# Utilization of Cogon Grass as a Thickener for Common Gypsum Boards

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***Abstract:*** **Gypsum boards are commonly known as drywall, plasterboards, Sackett board or wallboard. These boards are made of calcium sulfate dihydrate ($CaH_4O_6S$). Common gypsum boards contain paper as a thickener for less consumption of gypsum powder. The focus of the study was to develop a suitable mixture of cogon pulps in gypsum boards (*Imperata cylindrica*) as a substituting agent and a thickener for gypsum boards for which the researchers refer as the "cogoflex." Modulus of rupture, Screw pull resistance, weight per unit area, surface fire test, water absorption and thickness swelling test were performed in the study. The percentage of cogon pulps used to add to the mixture of the specimens are 0%, 5%, 10%, 15%, and 20%. The researchers were able to determine the most suitable proportion of cogon pulps that will be added to the mixture of gypsum.**

***Keywords*: Gypsum board, Cogon, grass, fiber reinforced board, drywall, plaster of Paris.**

## I. INTRODUCTION

Gypsum boards or plasterboards are boards that made of calcium sulfate dihydrate (CaH4O6S) and are widely used in interior application since it reduces the time and cost of construction. However, its mixture contains shredded paper to reduce consumption of gypsum, because gypsum consists of sulfate which may cause concrete deterioration. Thus, to decrease the concentration of calcined gypsum and to keep the quality of concrete for the longer period, the researchers aim to utilize the use of dried Cogon Grass (*Imperata Cylindrica)* as a substituting agent and a thickener for gypsum boards.

Cogon grass is globally known as a pest and one of the top ten worst weeds in the world. It affects the lives of vegetation around, wildlife habitat, recreation, site management, and even native plants that can only be found in specific places. Cogon grass fields are often burned after being cut. In some cases, farmers tend to burn the entire field to perform the farming technique called "*kaingin*" where people slash and burn fields, which can become destructive for the environment resulting in dangerous erosion [1]. Due to this different researches were conducted to utilize the potential use of cogon grass. Cogon grass pulps have been widely used as a substitute for both Styrofoam and paper cups. In a research conducted in the Philippines, it was actually found to be successful in reusing it for packaging materials. The specified study focused on the possibility of cogon grass as a replacement for a paper sheet to lessen environmental problems involving the depletion in the numbers of trees that is commonly used to make papers. Three different tests were performed on the samples produced including the strength test, water retention, and qualitative test which the results showed the feasibility of using pulps from cogon grass [2]. It contributed the methodology for extracting cogon pulps and the required chemical to be used in this study to obtain the desired material. One of the major benefits that the researchers see is that cogon grass grows at a rapid speed, which means that cogon grass' pulp can be produced noticeably quicker than shredded papers.

In recent years, natural fibers as reinforcement into gypsum composites have received much attention to see its performance and effectiveness. On a research, Assessment of Compression Resistance of Natural Fibers-Reinforced Gypsum Composites, the natural materials were prepared from the admixtures of sugarcane straw, sugarcane bagasse and classified pulp of bagasse with the concentrations of 1wt.%, 2 wt.%, 5 wt.%, 10 wt.%, and 20 wt.%. The ratio of water to gypsum used was 0.7 in all preparations while in pure gypsum was 0.4 and 0.7 respectively. Mechanical properties of the produced materials were tested. The best results obtained in reinforced gypsum was when the wt. the percentages were 1% and 2% of fibers used as reinforcement. The modulus was greater for the specimens when they are compacted. Mechanical properties of the samples were heavily affected by the amount of water present. The application of resin can possibly improve the needed performance of gypsum composites [3].

A study entitled Natural Fibers Reinforced Gypsum Composites discussed the use of a new construction material composed of gypsum and natural fibers, that some of the properties have potentiality of being useful in the technical aspect. The tests conducted in this research were in accordance with their specific standards, thermal insulation, and some of its mechanical properties namely compressive strength, flexural strength and for physical properties were moisture content and density. The natural fibers selected in the study are coir, jute, banana fiber, cotton, and wool. The researchers conclude that base on the results they obtain from the test they have done, the composite material will have good uses in false ceiling tile and non-load bearing wall partitioning since its density has decreased as fiber volume fraction increases its value [4].

