The analysis of physics concepts application on the foundation structure of the Jambi’s traditional house to build character education

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Abstract. The concept of physics can be applied to aspects of customs and culture in order to preserve local wisdom. One way to introduce the customs and culture of the local area can be done by studying traditional houses. The foundation structure of the Jambi’s traditional house uses wooden poles arranged to support the weight above where. Mass of each pole has a correlation with the amount of load that has been distributed evenly. The purpose of this study is to analyse and explain the application of physics concepts in the foundation structure of traditional Jambi houses and to build character education to new generation. The process of collecting data is done by interview, observation, and documentation. The results of interview section are about the advantage of using wood, philosophy and meaning of foundation structure. Based on the data analysis of observation, it is shown that the mass of each pole is strong enough to support the live and dead load that has been analysed. Because it has a pole mass greater than the distributed load. So this can educate the new generation to know the process of making foundation structures with certain calculations that can be analysed through physics concept.

1. Introduction

Local wisdom can interpret as a relation between human, nature, and the environment. There are two main elements from the local wisdom, which is the human mindset and the climate that affects the nature. Local wisdom also affected by the customs and culture that exist in the certain district, with that the development of the local wisdom are built naturally according to the elements that have been stated before that produce a local or regional culture that has its own characteristics. One of the forms of local wisdom are the house or building in each district that still retaining the building elements or the characteristics of the house or building architecture [1]. Building or house architecture as local wisdom usually know as a traditional house.

Local wisdom means an idea about a local community that contain the value of wisdom that are passed down from a generation to another generation. People adapt with their environment to develop knowledge and tools that have wisdom and been regulated by traditional norms. Local wisdom is not as
symbol or characteristic only, but also usefulness for locals [2]. Because of that, it is really important for us to continue the local wisdom to the next generation.

Indonesia has a lot of variety of traditional houses, those are spread across region. Jambinese traditional house is one of the traditional architectures in Jambinese local wisdom. The Traditional houses have known to its durability as a system structure which is the most important part of the house. There are two system structures known to the traditional house, primary structure and secondary structure. Primary structure consists of upper/top structure and lower/bottom structure that formed by beam and column. While the secondary structure is the structure connected to the primer which can be remove abled [3].

Footing structure is a primary structure to traditional houses or buildings. The foundation as a supporting base that support the whole part of building including the building above the upper structure [4]. The importance of a foundation in a structure is a major consideration in the construction of any building, whether it is intended for residential, commercial and industrial purposes. The load of the structure is the primary consideration in the design.

Footing structure of Jambinese traditional house with the shape of house on stilts use good wood type as a material. The type of the wood that used is the bulian wood or also called meranti wood. The wooden post arranged as the footings are mounted to the ground. The Jambinese traditional house include as a durable house type and still show its existence after hundreds of years. The footing structure used has its own attractiveness to be analysed. The range, length of the post and the amount of the post from Jambinese traditional houses are different, it depends on the size of the house. The load distribution and the ways it holds back the force has a great influence to the power and durability of the Jambinese traditional house.

In Jambinese traditional house, there’s a distribution load that produce a force to the footing structure. This thing has a linkage to the physical concept that the application can also learned from daily activity. One of the important things from the characters of the building are the implication. It means that student could connect the positive things could be learned and have self-awareness or concern between himself and its own experience [5]. According to the introduction that has been stated, hence the purpose of this research is analysing and explaining the application of physical concept in the footing structure of Jambinese traditional house and also building character education among the younger generation.

2. Methods

The method used in this research is descriptive qualitative. Data collection technique used by interview, observation, and documentation. The object in this research is 3 houses that are located in Seberang Kota Jambi. The interview instrument used to three Jambinese traditional houseowners. Interview instrument used to each houseowner as a research sample. Interview instrument also used to the customary community institution and public works department. Besides interview, there’s also observation and documentation that are used to strengthen the data analysis. Data analysis was performed descriptively and linked to physics concepts.

3. Results and discussion

Beside made an observation to measure the pile foundation of the house, researchers also had an interview section with related institution such as PU (Pekerjaan Umum), LAM (Lembaga Adat Masyarakat), and Jambi’s traditional house owners. The results we can get from the interview section are like the advantage of using wood as a house foundation, the philosophy and meaning of foundation structure. The foundation structure system of Jambi’s Traditional House is a base that supports the building as a whole. The advantages of use wood as a foundation that is wood if dismantled can still be installed, but if the cement is dismantled it will immediately be destroyed. With Philosophy: “Bertingkat naik berjenjang turun, betakak naik berjenjang turun”.

