



Prefabricated House Development With Tetra Pak Carton Recycling Processing

Seftiyandi Kurniawan^{*}, Caesar Rai Finaldy, Gumiwang Tresnakalingga

Departement Teknik Arsitektur, Universitas Komputer Indonesia, Indonesia

Email: *seftiyandi.10418055@mahasiswa.unikom.ac.id

Abstract. Damage to the environment due to the increasing volume of waste every day causes concern about the impact that will be caused and felt later, in addition, the need for shelter recently has increased in line with the growth of the population in Indonesia. So not a few people who do not have a decent place to live and a lot of garbage that is not recycled properly. This is nothing to worry about if it can create a system that can reduce the potential for environmental damage caused by garbage that continues to increase and can also be a solution to provide a decent place to live. Therefore, this study made a system that can process the waste into a material that can be used as a sturdy building material and does not require much cost. The novelty of this system is in the ability to provide solutions to the problem of environmental damage caused by waste that is not recycled as well as solutions for people who do not have a place to live because of the limitations of expensive costs. Prefabricated houses also mean cutting the time in house construction to be more efficient because the design components of the house have been made outside the construction site, the material components are then brought to the construction site to be arranged modularly. According to statistics from the Brazilian government of Curitiba, waste consists mostly of organic materials, wood, glass, and fabric, and 31.7% of it can be recycled. Therefore, there is an opportunity to use these materials in developing and applying them to building construction. In addition, the cost tends to be lower when compared to conventional construction materials.

Keywords: *Prefabricated house, tetra pack carton, recycling.*

1. INTRODUCTION

Tetra Pak was founded by Ruben Rausing and Erik Wallenberg in 1951 in the Swedish city of Lund. As of January 2013, the company Tetra Pak has supplied approximately 173, 234 million packages so that 77,307 million liters of milk, juice, nectar and other products could be delivered to consumers around the world [1]. Construction uses prefabricated techniques, otherwise known as the manufacture of construction parts that are done by the factory so that it is directly installed and combined on the spot. If associated with the

world of architecture, this prefabricated process can be said to be more practical and quite easy when assembling a house on the land. Prefabricated architecture is usually made of conventional materials such as cement in general, in its production will only add new problems, while in Indonesia there are big problems that need to be overcome such as waste problems, judging from the opportunity there is some waste that can be processed and utilized again, such as tetra pak cardboard that can be a conventional construction material in buildings, and is expected to be able to be a solution in enough housing shortages in the community in Indonesia because it is recorded that as many as 20% of families do not have a livable home based on data from the BPS (Badan Pusat Statistik, 2019).

A study of the thermal performance of tetra pak materials was conducted by Gabriel Viera, et al. In the study "Thermal Performance of Tetra Pak Package as a Ceiling Material", it was shown that tetra pak material is a cardboard material that is widely used in dairy packaging products or packaging products containing liquids, with tetra pak products can provide stability to a packaging [2]. Tetra pak material has a high quality of the application as insulation material, just like cork boards, fiber insulation boards, and foam glass, therefore the results of the study claim that tetra pak has the potential to be applied in the construction part of buildings. Tetra pak material has the potential as other environmentally friendly materials.

It is more economical and has good thermal performance [3]. In another study conducted on residents in the Serpong area, with a sample of 28 people, 86% answered that tetra pak packaging can be recycled. [4], meaning that the community has recognized the tetra pak material very closely with everyday life. In addition, other studies show that processed tetra pak cardboard paper can be an important point in developing recycling chains to reduce environmental impact, in addition, cardboard paper can be processed optimally separated by mechanical stirring and sodium hydroxide. These materials are easy to process and low cost and can produce competitive products [5].

This journal aims to review tetra pak recycled materials so that they can be used as conventional materials in the construction of houses at a more affordable cost. as construction materials or parts of buildings or infrastructure.

