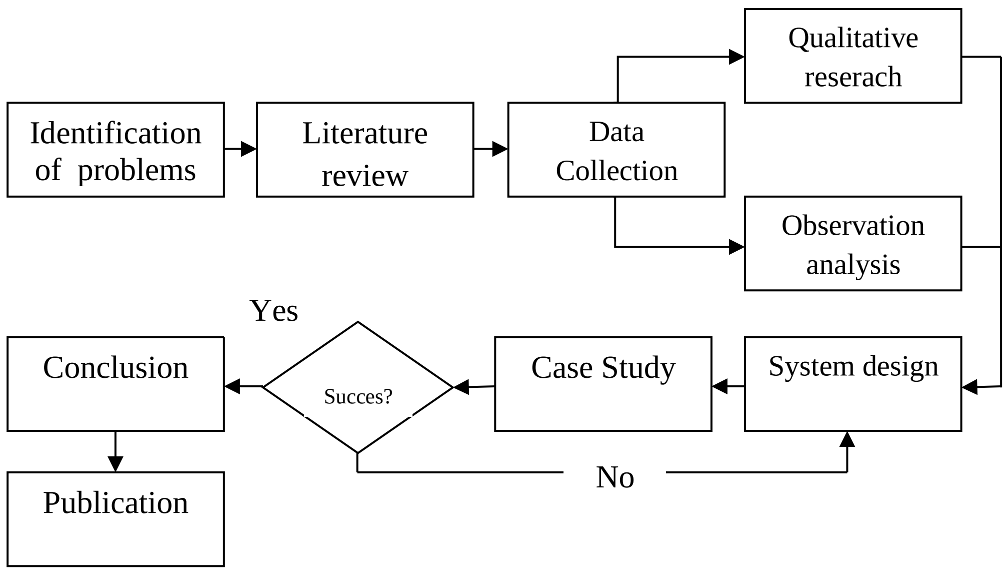

Figure 1. Research method.

The stages of the research carried out are:

1. Identification of problems
   This stage contains a problem identification system by prioritizing and answering the problem formulation, namely how the architectural system of residential buildings can overcome flood disasters.
2. Literature review

This stage contains a selection of reliable literature in discussing the process of soil abrasion, with the construction strength of the basic building materials used by dwellings in general. The collection of articles is sourced from trusted journals, such as indexed Sinta and Scopus, in order to create an element of science and accuracy of activities. The disbursement process by exploring the search for 'hydrology' and 'residential construction' in order to collect relevant literature quickly and accurately.

3. Data collection
   The data collection process was carried out using two sub-stages, namely on-site observation analysis, and qualitatively sourced from the nearest rain station post in collecting data on the level of flood risk at a certain vulnerability. The data collection process also emphasizes the collection of housing development and maintenance documents.
4. System design
   The creation of a design system begins with the image of a dwelling with the aspects underlying its construction. Base is a priority in this observation activity, because the base of a dwelling is a strong key to whether or not a dwelling is at risk of flooding.
5. Case study
   The case study also includes the influence of chemical waste flow, whether it affects the construction of residential buildings, and analyzes cases of large river flows during the rainy season requiring bolts on the base of the dwelling.
6. Conclusion
   The results of the case studies based on data collection are then used as a reference for drawing conclusions, and as an evaluation system for PT XYZ.
7. Writing report and publication
   The publication stage includes the process of displaying the results of observations in the field.

Results and Discussion

Environmental Engineering Review

Analysis using an environmental engineering science approach shows that the soil elements in the lower layer of the dwelling have peat soil properties. The observation process shows that the peat soil around PT XYZ employees' residential buildings is unsuitable for the development process construction. This statement aligns with previous studies that peat soils with high water content are unsuitable for development construction [8]. These findings were obtained using a soil testing tool, namely the Hand Drill, and can be seen in Table 1:

Table 1. Findings of peat soil.

