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Efficient Heat Energy and Embodied Energy of Compressed Earth Block House in East Java

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***Abstract*:** *Affordable housesusinga compressed earth block wallthere is still not found In East Java Indonesia. In general,Affordable housesusingbuilding materialsfrom thered brickwall. Compressed earth block is abrickwith earth raw material that is notburned, so thematerialislocalmaterialsandlowembodiedenergymaterials.*

This studyprovides an overview ofthe arrangwement of compressed earth block wallthat caninfluences toefficiency ofheat energyin the buildingand can also beappliedtoembodied energywalls. Sampleused wasa affordable housetype36.

Problemsin the studyfound formthe rightwalltoproducetheoptimumheat energyand embodied energy in the building.

The method usedis asimulationandoptimizationofthe wallconditions to theoverheatedand embodied energy into the building. Simulations of heatenergyused thearchipakprogram. Optimization was doneagainstembodied energy and overheatedthat was result. Variable of form ofwallused is aconditionson arrangement of block which form a wall. These conditionsformathickorthinwallwithaircavityorwithoutaircavities in it.

The result of researchis a form of arrangement ofthecompressed earth blocks in Wall that have athickandheat energyefficient. Thearrangement ofthe blockconsistsofthe followinglayers: outer1cmstucco; 5cm block; 1cm stucco;5cm block andin 1cmstucco. The layersform athickwall witha total of13cm.

Keywords: *compressed earth block; local material; embodied energy materials; overheated; arrangement of blocks; cavity wall.*

1. Introduction

Affordable houses are currently being built in Indonesia. This is done to realize the government's program of low-cost housing program.There are some simple building are as built by the government for the middle-class namely of 21, 27 and 36 m^2. The house scurrently use a red brick wall. The material is in the concept of sustainable design is a building material that has a high energy production or called high embodied energy. The concept of sustainable design according to Amatruda (2004) advocated: the building have a low Embodied energy of building materials, comfortable building conditions, using local building material sand without any pollution in the production process.

One of the walls of the building materials are low Embodied energy and has not been applied in the modest building in Indonesia is compressed earth block.This material is processed without theuse of combustion such as the red brick, so it does not require firewood from the forest. Compressed earth block is also alocal building material, because the raw material clays can use materials that come from around the site.

This study conducted a study of compressed earth block wall that has energy efficient heat energy and embodied energy. This will make the building as sustainable buildings. Problems arising in this study are: how the concept of wall construction design that can reduce heat energy and embodied energy in buildings.

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2. Method of research

The purpose of this study found to shape wall that efficient embodied energy and heat energy. Heat energy is the amount of overheated on the building for a year. While embodied energy is the amount of energy from the process of producing the type of wall construction. Energy efficient is optimization of heat energy and embodied energy of each building with walls of different shapes. Here's mindset research in Figure 1.

The model used is asimple building type 36 compressed earth block walled. As the variable is the shape of a wall that consists of 7 types of walls. There are 2 groups of the massive and cavity walls. Both groups have thick walls that different.

