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Experimental Study on Sawdust Reusing as Material of Light Weight Brick-wall to Reduce Building Mass Due to the Earthquake Risk, Case Study Papua

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ABSTRACT

Papua is a territory of Indonesia in which strong earthquake [2,3]. One of the solutions to reduce the seismic risk is reduce the building mass. Wall is the building parts contributed the greatest mass in a building. Papua region in general use brick-wall of local product (LLB) made of limestone-cement as wall material, sized of 27x19x9 cm and 8 to 9 kg of weight. Indonesian Building code of Load, 1983, required mass of a wall without holes is 200 kg/m2[4]. Local brick-wall predicted exceeded the code regulation, and will cause the building in a big of mass that the leads to the big seismic shear force. other side, Papua still has a large forest with the volume and quality of woods, produced any size of woods and byproducts that waste in the form of sawdust [1, 9]. The waste is simply dumped and pilled or sometimes burned. So far there has been no use of the sawdust. As environmental issues, it should be done the innovation for use of sawdust in a form of epoxy-sawdust brick (ESB) to be an extremely valuable economic and reduce the environmental issue [6]. Weight per unit area wall of the ESB-W is 102 kg /m2 or 51% respectively compare to the weight of wall required by Indonesian Building Code of Loading, 200 kg /m2 [4]. Other two specimen test, LB-W is 116 kg /m2 of weight or 58% and LLB-W is 220 kg/m2 or 110% respectively. LLB-W already exceeded the code but ESB-W is the lightest weight could reduce the building mass and impact to the horizontal seismic shear forces.

Keywords: earthquake, building mass, brick-wall, sawdust, epoxy-sawdust brick-wall

1. INTRODUCTION

Indonesia is known as a quake-prone region, spread almost all over the territory. One of the areas with a strong earthquake is Papua, where on Indonesian's earthquake map stay zone 5 and 6, area with the category of strong earthquake as shown in Figure 1 [2,3]. One of the solutions can be done to reduce the seismic risk is reduce the building mass.

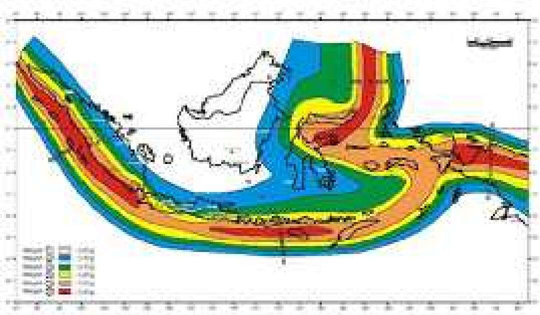

Fig. 1 Indonesian earthquake map

Wall is the one of building elements that contribute the greatest mass in a building. Papua region in general use brick of local product made of limestone mixed with cement as wall material, sized of 27x19x9 cm, as shown in Figure 2.

Fig. 2 Local brick of Papua

The population growth continues to increase make the need for houses, buildings, schools, offices and others infrastructure will increase. This will certainly increase, the use of local brick. It is an issue where the local brick weight in Papua is too big so it will increase the mass of the building. Weight of a local brick on the market is 8 kg to 9 kg.

Indonesian Building code of Load, regulated the unit weight of building materials in Indonesia. The planner will refer to this standard as the source of the load will be used. Specially the wall, Indonesian Building code of Load regulated that mass of a wall without holes is 200 kg/m^2[4]. With a heavy weight, local brick is predicted pass over the code regulation. This will cause the building in a big of mass that the leads to the big seismic shear force. This condition can aggravate the problem and the risk of an earthquake in Papua.

In another side, Papua still has a large forest with the volume and quality of woods. Wood processing businesses (sawmill) that grow and develop significantly, produce any size of woods and byproducts that waste in the form of sawdust [1, 9]. Usually the waste is simply dumped and pilled or sometimes burned, as shown as Figure 3. So far there has been no use of the sawdust. As environmental issues, it should be done the innovation for use of waste wood powder (sawdust) to be an extremely valuable economic and reduce the environmental issue [6].

Fig. 3 Pilled and burned of sawdust

Innovation that could be done to take advantage of the sawdust is by processing into boards or slabs for use on building materials. In this research, the sawdust will be used to make an epoxy-sawdust brick like the ones in the market. As the adhesive to be used epoxy glue so that the subsequent designation is epoxy-sawdust brick (ESB).

In order to verify the reuse of sawdust as material of brick manufacture, it would be done a research with a number of specimen using local limestone brick (*LLB*) and lightweight brick (*LB*) as a normal comparison specimen.

2. HORIZONTAL SEISMIC SHEAR FORCES

Earthquake is a vibrations or shocks occurring in earth's surface as a result of the release of energy from the earth suddenly, as the cause of earth's crust (tectonic plates) movement. Most earthquakes are caused due to the release of energy produced by pressure exerted of the moved plates. Longer, the pressure is maximum and can not be detained again by the edges of the plate. That's when an earthquake will occur. The most severe earthquakes typically occur at plate boundaries compressional and translational [8, 10].