No	Test indicator	Test result
1	Volume weight	3,63 gr/cm^3
2	Water rate	230 %
3	Type weight	2.2 gr/cm^3
4	Boundary – Atterbarg boundary	
5	a. Liquid limit	126.31 %
	b. Plastic limit	38.2 %
6	c. Plasticity index	88.65 %

Another finding is the water content, based on the archives of previous housing developments, which showed that the water content was still at 120% in 1991. The construction process in 1991 was found to use the architectural principle of stabilizing crushed red bricks on the peat layer so that construction could be carried out construction building. Changes in water levels from 1991 - 2023 are suspected to be caused by river overflow and downstream absorption of waste structures.

The analysis of the conditions shows that there has been a significant change in the increase in water content, and it can be said to be very dangerous for implementing new buildings. However, the nature of peatlands for the old residences of PT XYZ employees tends to be used as a flood control medium because it has hygroscopic properties, namely binding and releasing water. Visualization of peat soil layers can be seen in Figure 2:

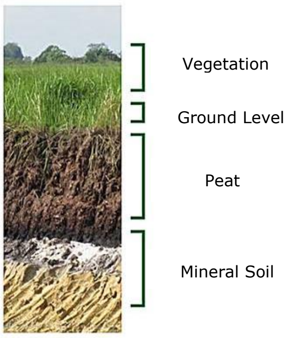

Figure 2. Peat soil layer.
Source : Department of Environment (WWF Malaysia).

Hydrological Survey

Hydrological analysis was carried out by observing when the river around the residence of PT XYZ employees experienced overflow and identifying PT XYZ's downstream waste. The process of water flowing underground will then collect in one position. This concept is intended so that all components in the house are not flooded, or it means that the high position of the house will keep it away from the surface of the flood.

Survey hydrology with a case study adopting the Archimedes Style was chosen because the residence of PT XYZ is located on the map location of Licensed Cultivation, by prioritizing the Green PROPER aspect (Figure 3). The observation aspect in the field uses fluid dynamics correlation that the upward lift causes the weight of the object (house) in the fluid to decrease. However, the fluid that occurs in a flood state is categorized as dynamic because the flood flow will continue to move. When the flood situation has receded, the upward lift on objects (houses) will disappear. Fluid flows such as floods can be modeled using the particle method.

