Development of Gypsum Broad Mixed with Water Hyacinth and Portland Cement Type1 for Environmental-Friendly

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DEVELOPMENT OF GYPSUM BROAD MIXED WITH WATER HYACINTH AND PORTLAND CEMENT TYPE1 FOR ENVIRONMENTAL-FRIENDLY

Abstract: This research aims to develop the gypsum broad mixed with water hyacinth and Portland cement type1. The 6 ratios of mixture were design including: a ratio gypsum broad, 2 ratios of gypsum broads mixed with water hyacinth fibers, a ratio of gypsum broad mixed with Portland cement, and 2 ratios of gypsum broads mixed with water hyacinth fibers and Portland cement type 1. These gypsum broads were mixed, poured in the molds, and installed the gypsum board papers. The TIS.219-2009 (gypsum broad standard) was used to control the property tests of gypsum boards. From the results, the proper amount of water hyacinth fibers in gypsum broads effected to decrease the density, and thermal conductivity properties of gypsum broads and also increase the surface water absorption, water absorption, longitudinal and transverse breaking load, and nail withdrawal properties of gypsum broads. And Portland cement type1 can increase the density, longitudinal and transverse breaking load, nail withdrawal, thermal conductivity properties of gypsum broads, and Portland cement type1 also can decrease the surface water absorption, and water absorption properties of gypsum boards. When compared the results and the TIS.219-2009 standard, it was found that all ratios of gypsum boards do not meet the TIS.219-2009 standard. However, the developed gypsum boards can use as same as the common gypsum board to decorate the building, although the strength of these gypsum boards are lower than the common gypsum board in market.

Keywords: Gypsum board; water hyacinth; water absorption; thermal insulation; environmental-friendly

Introduction

Gypsum boards are widely used in the building industry all over the world. These boards are very lightweight, low cost, and easy to install. The common gypsum boards are made from gypsum plaster, fiber glass and paper. The major problems of common gypsum boards are the high surface water absorption. When the gypsum boards expose to water, the gypsum plaster and fiber glass will spread to the environment (Weeranukul et al., 2018). In case of the water proof gypsum board, it is more expensive than common gypsum boards. Portland cement type1 is the binder which has more waterproof than gypsum plaster. And the water hyacinth is an aquatic plant native to the Amazon basin, and is often a highly problematic invasive species outside its native range. The fiber of water hyacinth is cellulose fibers which are linear chains of thousands of glucose units linked together allows a great deal of hydrogen bonding between OH groups on adjacent chains. These structures are tough, strong and lightweight (Ghosh et al., 1984). In Thailand, water hyacinth has been rapid expansion in waterways, clogging rivers and canals which caused the polluted water and the Thai government must spend too much money per year (The Secretariat of the Prime Minister, 2020). So this research used water hyacinth fiber in conjunction with Portland cement type1 to improve the properties of common gypsum boards and to solve the water hyacinth expansion problem. Moreover, the developed gypsum boards were able to produce by small local enterprise.

Research Methodology

The research methodology of this project can conclude as following:

Materials and Equipment

The materials and equipment of this research included gypsum plaster, Portland cement type 1, dried water hyacinth stalks, gypsum board paper, fiber granulator with 1 inch of sieve size, concrete mixing machine, mold sized 60x60x1.5 cm, oven, universal testing machine (UTM), and thermal conductivity testing apparatus.

Figure 1 Water hyacinth stalks.

Figure 2 Water hyacinth fibers grinded through 1 inch of sieve size.

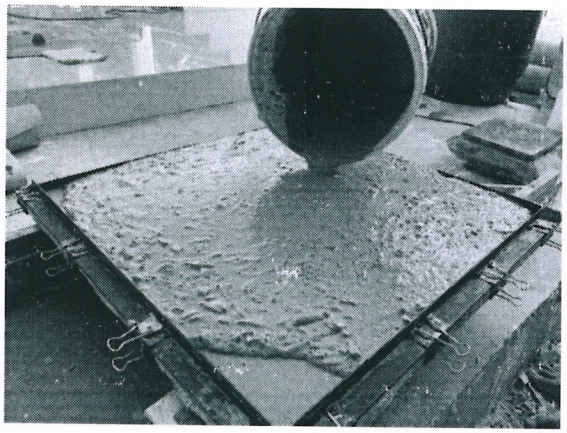

Figure 3 Pouring the mixture into the mold.