2. Literature Review

2.1. Characteristics of tetra pak

In general, a tetra pak is a material consisting of several basic layer components as follows:

1. Polyethylene: This is the basic material of plastic bags that are usually used to wrap oil and coconut milk liquids because it can protect moisture from the outside air.
2. Paper board: This is a type of paper that has a thickness of 0.4 mm to 4.3 mm, and also to maintain the stability, strength, and smoothness of the wall surface.
3. Polyethylene lamination: This is a layer made of polyethylene that serves as a wall coating to increase adle power.
4. Aluminum foil: A layer that can prevent stickiness.

5. Adhesive polymer: This is an adhesive glue that serves to glue each layer on the tetra pad wall.
6. Polyethylene metallocene: A material that has excellent optical properties, resistant to leaking and impact, is better than other types of polyethylene.

With the aluminum foil layer, polyethylene in the tetra pak layer proves that the material has good potential to be developed in this case as an additional coating material that can reduce thermally well.

2.2. Humidity Control Performance

The comfort factor that still gets attention in the context of energy saving is thermal comfort and visual comfort. Thermal comfort is concerned with the thermal environment formed from air temperature, airflow, air humidity, and solar radiation. Visual comfort is affected by the amount of light intensity in the room needed to move well [6].

The heat of sunlight can affect the temperature of space in three ways: conduction, convection, and radiation. Indonesia is a country that has a humid tropical climate, so material factors become very important in overcoming the performance of humidity control in a building. Materials with low conductivity can be good convection, whereas materials with high conductivity can conduct well [7,8].

2.3. Characteristics of Thermal Insulation

Research conducted by Handayani (2010) proves that using materials with heat delivery inhibitors that are good enough and have the ability to reflect heat effectively, can help reduce the use of air conditioning during the day, especially when added additional supporting materials such as aluminum foil on the roof cover [9]. Therefore research conducted by Rodriguez et al (2019), thermal comfort deficiencies are linked to low occupant's satisfaction, poor health and wellbeing, as well as, increases in the building's energy consumption and CO₂-e [10].

3. Method

In general, the methodology used is qualitative research methodology through the collection of secondary data using literature studies, scientific research articles, along with standards or regulations that have been established to be used as references and limitations of building design formulation as an interpretation of research results.

The first method used in the recycling of composite drinking cartons was the particle board method. The boards manufactured from processing the product without separating it into its components (thermal compression) were used in furniture, civil construction, and packaging industries. In later years, the recycling of paper (hydropulping) began, in which the paper fibers that constituted 75% of the composite drinking cartons were recovered [11]. The collected data is further analyzed through comparison methods through digital models and reviewed descriptively-evaluatively through the following stages:

1. The level of formula planning; Determine the specifications of material modules and building structures that support the application of tetra pak as a thermal insulation component in buildings through descriptive-evaluative comparative analysis to be developed as prefabricated modules.

2. Design stage; by applying tetra pak material to the building design module, so that the best and most efficient design is selected.

Factors studied include the effect of tetra pak material after being configured on the wall and ceiling layers on thermal performance such as humidity, along with climate factors as fixed variables in this study.

4. Results And Discussion

In Indonesia several related standards or regulations regulate how material quality standards are based on the type or classification of a building, this observation is done on the design of buildings measuring 42-48 m², with GRC board wall material with the addition of a layer made of tetra pak as a layer of thermal reduction, where the material comes from unused milk packaging waste, recovery of Tetra Pak type of waste which includes recycled materials including 75% paper, 20% polyethylene, and 5% aluminum. become a serious problem in the recycling of unfinished composite beverage cartons a lifetime and will be in vain if not processed [8]. With the designed system, the waste amount of countries going to the solid waste storage areas will decrease and the protection of our environment will be provided. Tetrapak recovery will be a long-term economic investment [11].

The majority of these products are easily found in liquid products whether food or beverage products with packaging materials made from tetra pak cardboard paper that can provide stability to several building structures, research conducted by Zawadiak et al (2017) prove that tetra pak is produced by laminating together paper, LDPE and Al into one composite material. Paper, responsible for 75% of packaging mass is used to help ensure rigid shape of final product as well as to increase material strength. Al foil (5%) is used because of its excellent barrier properties for agents such as light, oxygen, water vapour, odours and microorganisms [9]. By going through the following stages:

4.1. Preparation of tetra pak material

Preparations made include:

- Prepare tetra pak material taken from the packaging of a 1-liter drink
- Clean the packaging so that it is not sticky from the former drink
- Unpack the packaging so that it becomes flat and wider, then combined so that it forms a wide enough layer
- Before gluing it on the GRC Board board, first, the tetra pak cartons that have been collected in glue and combined until they cover the surface of the GRC Board, so that the GRC Board board is fully covered by tetra pak.
- After the GRC board is fully covered by the tetra pak, then attached to the ceiling structure and walls that have been provided.

