Wall Panel Of Waste Paper Tapioca 'Perva' Answering The Ecologic Building Material Challenge

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Abstract. Building material in a building occupies more than 90% physically. In accordance with the provisions and regulations in many countries construction of buildings requires certification as 'green' as green building regulations. One of the ways to obey the rule is through the use of ecological building materials. Waste paper wall panels - tapioca "Perva" can be one of the viable alternative. Waste paper when strived as raw material exists in the realm of 'recycle' ecological. Paper and tapioca are organic materials containing organic elemental cellulose 'non toxic' building material. Procurement of paper waste raw materials can be done by collecting used paper. The formation of 2 (two) basic materials into new materials can be produced by simple technology easily done by people or 'self-help' technology. The weakness due to the use of materials with high levels of vulnerability requires the collaboration of additional raw materials to complement each other and form a favorable positive force. Composity with other ingredients can be done by excluding the ecological value if it is not found, natural ingredients with the desired criteria provided minimal and with a low non-ecological percentage value. Research of wall building materials Paper Waste - Tapioca has been done since the embodiment determines the aggregate composition, forms the demensi of certain materials, and makes the walls in a conventional way. Testing was conducted on several aspects related to the feasibility of building wall materials. Research continued on increasing the value of the shape as a composite panel. Experimental laboratory tested in architectural aspect, material feasibility aspect, its application in building and also feasibility aspects of wall construction. The research performed aggregate percentage test, the way of printing, the feasibility of wall construction to the adhesive aspect of coating material or surface protector and adhesive media. Arrangement as a wall with a certain extent used the system of persuasion at a certain dimension. The lateral load testing of wall construction resulted in effectiveness of the area of paper wall - tapioca.

Keywords: *paper, tapioca, panel, composite, wall*

1. Background

The Indonesian economy is increasing along with the strengthening of national development that must be accompanied by the spirit of 'Sustainable Development' with real application. The regulation of green building applications in Indonesia has been established at the national level; some up to the municipal government deals with the existence of buildings. The eco-friendly 'Green Building' system is already a

demand in response to the worsening conditions of Global Warming and Climate Change. It responds to the country's commitment to reduce carbon emissions by up to 29% in responding to the decisions of some of the world's 'Green Conference' (COP) where almost every line of development leads to an eco-friendly footing. From the architectural aspect, the biggest influence is felt in the use of building materials. The selection and use of environmental friendly building materials are highly recommended and even controlled by regulation. Implementation in the field of building construction from residential houses to public facility buildings leads to 'Green Building' (Green Building). Building materials of more than 90% are used in a building, so it has a very important role when directed by the use of materials with ecological characteristics. Use of ecological building materials can increase the 'Green' value on a green building system. The effort of innovation and creativity is very important in the development of building materials. During this time almost all building materials seize enormous natural resources. Saving energy from non-renewable sources is very necessary as well. Many of them are 'toxic' and not hygienically safe. Perva is the name of the material we propose as the term of the new material we developed from 'paper' (paper) and 'cassava' (tapioca). The Perva composite panel classified as environmentally friendly building materials has been through a gradual experimental research review as a refinement. The problems that arise are the characteristics of raw materials on the core material of the panel products and the composite surface coating supporting material to the core panel. Other research that was carried out is the aspect of its ability to the construction application. The research of this new building material used Government and internal fund of Faculty, which is 'Multi years' and has stepped on 2nd year (two).

2. Methods

Discussion of research implemented in this research used quantitative and qualitative methods of laboratory experiments. Quantitative methods were performed using equipment with measurable indicators, while qualitative methods used laboratory means through visual and mechanical observations. The research method was done from the research of making substantial product of paper granule building - tapioca in the shape and demensi of brick and possibly other form with aesthetic character. The continuation of the research was the ability of building material product produced to construction aspects, such as compressive strength test, test of cutting success, test of surface coating with other material and screwing test. Research evolved towards the effectiveness of the area of the vertical wall against the lateral load of the wall. In the realm of production of new building materials waste paper - tapioca to the formation of wall construction was also through the research ability of the workmanship by the layman without a background of construction expertise.

Research increased on the formation of new building materials with panel products for building walls from waste paper - tapioca and composite panel which was a collaboration of paper materials - tapioca with other complementary building materials from the aspect of new material characteristics. The method discussed in this paper compared the results of research to the rules of ecological rules that could be achieved in new building material products.