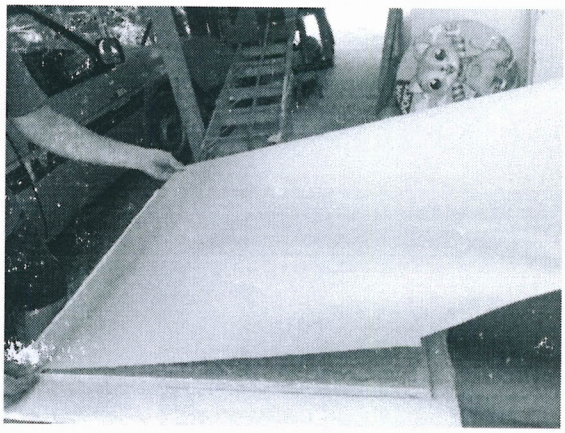

Figure 4 Gypsum board paper installation.

Mix Design

In the mix design, the 6 mixture ratios were designed by varying the amount of water hyacinth fibers to gypsum plaster, and the adding of Portland cement type1 as shown in Table 1.

Table 1 The mixture ratios of gypsum boards by weight.

Ratio / Symbol	Gypsum Plaster	Portland Cement Type1	Dried Water Hyacinth Fiber	Water
G-0	1	-	-	1
G-75	1	-	0.0075	1
G-150	1	-	0.0150	1
GC-0	0.75	0.25	-	1
GC-75	0.75	0.25	0.0075	1
GC-150	0.75	0.25	0.0150	1

Sample Casting

The sample casting processes of gypsum boards including: 1) Grinded the dried water hyacinth stalks to fiber by using the fiber granulator with 1 inch of sieve size. 2) Mixed the gypsum plaster, Portland cement type1, dried water hyacinth fiber, and water by using the concrete mixing machine as shown in Table 1. 3) Poured the mixture into the mold. 4) Sleeked and leaved the mixture in the mold for 6 hours. 5) Installed the gypsum board papers on the gypsum boards. 6) Cured the gypsum boards in the air.

Property Testing

The gypsum boards were tested by using the TIS.219-2009 standard (gypsum board) (TISI, 2009) and related standards such as ASTM C177 (ASTM, 2012). The property testing of developed gypsum boards at 28 days of curing included general characteristic, density, surface water absorption, water absorption, longitudinal breaking load, transverse breaking load, nail withdrawal, deflection, and thermal conductivity. Each ratio was tested by using the 5 samples per ratio.

Results and Discussion

From the property testing of gypsum boards mixed with water hyacinth fibers, the results and discussion were shown as following:

General Characteristic and Density

The general characteristic of 6 ratios of gypsum boards and gypsum boards mixed with water hyacinth fibers were considered by following the TIS.219-2009 standard (TISI, 2009). Sharp edges and smooth surface are the general characteristic of particleboard which all ratios of gypsum boards can pass. However, the high amount of water hyacinth fibers in gypsum boards affected to the rough of surface more than gypsum boards mixed with low amount of water hyacinth fibers. In the density results of gypsum boards mixed with water hyacinth fibers, the water hyacinth fibers affected to reduce the density of gypsum boards, while the Portland cement type1 affected to increase the density of gypsum boards. These density of gypsum boards (Figure 7) depended on the density of materials which water hyacinth fibers (406 kg/m^3) have the density less than gypsum board (868 kg/m^3) (Davies and Mohammed, 2011; Faherty and Williamson, 1995), and Portland cement type1 (1,440 kg/m^3) has the density more than gypsum board. For the chemical reaction between gypsum and Portland cement type1, the Portland cement type1 affected to decrease the setting time of gypsum (Jindaprasert and Jaturapitakkul, 2012).