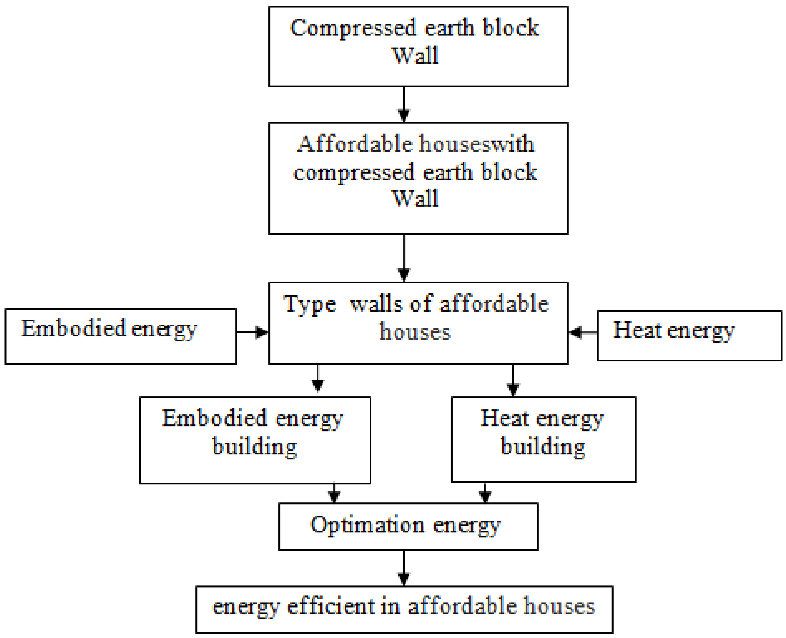


Fig.1: Mindset of research

Heat energy is calculated by using the program Archipak while embodied energy calculation using the multiplication between the volume or area of the embodied energy value perunit. Different types of walls will produce heat energy and embodied energy is different in buildings. Optimization is done to get the buildingshave the type of wall that can produce heat energy and embodiedenergy relatively low. The selected wall is type wall can produce optimum energy.

3. Discussion

3.1 Model building

The building that would become the model is the type of simple building with compressed earth block walled. Type of building is in great demand by midlle and low income group is building with 36 m^2area. Therefore appropriate building type to be a model in this study is the building type36 m^2. (see Fig. 2).

In Indonesia the heat is a major problem, so for case studythe research use the city with a hot climate conditions,mainly the city of Surabaya.The city located in Latitude -7.2 and has temperature 27 – 33^{0}C.

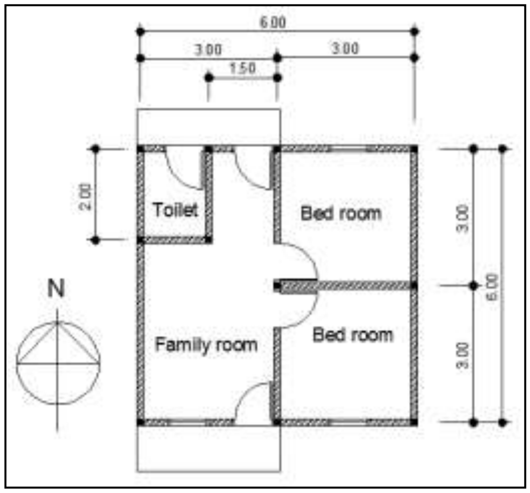


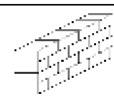
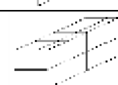
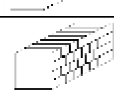
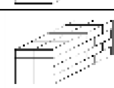
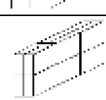
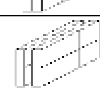
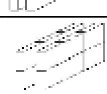
Fig. 2: Plan of building 36 types

Based on observation to the thermal energy of the most influential factors of the wall are: thickness, type of material and color of the walls (Adamson.1993). Wall thickness and certain conditions will produce minimal heat energy in the building. Therefore, the wall thickness and condition were variables into the study.

3.2 Wall Variables

In general, wall variables can be divided into 2 groups. Group 1 is the thickness of the wall that has massive form. Group 2 is the wallshave air cavity inside.Variabel used to study in groups 1 and 2 is measured based on the wall thickness and the dimensions of the block. The block dimensions are used accordance to the market with the standard 11 x 21 x 5 cm. Block wall with compressed earth block coated with 1 cm thick stucco mortar. This is done in order to avoid interference from the weather wall. Variants wall thickness can be seen Table 1.

TABLE I: Shapeandwall thickness

No.	Sampel code	Shape	thickness (cm)
1	SB1		13
2	SB2		19
3	SB3		24
4	SB4		25
5	SBU1		13
6	SBU2		17
7	SBU3		19

3.3 The heat energy

It is important in determining the heat energy in the building in relation to the wall is a U-value. U-valuedifferencecausedby theshape ofthe wall.The walls have a U-value is different because the shape of the wall. The results of calculations with using program Archipak obtained the results the U-value from each group (fig.3).At pictures show that the U-value of the wall SB1until the wall SBU1 has a U-Value which is relatively high when compared with wall to SBU2 and SBU3wall. SB1 wall to wall SBU1 is a massive wall. While SBU2 wall to wall SBU3 is a wall that has a cavity of air. This suggests that the U-Value which is owned by the massive walls are higher than the wall with air cavity.