3. Results and Discussion

The waste composite panel product was tapioca. This research aimed at testing effectiveness new wall building material never done before. This lead to creative innovation of easy raw material easily found but still maintained the strength and stability aspects of the wall. This initial step was to form a material that could be made from 2 (two) main raw materials of paper and tapioca. The collaboration of these two materials was very possible considering that both were derived from organic cellulosic elements of the ecological flora so that it could be incorporated adhesively. Basically organic cellulose was a natural element and not toxic, especially on tapioca raw materials. Paper raw materials were adjusted with

preservatives and dyes were chemical and toxic. The process of pourage was expected to dissolve the chemical levels of preservatives and colouring.

Mixing of raw materials to form new building materials required special processing. Because the paper in units of sheets with a lightweight could be heavy when stacked, so there was almost no cavity between them. For relatively light amount and weight efficiency, the processing must lead to the end result of the number of cavities, within the paper itself and the cavities between the papers. The paper grain shape (pulpy granule) would be able to answer predicted forecasts. The paper granules were still trapped in the air inside, and the grain of paper was put together in large quantities, allowing the presence of many cavities between them. Wasted paper was mixed up by stamping manually to become pourage and then dried in the outdoor area.

In aggregate formation, the paper granules were mixed with tapioca. Flour tapioca was used as a thick liquid colloidal. Tapioca coloid was cooked up to boiling point conversion with a total cooking time of only 15 minutes using a gas stove. It was mixed and ensured that each grain of paper was coated with tapioca colloidal as a means of adhesive gluing. New building materials in trials were conducted in the form of 50 x 50 x 50 mm demension and increased in certain format dimension with estimation still within reach of pressure pressures by hand and manpower. The recommended demands were 50 x 100 x 230 mm printed press and removed. Printing was done manually relying on human weight and drying of renewable solar heating.

The product of the object formed when applied as a building wall component would have a very vulnerable surface to the aspects of the outside, heat, rain, sound waves, pressure and air humidity. Some can be anticipated, but some would cause damage and even material destruction. Therefore the material product formed requires a surface protector to anticipate. Some materials are possible to collaborate with staple materials, among others, cement, cement-sand mortar plaster, white cement plamuur - PVAC glue, emulsion wall.

Table 1. Selection of surface coating materials

SURFACE COATING & SAMPLE MOCK-UP50X50X50 MM	**CEMENT PASTE**	**MORTAR CEMENT – SAND (1 : 2)**	**PLAMUUR WALL WHITE CEMENT – PVAC**	**WALL PAINT EMULSION**
A	Sticking almost full The coating is broken a little corner Strong hard	Less sticky The coating is intact Strong hard	Sticking full The coating is intact Strong hard enough	Sticking full The coating is intact Soft soft
B	Sticking full A broken middle crack coating Strong hard	Stick full The coating is broken a bit Strong hard	Sticking full The coating is intact Strong hard enough Sticking almost full The coating is broken corner Strong hard enough	Sticking full The coating is intact Soft soft Sticking full The coating is intact Soft soft
C	Sticking apart The coating is intact Strong hard	Stick full The coating is intact Strong hard		
EXPERIMENTAL RESULT	MIXED MIDDLE PERFECT	MIXED MIDDLE PERFECT	MIXED MIDDLE PERFECT	MIXED PERFECTLY

Those were experimental results of lateral load test of horizontal thrust against the vertical wall plane of the paper-tapioca brick structure with the same material adhesive medium. The test was performed on the area of 1.00 m2, 4.00 m2 and 9.00 m2 with edge frame.

Figure 1. Mock-up wall paper – tapioca

The experiment result showed that the feasibility of robustness, strength and stability of the recommended vertical wall was between 1.00 - 4.00 m2. This result was based on the effectiveness of the area. Every material wallpaper – tapioca 1.00 – 4.00 m2 had to apply the stiffness frame in every edges and could be categrized as partition wall.

The development of research focused on the effectiveness of wall without any reduction to the stiffness, robustness and stability of the wall. The result of optimizing the recommended area could be synchronized with the partition wall (although the shape was close to the wall filler), seen from the aspect of wall performance. Then an efficiency step was possible.

Configuring the arrangement of the shape of the paper brick - tapioca which was originally 'sleep' was changed to 'stand' so that the configuration of the order of the wall area had enough thickness, only 50 mm and forming 'wall panel'. Innovation steps led to the composity of the paper panels - tapioca form with the idea of leading to the recommended vertical demension of the area of 1.00 - 4.00 m2. It was necessary to add additional materials that strengthened the weakness factor of the wall panel, among others, the possibility of reinforcing the surface of the panel that could add the value of robustness in the ability of strength and stiffness of the field, especially lateral load strength. Stability led to the ability of the vertical panel to remain in position.