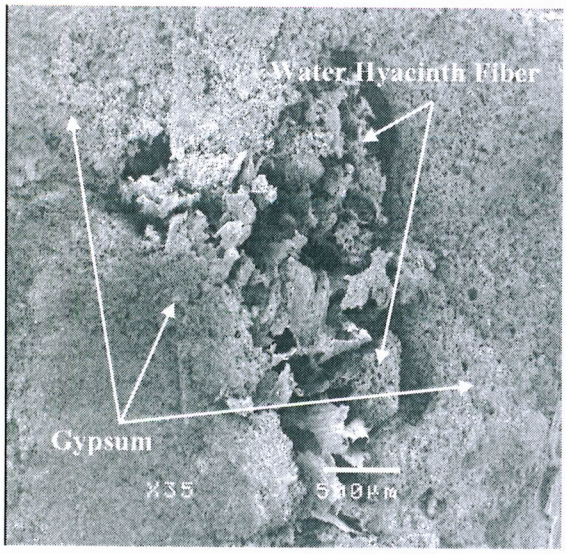

Figure 5 SEM of gypsum board mixed with water hyacinth fiber at x35.

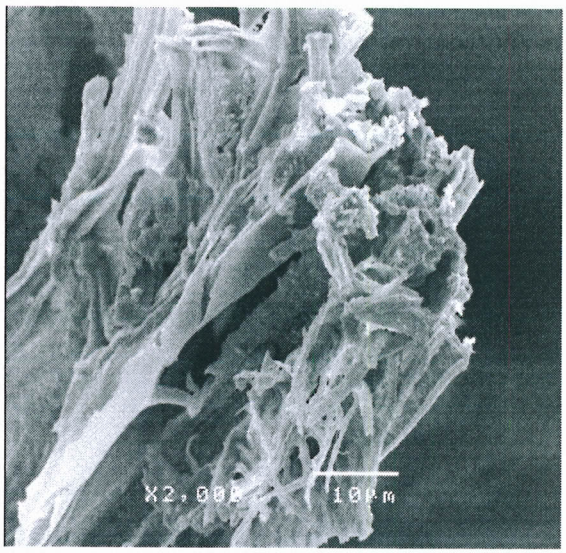

Figure 6 SEM of water hyacinth fiber at x2,000.

Surface Water Absorption and Water Absorption

The results of surface water absorption and water absorption test of gypsum boards mixed with water hyacinth fibers could be summarized as Figure 8 and 9. All ratios of gypsum boards cannot pass the TIS.219-2009 standard (waterproof type) (TISI, 2009) which required the surface water absorption less than 160 g/m^2. When compared the surface water absorption and water absorption of gypsum boards, gypsum boards mixed with Portland cement type1, gypsum boards mixed with water hyacinth fibers, gypsum boards mixed with water hyacinth fibers and Portland cement type1, it was found that the Portland cement type1 can decrease the surface water absorption and water absorption of gypsum boards because the Portland cement type1 is an insoluble material. But the water hyacinth fibers affected to increase the surface water absorption and water absorption of gypsum boards. Because of the water hyacinth fibers is a porous material which it can absorb the water (Davies and Mohammed, 2011; Weeranukul et al., 2018).

Longitudinal Breaking Load and Transverse Breaking Load

From the results of longitudinal and transverse breaking load tests of gypsum boards mixed with water hyacinth fibers in Figure 10 and 11, it was found that all ratios had the longitudinal and transverse breaking load less than the TIS.219-2009 standard (it must more than 620 N and 260 N, respectively) (TISI, 2009). But the proper amount of Portland cement type1 and water hyacinth fiber can improve the longitudinal and transverse breaking load properties. According to the higher strength of Portland cement type1 when compared to gypsum, so the mixing of Portland cement type1 will improve the strength of gypsum board. In case of reinforcement of gypsum boards by using the water hyacinth fibers, the water hyacinth fiber is a cellulose material that can improve the strength of gypsum board (Sair et al., 2019; Bledzki and Gassan, 1999).

Nail Withdrawal

According to the test results of nail withdrawal of gypsum boards mixed with water hyacinth fibers in Figure 12, it was found that all ratios had the nail withdrawal less than the TIS.219-2009 standard (it must more than 400 N) (TISI, 2009) as same as the longitudinal and transverse breaking load test. But the proper amount of Portland cement type1 and water hyacinth fiber can improve the nail withdrawal properties of gypsum boards too. These were affected from the strength of Portland cement type1 and water hyacinth fiber which are more strength than the gypsum (Weeranukul et al., 2018).