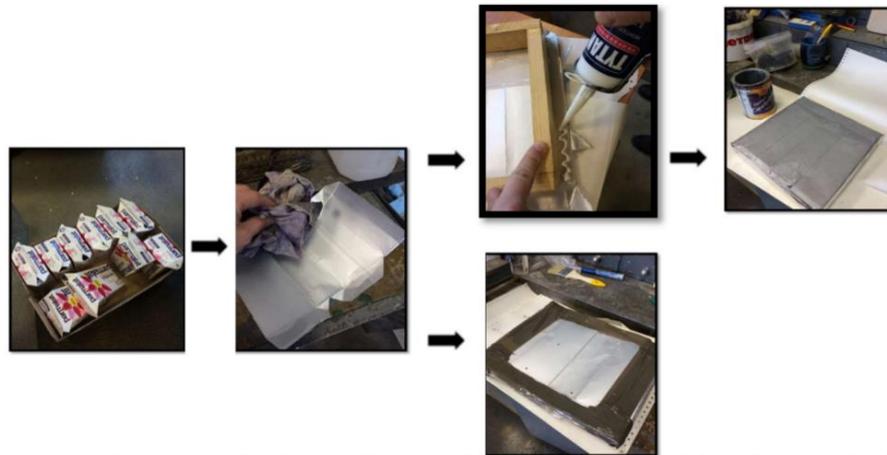


Figure 1. The process of making tetra pack layers

4.2. The level of design of tetra pack formula on building components

At this stage tetra pak material is applied directly as an additional layer on several components as follows:

- a. Application of tetra pak coating on the ceiling of the building.
- b. Application of metal stud (light steel) coating on the ceiling of the building.
- c. Application of gypsum coating on the ceiling of the building.

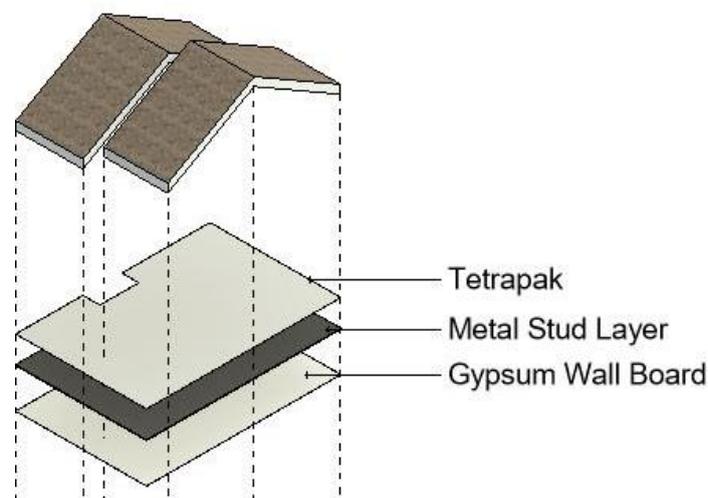


Figure 2. Ceiling Asymmetry

A study of the thermal performance of tetra pak materials was conducted by Gabriel Viera, et al. In the study "Thermal Performance of Tetra Pak Package as a Ceiling Material", it was shown that tetra pak material is recommended for use as insulation material. Because it has a thermal conductivity factor that is very similar to materials with a high application as insulation materials, for example, cork boards, fiber insulation boards, and foam glass. From experiments conducted on materials coated with tetra pak then conducted thermal testing, the results proved that the addition of tetra pak material on the ceiling can lower the heat

temperature, and make it stable over time. Furthermore, the potentiality of a good thermal performance of Tetra Pak when used as insulation material for the ceiling houses is high.[2]



Figure 3. Graphic obtained from the Guarded Hot Plate Test for Stacked TetraPak Packages (time x thermal conductivity)

d. Application of tetra pack coating on GRC walls

Not only applied to the wall, the components in the tetra pack can also be applied as additional coatings on the walls or sheath components in the dominant building, so that the high humidity and solar radiation in humid tropical climates affect the performance of the walls that influence the comfort factor of occupants in the building [6]. So that with the coating or additional protection made from tetra pack can lower the room temperature during the day, thus making the walls more comfortable thermally.