Successful addition of a surface layer of paper brick walls, one of which used 1 sand: 2 cement, showed perfect adhesiveness and added to the stiffness, robustness and stability value. The possibility of adding material strength to the surface of the field could inspire its application in wall panel research. Then it was possible to merge 2 (two) elements of materials with different characters into a form of composite material that could support each other from positive aspects that complement each other and strengthen. Therefore, the study led to the formation of new building materials in the form of Composite Panel of paper bricks - tapioca with other materials that needed to be tested before it was determined on many considerations. Of course in determining the material was also considered aspects of resistance to water and moisture.

There were various possible types of 'second' materials to be compiled with paper panels - tapioca including:

- Mortar cement - sand with composition (1: 2) (wet aggregate with ram wire)
- Calcium board (sheet)
- GRC (glass fiber reinforce concrete) (sheet)
- Acrilic thixotropic (pasta)

Table 2: Selection of composite panel composite materials

MATERIALS & ASPEK	**MORTAR PASTE CEMENT SAND (1 : 2) Thick 3 – 4 cm**	**LAYER CALSIUM CEMENT BOARD Thick 3 mm**	**LAYER GRC BOARD Glass Fibre Reinforce Concrete Thick 3 mm**	**PASTE PAINT ACRYLIC THIXOTROPIC (waterproof coating) Thick 0.5 mm**
The level of rigidity	Hard enough	Easily broken	Hard	Soft
Power level	Strong	Strong enough	Strong	Not very strong
Level of stiffness	Very stiff	Rigid	Very stiff	Bending
Waterproof level	Dainty	Simply impermeable	Very impeccable	Simply impermeable
Sticky media	Wire netting & interlocking cement paste	PVAC Glue	PVAC Glue	PVAC on the substance
Ease of workmanship	Need special skills	Easy simple	Easy simple	Quite hard & plated
DECISION	**NOT RECOMMENDED**	**RECOMMENDED** (2)	**RECOMMENDED** (1)	**NOT RECOMMENDED**

From the theoretical study conducted on 4 (four) possible materials that could be used as reinforcement of paper panel - tapioca panels, which was tested, it is concluded that the most recommended materials were GRC Sheet Board and Calsium Cement Board Sheet.

The composite panel formed was named as Composite Panel Perva - GRC and Composite Panel Perva - Calcium Cement. Composite Wall Panels Perva - GRC / Calcium Cement was formed with a demension of 1000 x 1000 x 60 mm, to meet the provisions of previous research results that the recommended effective area ranged from 1 to 2 m2, based on lateral load strength on the wall. A further recommendation is the provision of a stiffening frame and a wall holder in the form of steel or galvanish hollow mild steel. Composite Wall Panel Perva - GRC / Calcium Cement as partition wall can be collaborated with building structural system of any material such as reinforced concrete frame, profile steel frame, light galvanish steel frame for light building.

3.1. Tested Product

The cutting test of product showed the results of Composite Panel research that could be perfectly cut using manual hacksaws. Cutting with a hacksaw produced fine cut traces while using a wood saw produced pieces that were not perfect or fail because of the relative destruction. The cutting result could still be used as a component for the wall at a smaller demension.

Experimental test screwing outline using 3 types of screws each 3 sample showed that:

1. 50 mm long demension screw was firmly embedded, average scale was 6 out of 10 points

2. 40 mm long demanding screws were firmly embedded, averaging a scale of 4 out of 10 points

3. 30 mm long demanding screws were firmly embedded, average scale of 2 out of 10 points

The results read in this experimental study were only at the limit of vertical load embedded, not from the aspect of vertical tensile strength and lateral tensile strength given the softness of basic materials such as paper.

Self-help work test on experimental paper brick production - tapioca was done personally with no previous building construction expertise. At optimal working for 8 hours could produce an average of 45 - 50 pieces of brick size. The trials were also carried out to housewives and students and sixth semester students of the 3rd year on certain lectures, demonstrating the perfect results from the adhesive aspects of materials, product hardness and demension without deformation. Process production was only using simple tools with adding water and bake under the sun.

4. Conclusion

Production was carried out manually using print equipments and by hands. People involved did not require special skills and could even be done by the men and women of adolescence. People with no special skills could also do the construction of composite panels on the framework of the building. Therefore, the aspect from production to building construction could be categorized as ecological.

From the study of all aspects, among others materials, production processes and producers who involved even until the construction phase were categorized as ecological. Thus, the new building materials of Perva Composite Panel in this research could be categorized as ecological building material and have feasibility in ecological building. The Perva Composite Panel can be used as one building component to support the creation of ecological buildings and may be submitted in the proposing of 'Green Building Certification'.

5. References

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