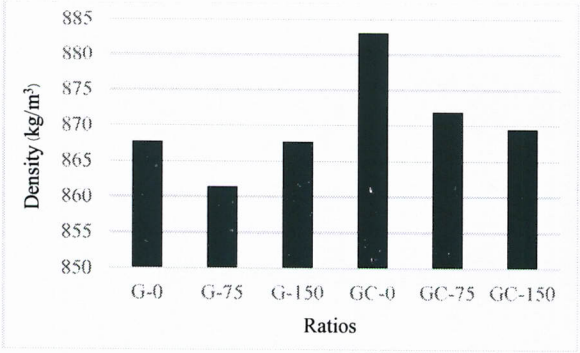

Figure 7 Density of gypsum boards.

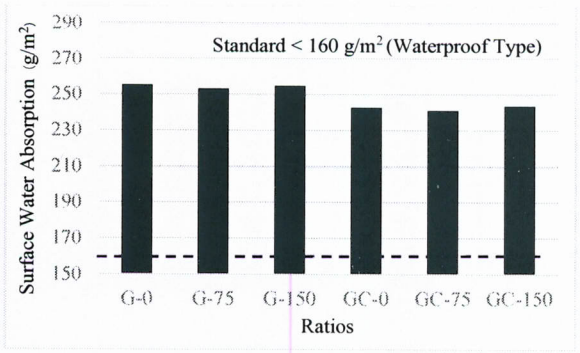

Figure 8 Surface water absorption of gypsum boards.

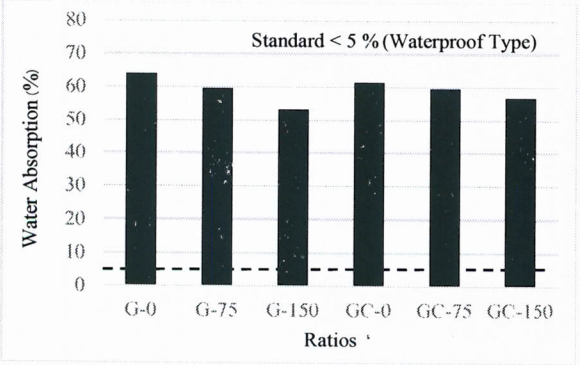

Figure 9Water absorption of gypsum boards.

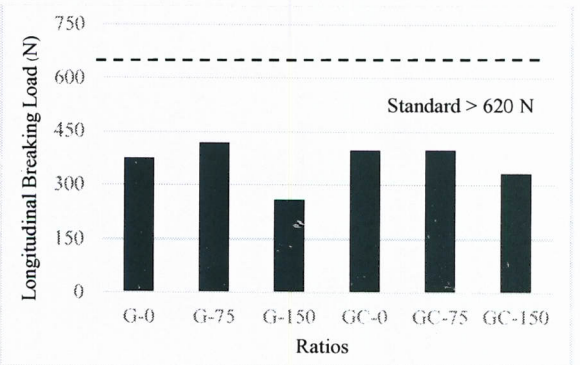

Figure 10 Longitudinal breaking load of gypsum boards.

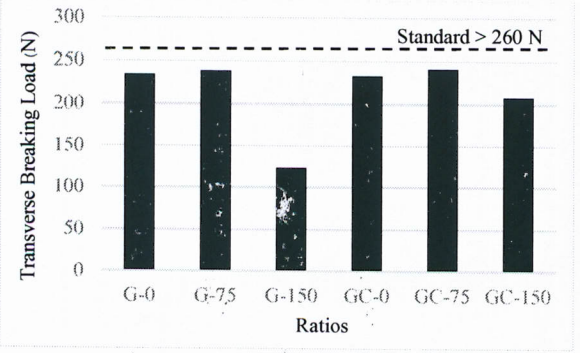

Figure 11 Transverse breaking load of gypsum boards.