The researchers aim to utilize wastes like dried cogon grass that comes in a massive amount and make it as a substitute for shredded paper. Also, to produce drywall with less sulfate content compared to the common gypsum boards that are available in the market. Cogon-based gypsum board may also catch future manufacturers' eyes and gradually utilize wild grasses not only for gypsum boards but also for other materials on site. With tons of cogon grass decomposing after being cut, turning it into a significant element for construction is something to be considered.

The objectives of this study are to (a) determine the most suitable proportion of cogon grass pulp that will be added to the mixture of gypsum that will also pass to the packaging and transportation test requirements based from the ASTM Standards, (b) to compare the physical properties weight per unit area, as well as the mechanical properties including the modulus of rupture and screw pull resistance of the cogon-based and common gypsum boards and (c) evaluate the cost of the appropriate mix design of the cogon pulps versus the commercial gypsum board.

This study focuses on the effects of using cogon pulps as an organic thickener or additive for gypsum boards to increase the volume of the gypsum slurry while having decreased concentration of gypsum. The number of cogon pulps to be added to the gypsum slurry will vary from 0%, 5%, 10%, 15%, and 20%, relative to the weight of the gypsum powder. The testing that will be conducted will circulate around the board's mechanical properties which are the modulus of rupture and screw pull resistance, also its physical properties including weight per unit area, water absorption, thickness swelling, and surface fire test. Only dried and cured cogon grass that was harvested will be used in addition to the fundamental composition of the common gypsum boards like water, calcined gypsum powder, and other chemical additives.

**Statement of the Problem:**

In today's era, the truth about modern construction is that most of the developers prioritize progress after safety and stability, leaving the economic state behind. It is the reason why engineers brought up the use of plasterboards or gypsum boards in the industry. It was initially called as "Sackett board" and was invented by the U.S. Gypsum Company named after the Sackett plaster company. It is a man-made material primarily used in the construction of the interior walls of a building (Allen, 2006). Technically, calcined gypsum powder or others call it "Plaster of Paris," is mixed with water, shredded paper, and foaming additives to form a slurry textured mixture. The slurry is then poured to a frame bedded with a thick sheet of paper to the desired thickness before fully sandwiching the mixture.(Business, 2016). Gypsum, however, isn't only applicable in the construction industry as it is also widely used in dentistry to make a replica of a person's teeth, in subtractive sculpting, and in farming as a soil additive.

On the other hand, gypsum consists of sulfate, and it poses a potential risk specifically to concrete. Sulfate attack is characterized into an internal attack and external attack. An internal sulfate attack occurs when a sulfate-based material is incorporated to concrete at the time of mixing while external sulfate attack occurs when sulfate particles from adjacent materials penetrate the concrete. Either of the two may cause extensive concrete cracking, expansion, and loss of bond between the cement paste and aggregates for which may further lead to the overall weakening of the concrete(Winter, 2012). And as cement with low heat of hydration isn't always available to small scale construction, this is where a full gypsum concentrated drywall becomes a disadvantage.

Relatively, cogon grass fields are often burned after being cut. In some cases, farmers tend to burn the entire field to perform the farming technique called "kaingin" where. People slash and burn fields, which can become destructive for the environment resulting in dangerous erosion (Locueville, n.d.).

These concerns fueled the researchers to study the use of cogon grass as a sustainable substitute material to be added to gypsum slurry to form a drywall. With tons of cogon grass decomposing after being cut, turning it into a significant element for construction is something to be considered. The researchers refer to it as "Cogoflex," a name derived from the combination of Cogon Grass & Hardieflex. One of the goals of the research is to utilize wastes like dried cogon grass that comes in a massive amount and make it as a substitute for shredded paper. The researchers also aim to produce drywall with less sulfate content compared to the common gypsum boards that are available in the market.

The product material of 12.7mm thickness must reach the ASTM standards.

**Objectives of the Study:**

The general objective of the study is to develop a cogon-based gypsum board that utilizes dried cogon grass as an additional thickener for the gypsum slurry. Specifically, the study aimed to:

1. To determine the most suitable proportion of cogon grass pulp that will be added to the mixture of gypsum that will also
   pass to the packaging and transportation test requirements based from the ASTM Standards.
2. To compare the physical property weight per unit area, as well as the mechanical properties including the modulus of rupture and screw pull resistance of the cogon-based and common gypsum boards.
3. To evaluate the cost of the appropriate mix design of the cogon pulps versus the commercial gypsum board.

