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Combinations of building construction material for residential building for the global warming mitigation for Malaysia

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HIGHLIGHTS

- We assess seven different building schemes in Malaysia.
- Best local material for building is wood for Malaysian climate.
- Lack of interest of wood is related to the defection of wood structure.
- We propose new scheme to encourage the use of wood components in the building.
- New scheme decrease the CO_2 emission from building sector in Malaysia.

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ABSTRACT

Global warming mitigation is used as a key to devise built environment strategies and sustainable policies in developed countries that aim to reduce the rate of carbon emissions. The goal of this research is to mitigate global warming from building construction by suggesting an alternative building scheme for Malaysia. A problem related to the building industry is releasing carbon dioxide emission. Use of timber for construction has less impact on the environment due to less carbon dioxide emissions, thus making wood the best material for wall construction. However, as the Malaysian climate is hot and humid, wood encounters many defects and deteriorates. Presently, most buildings in Malaysia are built from other materials such as concrete or brick. In the last 40 years, wood materials in building schemes in Malaysia have dropped from 60% to almost 5%. This research proposed a new approach to minimize the effect of CO_2 emission for buildings as well as to improve their structural stability for a longer lifespan because these would encourage the Malaysian construction industry to use wood components in their building schemes. In this study, SIMAPRO Software was used to assess CO_2 emissions caused by seven different types of building schemes in wall constructions. The results from a simulation of three time frames of twenty, one hundred and five hundred years showed that timber scheme is the best choice for construction. To promote the use of timber, a new building scheme that would solve the problem of timber wood structure in Malaysia were proposed. The alternative building scheme has combined precast concrete and timber (H8) to improve the timber scheme deficiency while releasing less CO_2 emissions compared to other systems. Therefore (H8) could replace current building schemes. This research can facilitate decision-maker to choose the most flexible scheme for Malaysian housing. Thus, this system could be positively and widely used in the Malaysian construction industry.

1. Introduction

Building construction has a vast impact on the environment, and more importantly, buildings are responsible for producing a large portion of carbon dioxide emissions [31]. Climate change mitigation of building construction or improvement in the building construction process will lead to extensive social, financial, economic, and environmental benefits [32]. To obtain such benefits, it is not merely necessary to choose wisely the appropriate strategies or technologies, but the right materials for the local [33]. Most barriers to building material selection have been addressed with the support of analytical tools such as multi-objective optimization [34].

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Since 1958 the Keeling Curve has been used to measure carbon dioxide gas in the atmosphere generated by human activity and the result shows that CO_2 has been increasing steadily in recent years. Recent research about climate change has estimated that CO_2 level will increase by as much as 415 PPM during the Pliocene. If CO_2 levels reach 415 ppm in atmosphere, average global temperatures will rise by 3 or 4 °C and by about 10 °C warmer at the poles. Consequently sea level ranged to 10–40 beats higher than where they are today [51].

Malaysia is one of the highest CO_2 emission producers in the world [12]. Malaysia is ranked in the category of "in trouble" in terms of the ability to control carbon dioxide in the climate change performance index [9] (CCPI). Malaysia has been rated as in "very poor" condition ranking 51st of 61 countries. Hence, Malaysia is one of the poorest countries in controlling CO_2 emission. On the other hand construction and manufacturing is one of the fundamental keys to control and decrease CO_2 emissions. Therefore, this study can account for a reduction of these emissions by a focus on controlling building emissions. The goal of this research is proposing a new strategy for Malaysian construction to improve their ranking on CCPI by eliminating CO_2 emitted from the building sector.

There are plenty of studies that have compared alternative building materials and their effect on the environment. Monteiro and Freire [5] assessed seven different wall schemes and result reveal that timber wall is most preferable scheme due to less release of CO_2 emission. The problem associated with Malaysian construction is that almost new projects and buildings have been built with brick and concrete [48]. The rete of natural resource consumption in Malaysia is amongst the highest in the region and the world and one sector that appear to corporate this challenge is the building sector. Building construction and material consumption in this sector contribute significantly to carbon dioxide emissions. Therefore, need for better designs that reduce the overall contribution of the sector to climate change.