Jambinese traditional houses at Seberang commonly used footing that are made from bulians wood or merantis wood. Each post has a post length, range between post, and a specific number of the posts that depends on the size of the house. As shown on Figure 1, Figure 2, and Figure 3 below.
Figure 1 shows that House A is one of the traditional houses that have 28 posts. The height of the poles visible from the ground surface is 2,169 m. The range between post with the column is 1,633 m. The range between the rows for the veranda and the main post has a significant difference. The range between the veranda between rows (first row) is 2,581 m. While the range of the main post between each line is 1,236 m.

Figure 2 shows that for the House B, the wood used for the footing is bulians wood. The amount of the posts are 44, with a different length between the main post and the veranda post. Which the height of the terrace pole taken from the ground surface below the floor surface is higher than the main pole, which is 2,009 m and 1,961 m. While the post range between column and rows have no significant differences length. The range between the post and column is around 1,799 m and the range between rows and the post is 1,746 m.

Figure 3 shows that for house C its same as House A and House B, where House C is a Jambinese traditional houses that used bulians wood for each of its footing post. The amount of the post used 55 posts. The height of the pole visible from ground level at House B is 2,393 m. While the range between the post and the column is around 1,810 m and 2,027 m for the range between the post and the rows. This house was built 150 years ago, and has been used from a generation to another generations. Based on the amount of the post that are used, House C is quite big for a Jambinese traditional house.

Based on the data that have been collected, the following are the physical concepts that can be applied to analysed the footing structure of Jambinese traditional house.

3.1. Density
An important property of any material is its density, defines as its mass per unit volume. A homogeneous material such as ice or iron has the same density throughout. We use $\rho$ (the Greek letter rho) for density. If a mass $m$ of homogeneous has volume $V$, the density $\rho$ is [6].

$$\rho = \frac{m}{V} \quad (1)$$

One of the most important things from the material is the density, defined as a mass unity volume. The density for each material is different. Based on the explanation, we could determine the weight of the wood that used. As we know, the footing that used are pile footing. Where the wood is mounted to the ground. Even though we could still count based on the height that are visible or the height of all the post from the data obtained [6]. In Table 1. That examine the weight of the wood that are seen based on the mass of the wood type. In the photo or the picture of the post, there’s a different in taking the pictures between one another. So, it will look incompatible with the original circumference.
Table 1. Weight analysis of the footing posts on the footing structure from Jambinese traditional houses based on the wood density

| No | House Code | Picture of the House post | \( \rho \) (kg m\(^{-3}\)) | Circumference (m) | Radius (m) | Height (m) | V (m\(^3\)) | mpost (kg) | W (N) |
|----|------------|----------------------------|-----------------|------------------|-----------|-----------|---------|----------|------|
| 1. | House A    | 1040                       | 0.98            | 0.156            | 2.393     | 0.183     | 190.18  | 1863.8   |
| 2. | House B    | 1040                       | 0.74            | 0.120            | 2.099     | 0.089     | 98.70   | 967.3    |
| 3. | House C    | 1040                       | 1.04            | 0.166            | 2.169     | 0.095     | 195.18  | 1912.8   |

Table 1 shows that the sample from analysing the mass of the pillar or log is one of the pillars of each house. This pole mass analysis is based on the density of the wood used. Because the average wood used is bulian wood. Bulian or ironwood has physical properties with a density or density of 1040 kg m\(^{-3}\) and is classified as class I wood in strong wood class [7]. To get the mass of the pole through the concept of density, the first step we take after knowing the density of bulian wood is to find the volume of the log. Volume is obtained from the circumference of the pole or log. The result is we will get the radius and volume in question. Thus, the mass of poles or logs can be known, based on the concept of density. The results obtained for the mass of the pole at home are 190.18 kg at pole house A and 98.70 kg and 195.18 kg at pole house B and house C.