**Significance of the Study:**

Cogon grass is globally known as a pest and one of the top ten worst weeds in the world. It affects the lives of vegetation around, wildlife habitat, recreation, site management, and even native plants that can only be found in specific places. Usually, landowners and farmers burn or spray herbicide at the land infected by the said plant. Despite the efforts to eradicate the growth of this plant, it still finds its way to grow. The researchers thought that instead of forcefully removing the plant, reusing it as a sustainable part of construction material may become a plan with sense.

One of the major benefits that the researchers see is that cogon grass grows at a rapid speed, which means that cogon grass' pulp can be produced noticeably quicker than shredded papers. With fewer to no papers to be used, fewer trees are needed to be cut, making the proposed project environmentally inclined. In line with that, cogon grass when trimmed is also considered as organic waste. But giving the plant a purpose like this, it can potentially create opportunities for people that can be called as "cogon harvesting".

The study and implementation of the product will also benefit the construction side by decreasing the concentration of calcined gypsum compared to the common gypsum boards. As what the researchers have mentioned in the previous sections, gypsum being consisted of sulfate makes it a threat for concrete in the long run. Having an eco-friendly gypsum board with lesser chemicals in it devises a new innovation that can someday be applied and brought into the new generation of green buildings. Though the usage of Cogon pulps isn't new, its application to gypsum boards sets it apart from other researches about construction materials. Cogon pulps have been widely used as a substitute for both Styrofoam and paper cups. It was actually found to be successful in reusing it for packaging materials. Having that outcome, cogon-based gypsum board or what the researchers refer to as the "Cogoflex" may also catch future manufacturers' eyes and gradually utilize wild grasses not only for gypsum boards but also for other materials on site.