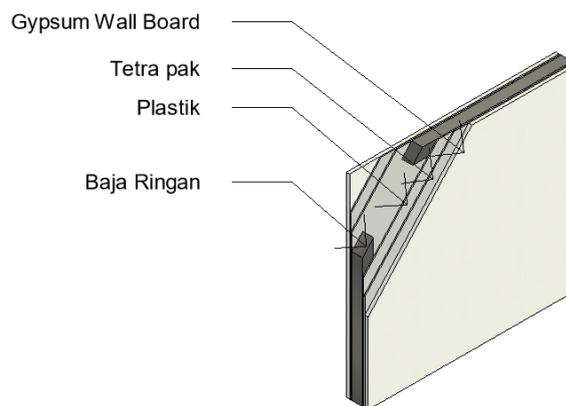


Figure 3. Application of tetra pack on the walls of buildings

4.3. Final application to the design of the building

The final application of building design in the form of planning the addition of tetra pack layers on the ceiling and partition walls of the building, because based on the literature study obtained the result that the presence of sunlight heat in the morning to evening will affect comfort at room temperature through conduction, convection, and radiation, so the selection of material specifications in the design of the building becomes important.

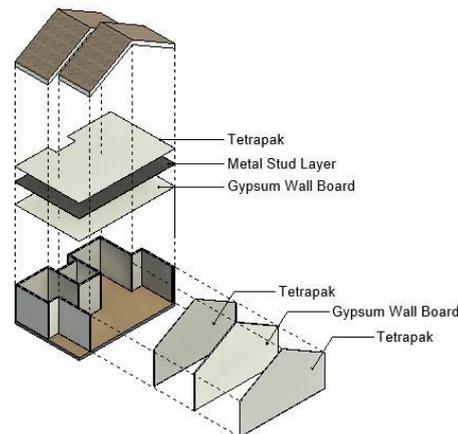


Figure 4. Building isometry

However, many of the people with the low economy are only able to provide low material specifications in their occupancy, to be able to provide thermal comfort to people with low economy occupancy, who still use the GRC Board board as a partition wall in the building can be maximized by the addition of tetra backpack conductivity coating. high and able to become an additional coating material that can reduce heat well. So that it can create the concept of energy-efficient building design, and become a solution for low society in building their dwellings, According to a study conducted by Mustofa karaboyaci in the journal "Process Design for the Recycling Of Tetra Pak Components", Tetrapak processing will be a long-term investment. The recycling sector will be one step ahead Advanced studies will also result in new technologies and reduce the need for raw materials [8]

5. Conclusion

The addition of tetra pack material in the structure of the building in this case the ceiling and partition wall, can reduce heat well, this is because tetra pak has a thermal conductivity factor that is very similar to materials with a high application as insulation material, and allows it to be developed as a prefabricated material, and applied to simple house buildings. Tetra pak material is easy to get, if not directly from the manager's factory can be obtained from recycled beverage packaging made from such as cardboard paper, so it does not cost much when choosing this material as an additional material to build a house. Tetra pak can be an alternative to the main material of the building, although it must be coated again with other materials such as GRC board and gypsum. This material is also very suitable for tropical climates such as in Indonesia because it has good heat conduction. The greatest reason why paper and carton (cardboard) manufacturers prefer recycled paper as raw materials is because they are able to obtain the cellulose necessary for paper for much cheaper. The paper that will be obtained in the envisaged project is in the form of paper-



mache (pulp), which will be a reason for preference as it will not require any additional pulpification.

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