3.2. The force due to gravity: Weight

If you drop an object near Earth’s surface, it accelerates toward Earth. If air resistance is negligible, all objects fall with the same acceleration, called the free-fall acceleration \( g \). The force causing this acceleration is the gravitational force \( F_g \) exerted by Earth on the object. The weight of the object is the magnitude of the gravitational force on it. If the gravitational force is the only force acting on an object, the object is said to be in freefall. We can apply Newton’s second law (\( \Sigma F = ma \)) to an object of mass \( m \) that is in freefall with acceleration \( g \) to obtain an expression for the gravitation force \( F_g \): [8].

\[
F_g = mg
\]  

(2)

Weight is distinguished from mass and is often defined as the force of gravitation exerted on a particular object (“gravitational weight” approach) [9]. The gravity on the foundations of a traditional Jambi house can be used to calculate the load delivered. Such as dead load and live load supported by foundation. The following is an analysis of the gravity based on the live load and dead load supported by the foundation as in Table 2. In the dead load, there are some basic furnishings that can be recorded by estimating the original load mass approaching through several sources.
Table 2. Gravity analysis on the foundation structure of Jambi traditional houses.

| No. | House Code | Data Load | Σm (kg) | \( F_g \) (N) | Σ\( F_g \) (N) | Number of Poles | Distribution of Load on Post (N/post) |
|-----|------------|-----------|---------|--------------|----------------|----------------|-------------------------------------|
| 1   | House A    | Family member I | 75      | 735          | 7617,5         | 44             | 173,12                               |
|     | Family member II | 50   | 490          | 5390        |                | 15             | 358,62                               |
|     | Family member III | 20  | 196          | 392         |                | 5              | 78,43                                |
|     | Family member IV | 16  | 156,8        | 2509,2      |                | 3              | 836,38                               |
|     | Family member V | 12  | 117,6        | 1411,2      |                | 2              | 705,6                               |
|     | Family member VI | 75  | 735          | 55125       |                | 15             | 3741,7                              |
|     | Family member VII | 75  | 735          | 55125       |                | 15             | 3741,7                              |
|     | Plastic wardrobe (4) | 16 | 156,8        | 2509,2      |                | 3              | 836,38                               |
|     | Wooden Cabinet (3) | 93  | 911,4        | 2734,2      |                | 3              | 911,4                                |
|     | A set of table and | 100 | 980          | 9800        |                | 10             | 980                                  |
|     | Small table | 13,8 | 135,2        | 1352        |                | 5              | 270,4                                |
|     | Square wooden table | 25 | 245          | 6125        |                | 5              | 1225                                 |
|     | Low buffet | 61   | 597,8        | 3683        |                | 10             | 368,3                                |
|     | Dish rack (2) | 10  | 98           | 196         |                | 2              | 98                                   |
|     | Sewing machine | 42  | 411,6        | 8643        |                | 10             | 864,3                               |
|     | Desk | 28,5 | 279,3        | 2793        |                | 10             | 279,3                                |
|     | LED TV | 8    | 78,4         | 784         |                | 10             | 78,4                                |
|     | TV rack | 27   | 264,6        | 7298        |                | 10             | 729,8                               |
|     | Refrigerator | 30 | 294          | 8820        |                | 10             | 882,0                               |
| 2   | House B    | Family member I | 41      | 401,8        | 2604,8         | 28             | 93,03                                |
|     | Plastic cabinets (3) | 12 | 117,6        | 352,8       |                | 2              | 176,4                                |
|     | Wood cupboard | 31  | 303,8        | 912,4       |                | 3              | 304,1                                |
|     | A set of table and | 100 | 980          | 9800        |                | 10             | 980                                  |
|     | Wooden table | 25   | 245          | 6125        |                | 5              | 1225                                 |
|     | Small table (2) | 13,8 | 135,2        | 2704        |                | 5              | 540                                  |
|     | Medium tube TV | 7   | 68,6         | 476         |                | 10             | 47,6                                 |
|     | Refrigerator | 30   | 294          | 8820        |                | 10             | 882,0                               |
|     | Um | 6    | 58,8         | 588         |                | 10             | 58,8                                 |
| 3   | House C    | Family member I | 68      | 666,4        | 3187,9         | 55             | 57,96                                |
|     | Family member II | 55  | 539          | 2935        |                | 10             | 293,5                                |
|     | Family member III | 3   | 29,4         | 147         |                | 10             | 14,7                                 |
|     | Family member IV | 18  | 176,4        | 31724       |                | 10             | 3172,4                               |
|     | A set of table and | 42  | 411,6        | 8643        |                | 10             | 864,3                               |
|     | Wood display shelf | 5   | 49           | 490         |                | 10             | 49                                   |
|     | Wood cupboard | 31   | 303,8        | 912,4       |                | 3              | 304,1                                |
|     | Plastic wardrobe (2) | 8  | 78,4         | 156,8       |                | 2              | 78,4                                 |
|     | Wooden table | 25   | 245          | 6125        |                | 5              | 1225                                 |
|     | Um | 6    | 58,8         | 588         |                | 10             | 58,8                                 |
|     | Refrigerator | 30   | 294          | 8820        |                | 10             | 882,0                               |
|     | Small tube TV | 7,3  | 71,54        | 505         |                | 10             | 50,5                                 |
|     | TV rack | 27   | 264,6        | 7298        |                | 10             | 729,8                               |