**Conceptual Framework:**

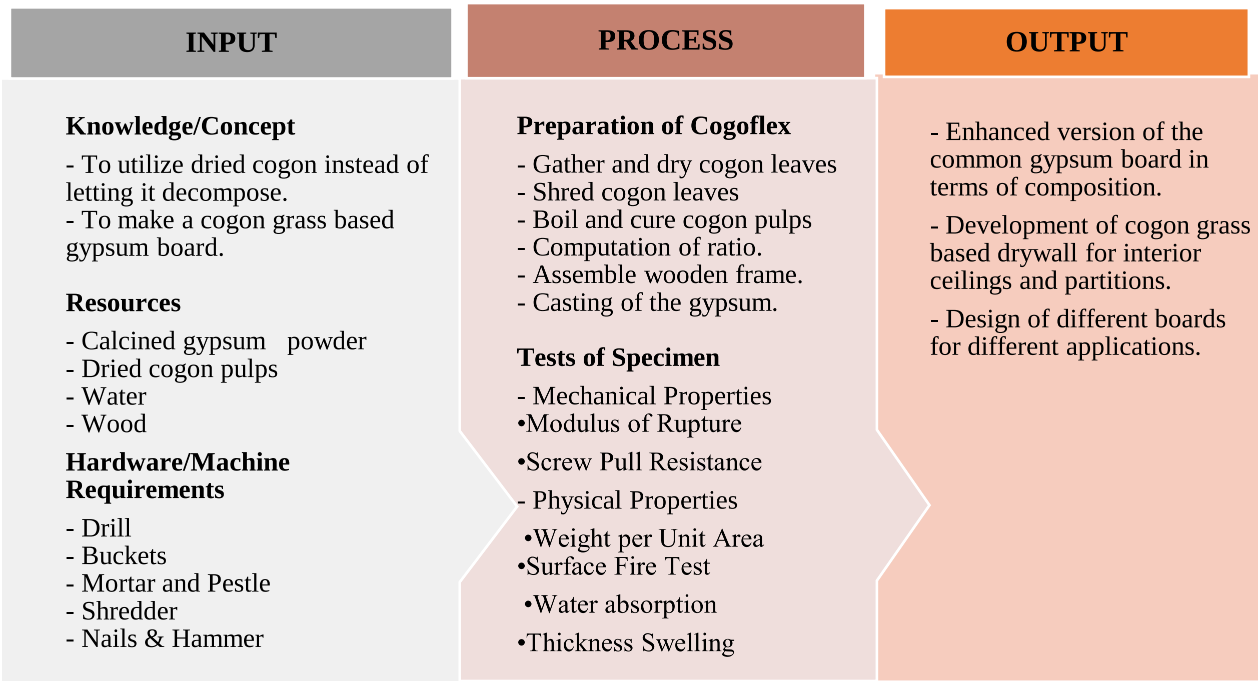


**Figure 1: Theoretical Conceptual Framework**

**Scope and Delimitation:**

This study focuses on the effects of using cogon pulps as an organic thickener or additive for gypsum boards to increase the volume of the gypsum slurry while having decreased concentration of gypsum. The number of cogon pulps to be added to the gypsum slurry will vary from 0%, 5%, 10%, 15%, and 20%, relative to the weight of the gypsum powder. The testing that will be conducted will circulate around the board's mechanical properties which are the modulus of rupture and screw pull resistance, also its physical properties including weight per unit area, water absorption, thickness swelling, and surface fire test. The modulus of rupture, water absorption, thickness swelling and surface fire test will be based from the standards from the ASTM while the screw pull resistance shall be based from the standards followed on the research about gypsum particleboard. Only dried and cured cogon grass that was harvested will be used in addition to the fundamental composition of the common gypsum boards like water, calcined gypsum powder, and other chemical additives

**Definition of Terms:**

To understand the overall characteristic of the project, the following technical terms must be clarified:

**Calcium Sulfate Dihydrate ($CaH_4O_6S$).** The chemical composition of gypsum board.

**Cogoflex.** The term coined by the researchers to call the cogon-based gypsum boards.

**Drywall.** Another term for gypsum board on site.

**Gypsum.** A sulfate mineral composed of calcium sulfate dihydrate used for creating gypsum boards and teeth replicas.

**Hardieflex.** A common fiber-cement board that is widely used in the industry of construction.

**Plaster of Paris.** The common term for gypsum powders in the Philippines.

**Sackett Board.** The first name of the gypsum board when it was first initially released.

**Slurry.** A mixture of gypsum powder, shredded organic and dry materials, and water.

**Review of Related Literature:**

This chapter focuses on the study of how gypsum boards are efficiently utilized in almost any construction industry and how cogon pulps are extracted from the grass itself. This also explains the required values on various test conducted that is not stated in any ASTM chapter.

## II. RESEARCH METHODOLOGY

This section presented the research's methodology and design in attaining the objectives of the study.

**Research Design:**

The study entitled "Utilization of Cogon Grass as a Thickener for Common Gypsum Boards" is an experimental investigation that seeks to discover the effectiveness of utilizing cogon grass pulps as a natural thickener for gypsum boards.

**Project Development:**

**1. Extraction of cogon pulps.** The dried Imperata Cylindrica was boiled for at least three hours. The cogon grass was pulped using caustic soda and water for at least two hours. The proportion of the majority of the cogon grass to caustic soda is 1:0.18 in kilograms. After extraction, the pulps were ground, compressed, and dried to determine its dry density and mass before adding it to the gypsum slurry.

**2. Gypsum slurry.** The extents of cogon pulps that were added to the slurry, in light of the researchers' evaluation, it was shift from 0%, 5%, 10%, 15%, and 20% comparative with the mass of the gypsum powder. The equation that was utilized to ascertain the extent is: $\boldsymbol{M_{CP}} = (\boldsymbol{P_{CP}})(\boldsymbol{M_{GP}})$. Where $\boldsymbol{M_{CP}}$ represents the mass of cogon pulps, $\boldsymbol{P_{CP}}$ represents the level of cogon pulps, and $\boldsymbol{M_{GP}}$ represents the mass of the gypsum powder.

After determining the mass of the cogon pulps, water and gypsum powder was mixed at a water-gypsum proportion of 1:2 in volume. Cogon pulps was slowly added into the mixture while continually mixing the mixture.

**3. Casting of the gypsum.** Gypsum slurry was placed into frames with measurements as per testing examples. The mixture was permitted to set and was unmolded following 60 minutes. The samples were restored via air drying for in any event 3 days before testing.