Seismic load is unpredictable both magnitude and direction. Magnitude of earthquake forces is determined by the kind and properties of the structure. A horizontal seismic shear force that occur is dependent on a vibrating time of structure, eccentricity of the central structure rigidity to the center of building mass and mass of the structure. Magnitude of seismic shear forces is expressed in equation 1 [2, 9].

$$V = C\ I\ K\ W_t = \frac{C \cdot I}{R} W_t \qquad \text{eq.1}$$

Where:

V = Horizontal seismic shear force

C = Coefficient of seaquake

I = Structure virtues factor

K = Types of structure factors $= \frac{1}{R}$

R = Earthquake Response Modification Factor

W_t = Mass of building, combinations of dead load and life load.

As known due to the equation 1, reduction of building mass will also reduce the horizontal seismic shear force.

3. EXPERIMENTAL METHODOLOGY

This research was done using basic materials are sawdust and epoxy-resin adhesive. To be easily mixed, the epoxy-resin diluted by using gasoline. The composition of the used mixture is epoxy-resin 1 kilogram, 3 kilograms of dry sawdust and 8 liters of gasoline. The process of mixing and molding the mixture is done manually as shown in Figure 4.

Fig. 4 mixture of a brick-making process

Dimensions of the epoxy-sawdust brick specimen is 30cm x 20cm x 8 cm was made using a mold of the wood board. Digesters are ready, put into the mold and compacted manually. The series manufacture of the ESB is shown in the Figure 5.

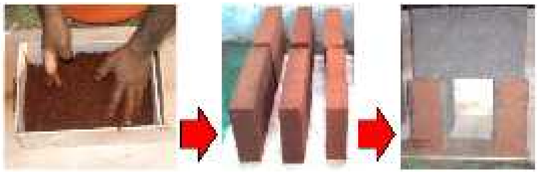

Fig. 5 Manufacturing process of epoxy-sawdust brick

Specimen ESB that has been formed sprinkled with sand to be easily attached by mortar during installation and plastering. Next process, the ESB aerated in the open space to dy. Before the ESB plugged into a 100cm x 100 cm of wall, the WSB is weighing. The dry ESB already to be plugged into a wall and plastering on both sides. Used as normal specimens to comparing, are lightweight brick (*LB*) and local limestone brick (*LLB*). The wall specimens are shown in the Figure 6, 7 and 8.

Fig. 6 Wall specimen of epoxy-sawdust brick, before and after plastering

Fig. 7 Wall specimen of lightweight brick, before and after plastering

Fig. 8 Wall specimen of local limestone brick, before and after plastering

4. RESULT AND DISCUSSION.

Under the brick specimens test, here is the result as shown in table 1 and table 2 for the wall specimens.

Due to the test results in Table 1, indicate that the ESB weight per unit volume is very light compared to the LLB, just 16% respectively, even more still less than LB. As known that LB and LLB are both sell in the market, but the more widely used is the LLB as it is cheaper and easier to obtain.

Table 1. Test result of brick specimens

No	Specimen	code	Size (cm)	Weight (kg)	Unit weight (kg/m^3)	Ratio to LLB (%)
1	Epoxy-Sawdust Brick	ESB	30x20x8	1.5	312.5	16.0
2	Lightweight Brick	LB	60x20x7.5	6	666.7	34.2
3	Local Limestone Brick	LLB	27x19x9	9	1,949.3	100.0

Based on the test results in Table 2, as known that the weight per unit area of the ESB-W is 102 kg /m^2, the lighter of the two other test objects, only 51% respectively to the weight of wall required by Indonesian building code of loading, 200 kg /m^2 [4]. LB-W test specimen has a weight of 116 kg /m^2 or 58% respectively to the code. But LLB-W was 220 kg/m^2 or 110% respectively, already exceeded the code. All of the three specimens, seems that the ESB-W is the lightest. Using of ESB-W could reduce the building mass and impact to the horizontal seismic shear forces as expressed in equation 1. It means that the risk of earthquakes also reduced.

Table 2. Test result of wall specimens

No	Specimen	code	Weight		Ratio to LLB	Ratio to Indonesian Building code of Loading
			Unplastering wall	Plastering wall		
			(kg/m^2)	(kg/m^2)	(%)	(kg/m^2)
1	Epoxy-Sawdust Brick Wall	ESB-W	60	102	46.4	51.0
2	Lightweight Brick Wall	LB-W	74	116	52.7	58.0
3	Local Limestone Brick Wall	LLB-W	178	220	100.0	110.0

5. CONCLUSION

Epoxy-sawdust brick with its small weight unit area could reduce the horizontal seismic shear forces that lead to reducing of earthquake risk. Other side, reusing of sawdust will lead to the green environment and economic advantage.

6. ACKNOWLEDGEMENT

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