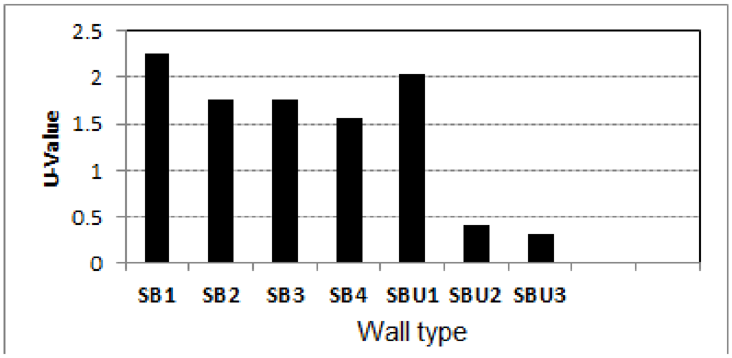


Fig. 3: U-Value of typewall

In figure 3 the highestU-Value is on the SB1wall with the massive wall,the thickness wall is 13 cm (including thick stucco). While the SB4wall is the massivewall which has a low U-Value with 25 cm thick. Generally it can be observed that the highestU-Value is on the wall which has a relatively thin thickness, while the lower the U-Value contained in the air cavity wall with relatively thick wall. Air cavity determine the value of the U-Value in this case, because the air can lower the U-Value. Also the air can blockthe hot air.

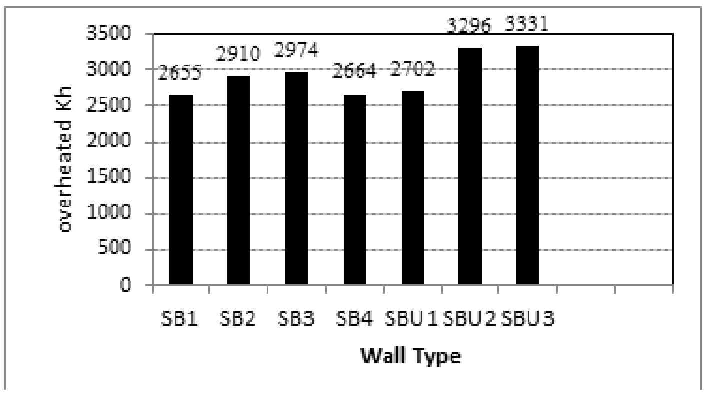


Fig. 4: Overheated in the buildings on the appropriate type of wall construction

Conditions of heat in the room besides the temperature is overheated. The amount of overheated determined also by the condition of the building wall. In this study overheated on buildings is calculated for 1 year. Figure 4 shows the overheated condition due to the use of the type of wall. SBU2 wall andSBU3wall have the same overheated value. The overheated owned by these walls isthe highest overheated value. SB1, SB4 and SBU1 wallshave almost the same relative value as well, but their overheated is the lowest value. SB2 and SB3 wall has overheated relative value almost same. From these conditions showed a tendency that walls with air cavity have relatively high overheatedwhen compared with the massive walls. Highvalueoverheated is not always owned by thinwalls.

Overheated condition at the SBU2wall and SBU3 SBU2showed improvement (Fig. 4). While the overheated condition on SB1 to SB3 walls also increases. This shows that there is a relationship enhancement overheated on the wall with air cavity, the thicker wallshave the higher overheated. These conditions also occur in the massive wall, but the increase is limited to a certain wall conditions.