**Mechanical Properties:**

The testing that will be conducted will circulate around the board's mechanical properties which are the modulus of rupture that was based from ASTM-C1396 and screw pull resistance. The specimens for modulus of rupture and screw pull resistance was measured 14 days after manufacture. The outcomes were calculated from the arithmetic average of a series 3 specimens for each sample.

The modulus of rupture (MOR) was determined using the equation: $\boldsymbol{MOR} = \frac{3\,FL}{2\,wd^2}$

F = Force applied (N) W = width of the specimen (mm)

L = Length between support (mm) D = depth of the specimen (mm)

**Physical Properties:**

For the physical properties, the standards for weight per unit area, water absorption, and thickness swelling was based from ASTM-C1396 while surface fire test was based from ASTM-E119. The calculation of water absorption and thickness swelling, the specimen was immersed in water for about two hours and 24 hours. The specimen's weight was measured prior to immersion, and then measured again after immersion.

Water absorption and thickness swelling was determined using the equation:

$$\boldsymbol{water\ absorption}\ (\%) = \frac{Mw-Md}{Md}\ \boldsymbol{x\ 100}$$

Mw = Mass of the specimen after immersion (kg) Md = Mass of the specimen before immersion (kg)

Thickness swelling was determined using the equation = $\textit{thickness swelling}\ (\%) = \frac{Tf-Ti}{Ti}\ x\ 100$

Ti = Thickness before immersion(mm) Tf = Thickness after immersion in water (mm)

The samples for the Weight per Unit Area was additionally measured 14 days after manufacture, it was calculated by multiplying the density and the thickness of the specimen.

$$\textit{weight per unit area} = \rho \bullet t = \frac{m}{v} \bullet t$$

$\rho$ = density ($\frac{kg}{m^3}$) t = thickness of the specimen (mm)

v = volume of the contact specimen ($mm^3$) m = mass of the specimen (kg)

**Project Testing, Evaluation, & Validation:**

**1. Modulus of Rupture**

**TABLE 1: MODULUS OF RUPTURE OF GYPSUM BOARDS AS STATED IN ASTM-C1396**

| Effective Modulus of Rupture (MOR) (minimums) (Based on Flexural Strengths per ASTM C 1396) | | | | |
|---|---|---|---|---|
| Thickness in. (mm) | Machine Direction | | Cross Direction | |
| | psi | MPa | psi | MPa |
| 3/8 (9.5) | 970 | 6.7 | 350 | 2.4 |
| 1/2 (12.7) | 750 | 5.2 | 260 | 1.8 |
| 5/8 (15.9) | 660 | 4.6 | 220 | 1.5 |

**2. Screw-pull Resistance**

**TABLE 2: SCREW PULL RESISTANCE AS REPORTED BY FRICK (1988) FOR GYPSUM BOARDS**

| Board Type | Screw Pull Resistance (Force) |
|---|---|
| Gypsum Cardboard | 60N to 80N |
| Gypsum Flakeboard | 300N to 400N |
| Gypsum Fiberboard | 400N |
| Gypsum Particleboard | 400N to 800N |

**3. Weight per unit Area**

**TABLE 3: COMMON GYPSUM BOARD WEIGHT PER UNIT AREA**

| Weight per Unit Area (for use in calculating dead loads) | | |
|---|---|---|
| Thickness in. (mm) | Weight | |
| | psf | kg/m² |
| 1/4 (6.4 mm) | 1.2 | 6.0 |
| 5/16 (7.9 mm) | 1.3 | 6.4 |
| 3/8 (9.5 mm) | 1.4 | 6.8 |
| 1/2 (12.7 mm) | 2.0 | 9.8 |
| 5/8 (15.9 mm) | 2.5 | 12 |
| 1 (25.4 mm) | 4.0 | 20 |

**Test Conduction & Data Analysis:**

The researchers will base the research outcome from ASTM-C1396, testing methodology from ASTM-C437, screw pull resistance based from the values reported by (Frick, 1988) as used in the research by (Espinoza-Herrera & Cloutier, 2011) and fire resistance test based from the ASTM E119. On the flexural test, the researchers must test the bending of the board both parallel and perpendicular to the cross-sectional grain.

## III. RESULTS AND DISCUSSION

This chapter deals with the gathered data and interpretation of the results in relation to the objectives of the study. This chapter discusses the result of the various tests conducted on certain samples. This section is divided into 8 tables; (a) Modulus of rupture (perpendicular), (b) Modulus of rupture (parallel), (c) Screw pull resistance, (d) Weight per unit area, (e) Fire resistance.