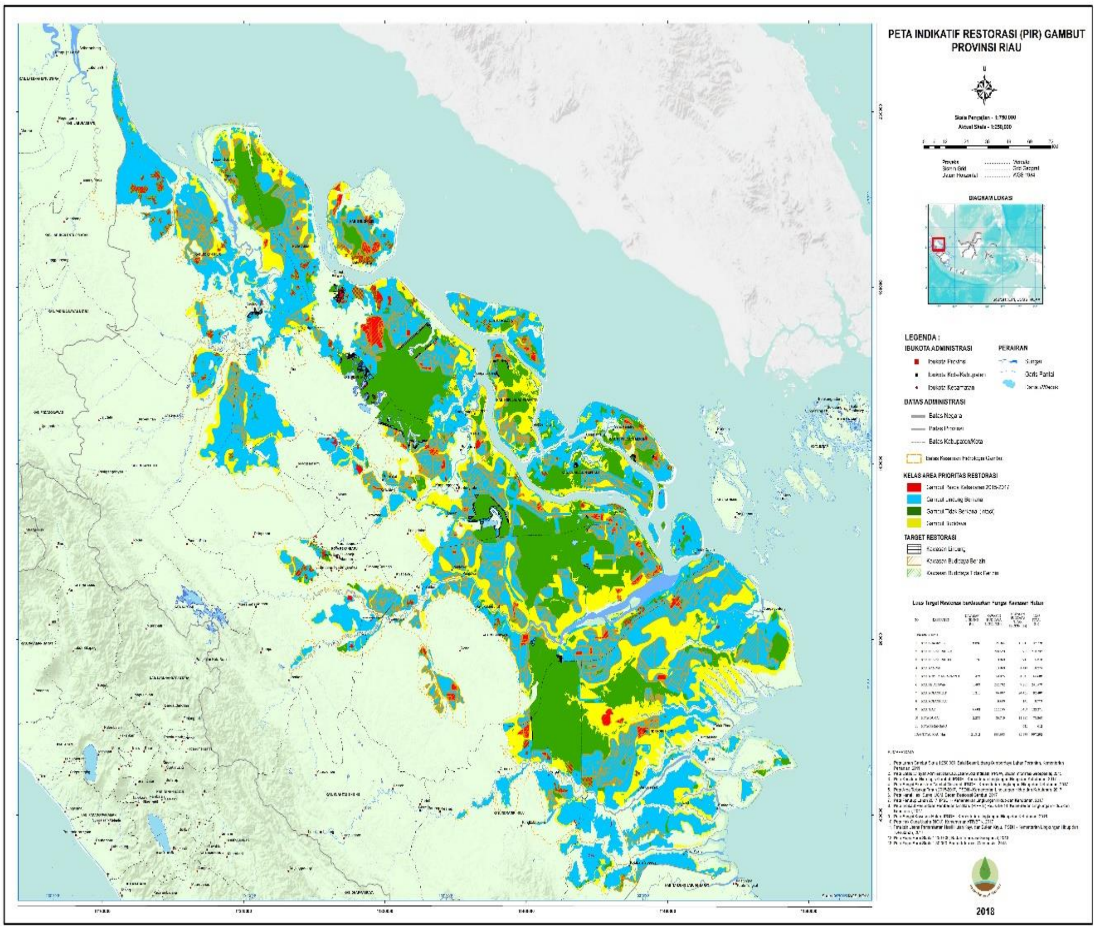

Figure 3. Peat restoration indicative map.
Source: Peat Restoration Agency (2018).

The particle method is widely used in the field of fluid dynamics Smoothed Particle Hydrodynamics (SPH) [9] (Figure 4). The author evaluates the design of the house using a reference number of gaps, with the same gap width. The number of scenarios is carried out up to 8 times to determine the flood height, which can be seen in Table 2. The results of the flood test with a total of eight trials, show the results that can be seen in Table 3.

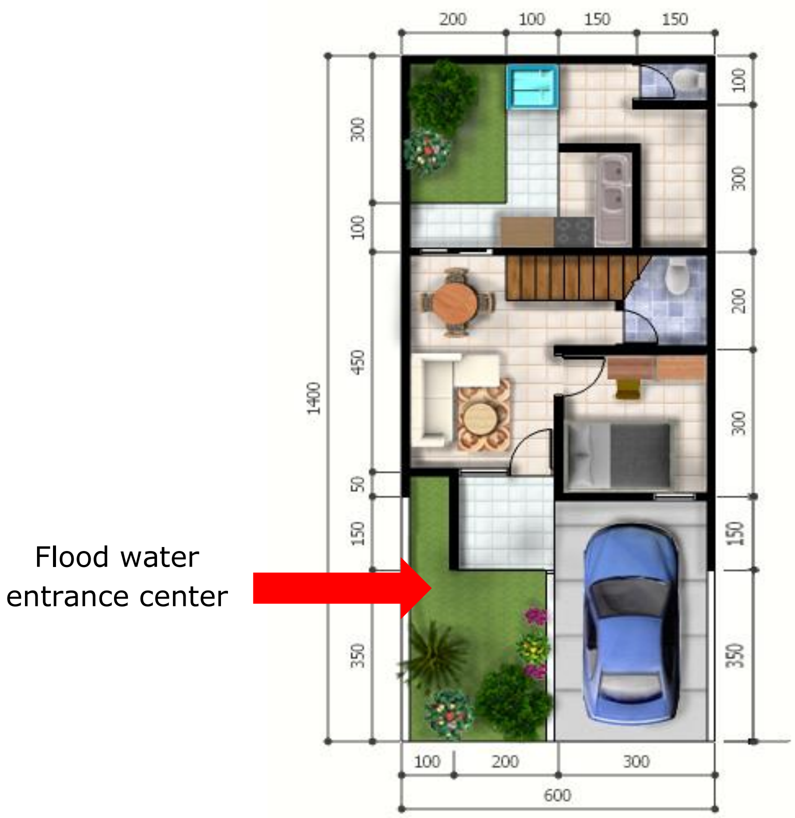

Figure 4. Visualization of PT XYZ employee residential plans.
Source: NCEP (2023).