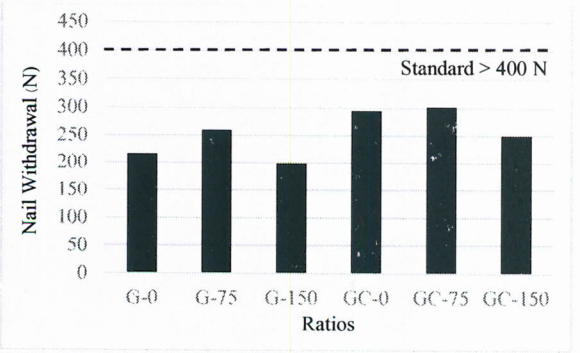

Figure 12 Nail withdrawal of gypsum boards.

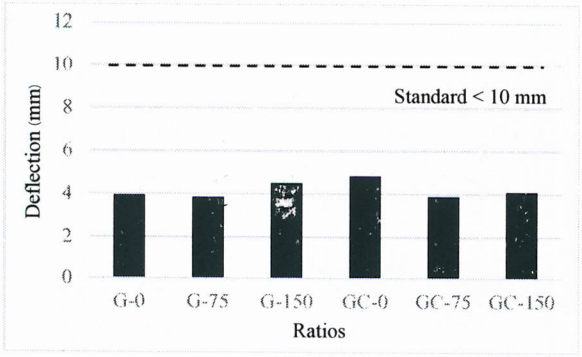

Figure 13 Deflection of gypsum boards.

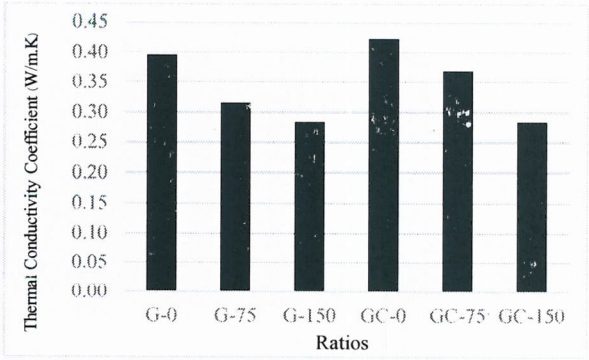

Figure 14 Thermal conductivity of gypsum boards.

Deflection

From the results of deflection tests of gypsum boards mixed with water hyacinth fibers in Figure 13, it was found that all ratios had the deflection properties less than the TIS.219-2009 standard (it must less than 10 mm) (TISI, 2009). These results shown that the grinded water hyacinth fibers had too short, so the fibers were difficult to reinforce the deflection properties of gypsum boards (Weeranukul et al., 2018; Bledzki and Gassan, 1999). However, the high amount of Portland cement type1 can improve the deflection properties of gypsum boards mixed with water hyacinth fibers.

Thermal Conductivity

From the results of thermal conductivity of gypsum boards in Figure 15, the water hyacinth fibers can improve the good thermal insulation of gypsum boards. Because of the water hyacinth fibers are the porous material (see Figure 6) which made the water hyacinth fibers to be low thermal conductivity coefficient (Park et al., 2019; Tanunchai et al., 2006). These gypsum boards have the thermal conductivity coefficient lower than other construction materials such as the concrete (1.95 W/m.K), concrete block (0.519 W/m.K), and brick (0.473 W/m.K) (Weeranukul et al., 2018).

Conclusion

In conclusion, the water hyacinth fibers can use as the raw material for improving the density, longitudinal and transverse breaking load, nail withdrawal, deflection, and thermal insulation properties of gypsum boards. But the water hyacinth fibers also affected to increase the surface water absorption and water absorption values. Although the water hyacinth fibers can improve many properties of gypsum boards, but the all ratios of gypsum boards mixed with water hyacinth fibers still cannot meet the TIS.219-2009 standard. For the mixing of Portland cement type1, Portland cement type1 also can improve the surface water absorption, water absorption, longitudinal and transverse breaking load, nail withdrawal, and deflection properties excepted the density and thermal insulation properties. The developed gypsum boards can use as same as the common gypsum board to decorate the building, although the strength of these gypsum boards are lower than the common gypsum board in the market. This research shown that the water hyacinth fibers and Portland cement type1 can use to improve the

properties of gypsum board, but the developed gypsum boards have to reinforce with other materials to meet the TIS.219-2009 standard.

Acknowledgements

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