**Results of the Test:**

**TABLE 4: RESULTS OF MODULUS OF RUPTURE TEST - PERPENDICULAR**

| MODULUS OF RUPTURE (PERPENDICULAR) | | | | | |
|---|---|---|---|---|---|
| **SPECIMEN** | **AGE OF CURING (days)** | **L (mm)** | **w (mm)** | **d (mm)** | **MODULUS OF RUPTURE (Mpa)** |
| 0 % | 7 | 136 | 12.96666667 | 51.38886667 | 2.3460 |
| 5 % | 7 | 136 | 13.39996667 | 51.06666667 | 1.9300 |
| 10 % | 7 | 136 | 13.99446667 | 49.8889 | 1.2813 |
| 15 % | 7 | 136 | 14.4111 | 49.47776667 | 1.1945 |
| 20 % | 7 | 136 | 13.76666667 | 50.36113333 | 1.0177 |

**TABLE 5: RESULTS OF MODULUS OF RUPTURE TEST - PARALLEL**

| MODULUS OF RUPTURE (PARALLEL) | | | | | |
|---|---|---|---|---|---|
| **SPECIMEN** | **AGE OF CURING (days)** | **L (mm)** | **w (mm)** | **d (mm)** | **MODULUS OF RUPTURE (Mpa)** |
| 0 % | 7 | 136 | 51.13333333 | 12.73333333 | 3.1151 |
| 5 % | 7 | 136 | 51.17776667 | 13.21666667 | 2.5351 |
| 10 % | 7 | 136 | 50.43886667 | 14.5222 | 1.7247 |
| 15 % | 7 | 136 | 49.98886667 | 14.2 | 1.5643 |
| 20 % | 7 | 136 | 50.56656667 | 13.45546667 | 1.4043 |

**TABLE 6: RESULTS OF SCREW PULL RESISTANCE TEST**

| MODULUS OF RUPTURE (PERPENDICULAR) | | | | | |
|---|---|---|---|---|---|
| **SPECIMEN** | **AGE OF CURING (days)** | **L (mm)** | **w (mm)** | **d (mm)** | **SCREW PULL RESISTANCE (N)** |
| 0 % | 7 | 5 | 5 | 12 | 352.36 |
| 5 % | 7 | 5 | 5 | 12 | 283.11 |
| 10 % | 7 | 5 | 5 | 12 | 226.27 |
| 15 % | 7 | 5 | 5 | 12 | 211.47 |
| 20 % | 7 | 5 | 5 | 12 | 154.90 |

**TABLE 7: RESULTS OF WEIGHT PER UNIT AREA**

| WEIGHT PER UNIT AREA ( kg / m² ) | | | |
|---|---|---|---|
| **SPECIMEN** | **b (mm)** | **DENSITY (kg/m³)** | **WEIGHT PER UNIT AREA ( kg / m² )** |
| 0% | 12.85 | 1263.28 | 16.22 |
| 5% | 13.31 | 995.98 | 13.25 |
| 10% | 14.26 | 806.63 | 11.50 |
| 15% | 14.31 | 740.38 | 10.50 |
| 20% | 13.61 | 670.50 | 9.12 |

TABLE 8: RESULTS OF SURFACE FIRE RESISTANCE TEST

| SURFACE FIRE RESISTANCE | | | | |
|---|---|---|---|---|
| SPECIMEN | b (mm) | w (mm) | Time (min) | TEMPERATURE CELCIUS, °C |
| 0% | 50 | 150 | 3:00 | 89.06 |
| 5% | 50 | 150 | 3:00 | 86.76 |
| 10% | 50 | 150 | 3:00 | 81.26 |
| 15% | 50 | 150 | 3:00 | 72.23 |
| 20% | 50 | 150 | 3:00 | 70.36 |

**Analysis and Interpretation of Data:**

The mixture of the cogon pulps and gypsum powder affects the mechanical properties and physical properties of a gypsum board. As the volume of cogon pulps increases, its modulus of rupture and screw withdrawal resistance deceases. The result for thickness of swelling and water absorption was determined that the higher amount of pulps leads to higher percentage of the water absorption and thickness of swelling. While in weight per unit of area, as the cogon pulps increases, the weight per unit of area falls. Having a higher amount of pulps in gypsum, can developed high smoke emission.