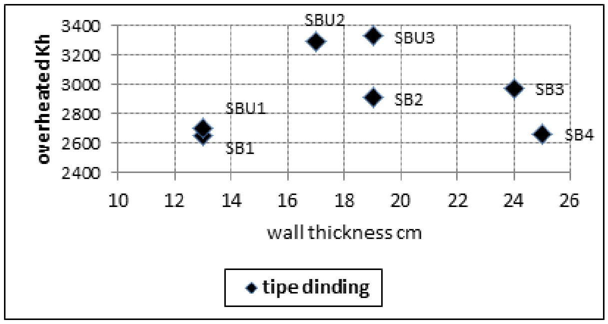


Fig. 5: The relationship between overheated with thick walls

3.4 Embodied Energy

Each building materials require energy to produce the building materials. The energy is called Embodied energy of building materials. Each Embodied energy of building materials have different buildings. This is due to the basic materials and methods of construction material manufacturing process is different. Here Embodied energy of each of the building elements used in building the sample (Table 2).

TABLE II: Embodiedenergyofbuilding elements

Building element	Embodied energy	
Compressed Earth Block	750	MJ/m^3
Stone fondation	235,18	MJ/m
Clay roof	251	MJ/m^2
Floor plastered	5250	MJ/m^3
Window/door	388	MJ/m^3

Sourc : Lawson Buildings, Materials, Energy and the Environment (1996)

Based on the calculation of area and volume elements of the building it can be seen embodied energy of building elements in the building. Embodied energy totalis the amount of building elements embodied energy in buildings. Embodied energy per area is embodied energy total compared with the building area. This needs to be done to compare values between embodied energy efficiency in buildings. So it can be known which buildings are more efficient with its embodied energy.

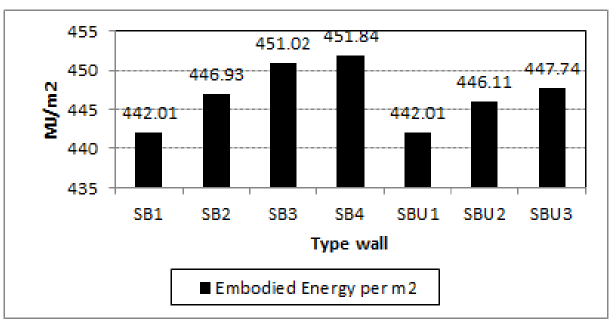


Fig. 6: Embodied Energy perm^2 of all types of wall

Fig. 6 showsa building with thick wall sand massive has embodied energy relatively high. This is demonstrated by building walled SB3 and SB4. While the lowest embodied energy is the buildings use SBU1 and SB1 walls. The walls are a massive and thin wall.

3.5 Optimization

To find the wall that have embodied energy and heat energy most optimum sought by optimization of the entire wall with variable heat energy and embodied energy. Here the position of each wall of the embodied energy and its heat energy (fig.7).

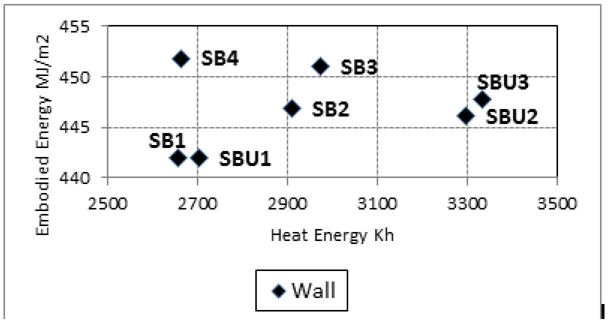


Fig. 7: Position embodied energy and heat energy on the walls type

Fig. 7 shows that the walls with the air cavity have a relatively high heat energy. This is evidenced by the SBU2 and SBU3 wall. Meanwhile, the massive walls mainly SB1 to SB4 have relatively lower heat energy. The walls that have low embodied energy and low heat energy are SBU1 and SB1 wall. Both of these walls are a massive wall. The walls have the same thickness but differ in the arrangement of blocks.

4. Conclusions

Energy efficient walls were to the massive wall, in this study are SB1 and SBU1 walls. During this time opinions stating that the air cavity that lies between the wallswill help decrease the heat energy in the building. In this research cavity walls havemoreenergythan massive walls.

The walls of the building in the tropics do not need to use a thick wall. Although the wall produces a low overheat, the Walls still produce high embodied energy.

The result of this study was the concept for handling problems at wallsof affordable house that energy efficient. The uniqueness of this study was the use of building materials that have never been used in a affordable house in Indonesia.

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