Based on the data in Table 2 show that can be seen that the distribution of the load evenly is one of the strength factors of the foundation in the traditional Jambi house. The more poles used, the more stable the house will be, depending on the size of the house. For example in House C which has the most poles, the distribution of the burden evenly distributed to each pole will be smaller. To find this out, after finding the mass of each pole, it is also necessary to know the weight of each pole. Through analysis using gravity then for house A with that mass has a gravity of 1863.8 N. While house B and house C have a gravity of 967.3 N and 1912.8 N. Thus the pole will be sturdier and more durable, if the amount of load analysed does not exceed the available gravity on each pole.

After knowing the weight of each pole, it appears that the distribution of the burden that has been divided equally does not exceed the ability of these poles to support the load. Because the amount of gravity on the load that has been distributed is around 173.12 N at house A, 93.03 N for house B, and 57.69 N at house C. The load is analysed through the basic theory of gravity because it is not only the distribution of loads, but the distribution of forces will also occur in this process in the next discussion.
3.3. Newton’s third law
Two bodies are said to interact when they push or pull on each other - that is, when a force acts on each body due to the other body. Newton’s third law states that “when two bodies interact, the forces on the bodies from each other are always equal in magnitude and opposite in direction”.

For the book and create, we can write this law as the vector relation: [10].

\[ F_{\text{action}} = -F_{\text{reaction}} \]  

After determining the weight of each load supported, we know that there is a force acting on the foundation. And the foundation of the traditional Jambi house is famous for its strength, because there is no significant deformation. This also proves that there is a reaction from the ground which forms the base of the stick. Because of the burden is the emergence of the force of action. So based on the analysis, there is a reaction force that can be used as one of the factors of wooden poles made as a foundation that can be made firm.

4. Conclusion
Based on research that has been done, character education can be built through local wisdom. One form of local wisdom is traditional house. In various fields of science including physics there are various concepts that can be analysed from traditional Jambi houses. That way, not only learn the theory or concept of physics, the foundation structure of the traditional Jambi house can also educate the young generation today about the values of local wisdom in the local area. As we know, traditional houses in every region and Jambi traditional houses have their own structure and philosophy. However, the focus of the research is the structure of the lower part or the foundation of the Jambi traditional house. The results of observations made on the structure of the foundations of traditional Jambi houses obtained that the foundation used is the pillars made of wood. The wooden poles of the 3 Jambi traditional houses studied in Seberang have a certain length and are generally made of bulian wood. Furthermore, after data collection and literature study of physical concepts that can be analysed are the wood weight of the density of bulian or meranti wood, the gravity of the life / death load supported by the foundation, and Newton's third law. And there is a relationship between the mass of each pole with the distribution of loads that have been divided evenly and affect the strength of the foundation. Where the distribution of loads that have been divided equally has a weight that does not exceed the mass of each pole or log. Based on the results that have been analysed with a pole mass of house A 190.18 kg, it is obtained the gravity of 1863.8 N and the amount of gravity supported by house A is 173.12 N. House B has a pole mass of 98.70 kg, hence the gravity obtained is 967.3 N, whereas for the total weight force supported on this pole is 93.03 N. Finally for house C the mass of the mast and the weight gained are 195.18 kg and 1912.8 N, and the total weight the burden that has been distributed evenly for the house pole C is 57.96 N. So it does not rule out the possibility that the interpretation of science or physical concepts can also be applied to existing local wisdom, such as the traditional house of Jambi. That way, character education also speaks in recognizing the values or philosophies of local wisdom so that it can continue to be preserved until the next generation.

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