## IV. SUMMARY, CONCLUSION, AND RECOMMENDATION

**Summary:**

The rapid growth of the construction industry requires numerous factors to be more economical such as construction materials. The utilization of cogon grass as a thickener to common gypsum board aims to provide a more economical gypsum board that utilizes materials extracted from a vegetation pest, cogon grass.

Papers, on the other hand, require wood that needs to be cut from trees while cogon grass grows almost at anywhere regardless of site conditions. Majority of the common gypsum board / gypsum cardboard is composed of papers, and as cogon grass yields a reasonable amount of paper pulp, the researchers thought that utilizing such material for gypsum boards would be feasible. The extraction of pulp from cogon grass requires a chemical named “Sodium Hydroxide” or “Caustic Soda” that would extract the pulp upon boiling.

The purpose of the study was to determine the appropriate amount of the cogon pulp to be added, compare the mechanical and physical properties of cogon-based gypsum boards, and evaluate the cost that would be needed if the pulps were to be imposed to the production of gypsum board. The researchers chose the 12.7 mm thickness to be the reasonable thickness and to attain that, the following tests and its initial parameters were considered: Water Absorption Test (9.8 $kg/m^2$), Modulus of Rupture – Perpendicular (1.8 MPa), Modulus of Rupture – Parallel (5.2 MPa), Screw Pull Resistance (60N to 80N), and tests like Water Absorption (24 hrs immersion), Water Absorption (2 hours immersion), Surface Fire Test, and Swelling.

**Conclusion:**

The specimen with 5% concentration of cogon pulp relative to the mass of the gypsum powder has the closest results value next to pure gypsum that also qualifies in the ASTM Standards.

Comparing the properties of the 5% concentration of cogon pulps gypsum board with common gypsum board having the initial parameters as per ASTM for 12.7 mm specimens were: 1.8 MPa on Modulus of Rupture at Perpendicular direction, 5.2 MPa on Modulus of Rupture at Parallel direction, and 9.8 kg/m2 of weight per unit area and the initial parameters for the screw pull resistance was adapted from [5] at 80 N for gypsum cardboards / common gypsum boards. The results obtained were 1.93 MPa of Modulus of Rupture at Perpendicular direction, 2.53 MPa of Modulus of Rupture at Perpendicular direction, 13.25 kg/m2 of weight per unit area, and 283.21 N of Screw Pull Resistance. Based from the given results, only the mechanical properties including screw pull resistance and the Modulus of Rupture in Perpendicular (MOR) of the 5% cogon concentration passed the required parameters.

As far as the cost, the 5% concentration of cogon pulp relative to the mass of the gypsum powder was not able to beat the price of the common gypsum cardboard having a cost of PHP 16.85 compared to the 5% having a cost of PHP 28.98 both having dimensions of 30 cm x 40 cm due to the following reasons: (1) common gypsum cardboards or commercial boards only contains 25% of gypsum powder, and 75% is composed of air [6], (2) the researchers focused on the pure strength of gypsum without any additives nor covering to ensure that the results that will be gathered from the tests are genuine and that no additive may affect the results of the tests. However, comparing the costs between 0% cogon pulp and 5% cogon pulp, there is a notable difference in costs of 17.56%.

**Recommendations:**

The study proved that the cogon grass pulp can be utilized as a thickener in gypsum board, but there are numbers of possible improvements in this study that would benefit further researches including the following:

1. While this study focused only on the material utilization in common gypsum board, further studies may also try other types of gypsum boards including prefabricated gypsum boards.

2. Further studies may use other kinds of grass in incorporation to gypsum board to determine the best replacement for common paper or foaming agents.

3. The application of different types of papers as a thickener and the suitability of grass paper as a cover for the gypsum board could be furtherly studied.

4. It is recommended to use a much bigger cauldron and machine grinder for the extraction of pulp, to produce more papers in a shorter time.

5. Further studies may also improve the physical and mechanical properties of the gypsum board that surpass the given standards of the material by also utilizing grass papers as an external cover for gypsum boards.

6. Future researchers may study the effect of adding foaming agents to cogon-based gypsum board to determine the effect of using cogon pulp into a foamed gypsum board.

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