Table 2. Simulation scenario comparison.

Scenario	Number of gaps	Gap width (m)
1	10	0.023
2	11	0.023
3	12	0.023
4	13	0.023
5	14	0.023
6	15	0.023
7	16	0.023
8	17	0.023

Table 3. Simulation results.

Scenario	Number of gaps	Height (m)
1	10	0.19
2	11	0.2
3	12	0.23
4	13	0,26
5	14	0,27
6	15	0,3
7	16	0,31
8	17	0,32

Based on observations regarding the number of gaps and the height of internal flooding with a fluid dynamic replacement system, the higher the number of gaps that occur, the higher the flooding around the dwelling. The house is getting taller. The concept is then visualized in a scatter diagram, with the number of gaps as the X variable, the flood height as Y, and the function y = 0.2x – 0.01 and $R^2 = 0.9767$ (Figure 5).

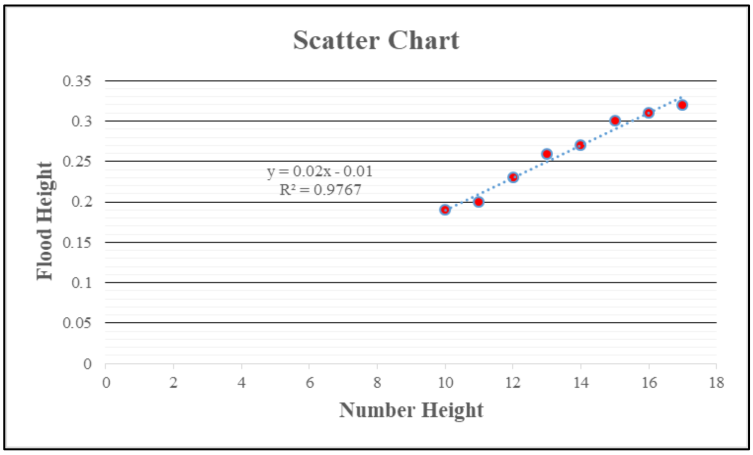

Figure 5. Causality.

The results of the calculation of the Y function state that the condition of the number of gaps in the base of the dwelling is directly proportional to the height of the flood. Calculation of this data is also expected as a form of evaluation of non-physical aspects and physical aspects. The non-physical aspects, namely environmental comfort, consist of environmental tranquility, social relations, health, and environmental mitigation. At the same time, the physical aspect consists of facilities, infrastructure, location, and accessibility, as well as design [10].

Conclusion

Observation results using the environmental engineering hand drill approach show that the peat soil element of 3.63 gr/cm^3 has increased water content from 120% in the initial year of development to 230% in 2023. Mashed red brick stabilization at the start of construction was also declared lost, making it vulnerable to flooding and difficult to build new residences. These conditions were suspected to be caused by the river overflow and downstream sewage, which was not entirely anticipated by the gaps at the bottom of the house. Evaluation of the house design regarding the number of gaps and the width of the gaps equal to eight experiments using hydrological techniques with a particle method approach, namely Smoothed Particle Hydrodynamics (SPH).

Processing and calculating this data can be a reference for the housing community and PT XYZ stakeholders if they want to build new housing. However, stabilization must occur if a new residential development is carried out. Smoothed red bricks can be strengthened, and their capacity increased, given that the peatlands around the area have relatively high water content. If the company does not want redevelopment, it is necessary to strengthen the level of the gap under the dwelling to prevent overflow from flooding and infiltration of company waste.

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