In 2009, Prime Minister of Malaysia, Datuk Seri Najib Razak announced that Malaysia would cut 40% of the carbon emission intensity by 2020, based on 2005 carbon emissions levels. However, the CCPI ranking [9,12,13,35] has shown there has been no improvement since 2005 and in fact Malaysia's ranking dropped slightly from 52nd in 2009 to 55th in 2013. While all the previous research has shown that wood is the best component for house scheme as it has less effect on climate change, why does new construction building trend in Malaysia not use timber material and the wood scheme in their own construction?

Malaysia Carbon Dioxide Emissions are at a current level of 218.76 M (2012), up from 215.52 M (2011) 1 year ago, a change of 1.50% (Malaysia Carbon Dioxide Emissions Historical Data). Results show an increasing trend every year in Malaysia despite attempts to decrease CO_2 emission [36].

Choice of appropriate material for building scheme is constantly a critical decision. This research assesses the current building schemes in Malaysia; meanwhile shows what is the problem of current construction that stops built the timber frame in Malaysia. The solution can help decision makers with the selection of an appropriate combination of materials aimed to decrease climate change.

2. Literature review

Many studies have focused on building materials and their effect on the environment. For example, a study has been conducted by Cole and Kernan [23] on office building in Canada that constructed by different structural frame materials namely wood, steel, or concrete. The result indicated that the manufacturing and production of concrete frame used more energy than production of steel and wood frames about 6% and 14%. Therefore, wood was nominated as less energy-intensive for building construction. Meanwhile, wood has a less carbon emission compared to other building material choices. Koch [24] studied about carbon emission of structural wood, steel, aluminum, concrete and brick. The result reveals that the net CO_2 emission in wood structure has less emissions and hence, less environmental impact.

Künniger and Richter [25] assessed three different materials namely: concrete, wood and steel. The result shows that wood have lower environmental impact consequently lower GHG emission, than the other materials. Another study about net GHG has accomplished by Scharai-Rad and Welling [26]. Scharai-Rad assessed the single-family house that made with wood or brick. Result reveals that net GHG emission decreased as the volume of recovered wood increased. Petersen and Solberg [37–39] assessed the applying of wood components instead of non-wood components in Norway and the result shows wood has release much lower GHG emission than non-wood components in buildings. Gustavsson and Sathre [22] studied the CO_2 emission of buildings with wood and concrete frames. The study found that wood-framed buildings had lower energy and CO_2 balances than concrete-framed buildings.

Some study has assessed the environmental impact of a single building material on the environment. Keoleian et al. [4] assessed the LC energy, greenhouse gas (GHG) emissions, and costs of a single-family house in Michigan to discover opportunities for conserving energy throughout the whole phase of the life cycle of residential building.

Other studies have compared alternative building materials and their effect on the environment. Monteiro and Freire [5] characterized the main LC processes assessing seven alternative exterior walls to identify environmentally preferable solutions. Monteiro and Freire [5] studied a Portuguese single-family house and compared three different life cycle impact assessment methods. Thus, the result of this study indicated that wood-wall is the preferable solution. Peuportier [2] accomplished a life cycle assessment study for three different houses namely: concrete blocks, house with a solar heating system and high-insulated wood house. The result shows that wood high-insulated house mainly had the lowest impacts, holding about half of the concrete house. Ortiz et al. [17] assessed the exterior and interior wall scenarios of typical block to evaluate environmental impacts during the construction phase. The CML LCIA method had been chosen to assess the GWP (global warming potential, acidification, and ionizing radiation). The result revealed that with regard to the environmental impact of global warming potential (GWP), 85% of energy is consumed during the fabrication of material while the rest was due to the energy consumed (8%), transport (6%) and waste management (1%).

Although in previous studies wood structures have been nominated as most environmentally friendly products for buildings because of zero carbon, thermal efficiency, speed of construction and design flexibility, timber houses in Malaysia are considered a forgettable house scheme. There are so many building companies and house-makers that prefer to use an alternative material for housing than timber as timber performs poorly in the humid weather in Malaysia. The report from Housing and Population Census [49] in Peninsular Malaysia shows that timber had been used more extensively in building construction in Malaysia. However, since the 1970s, it has been replaced by concrete, brick and block. Other research had reported on the defects of timber housing or the negative impact on the environment such as humidity on timber components. Many studies have assessed construction material and their related environmental impact of nature, but few studies have been able to suggest a new approach that can improve the effect of construction to the environment.