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Physical Properties Analysis and Quality Assessment of Gypsum-Kalsiboard Marketed in Ambon City

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ABSTRACT

The objectives of this research were to analyse the physical properties and quality assessment of Gypsum Kalsiboard in the Ambon city market so that the physical properties of the boards and their quality are analysed and controlled. The material used was composite board in the form of gypsum-kalsiboard panels with length of 244.0 cm, width of 122.0 cm and thickness of 3.5 mm. This experimental model used Completely Randomized Design (CRD) and assessment the quality by control chart evaluated using 3-sigma control limits through the Upper Control Limit (UCL) and lower control limit (LCL). The result showed that the average of overall density was about of 1.41 g/cm^3, moisture content of 9.12%, water absorption of 25.21% and thickness swelling about of 1.91% which meets the standard limits required by SNI No. 03-6434-2000. Although by quality assessment there were several points that are above the upper control limit (UCL) and below the lower control limit (LCL), the physical properties values of this board were still within the tolerance limits because the condition of the board does not show significant changes such as those related to water absorption and thickness swelling, indicating that the board was quite stable and high dimensional stability after 24 hours of immersion.

Introduction

Composite board is a material formed from a combination of two or more materials that have stronger of mechanical properties than the constituent material (Haygreen, 1982; Simatupang et al., 1991; Subiyanto, 1998). Composites consist of two parts, namely the matrix as a binder or composite protector and a filter as composite filler. The constituent materials have different properties and characteristics, so that composites have unique properties and characteristics and are superior to the constituent materials. Natural fiber is alternative filler composite for various polymer composites because of its advantages compared to synthetic fibers. Natural fibers are easy to obtain at low prices, strong, lightweight, good electrical insulation, easy to process and combine with other materials and are environmentally friendly products (Lange, 1989).

Gypsum board as composite panel is one type of inorganic board that is used as an interior coating material for dividing walls and ceilings, and can be applied as a brick wall coating (Sanusi, 1986). There are many advantages of using gypsum board over traditional plaster walls. Gypsum board is lighter and can be used for room walls and room partitions (gypsum partitions), have a solid and dry shape so that it greatly simplifies the installation or construction process. It does not take long to wait for the plaster to dry (Ramirez, 1998). The design of the building or work does not depend on the weather. These advantages can make it easier for designers to build room construction, office and home room partitions.

Installation of gypsum is one of the complementary decorations of the house apart from being a partition; gypsum can be used for ceilings. Installation of gypsum / gypsum ceilings in the room can maximize the impression we want, but the installation of gypsum should be done in the right way or using experts so that the installation of gypsum produces a neat and beautiful impression as expected (Hubson, 1987; Kharazipour, 1998).

There are several gypsum installation techniques based on the type of gypsum ceiling support frame. Gypsum ceilings that use a wooden frame must be shaved so that they are flat and the installation of gypsum ceilings is neat. Meanwhile, the installation of a gypsum ceiling with a hollow frame is much faster because it generally has a flatter surface. Also the installation of a gypsum ceiling with a hollow frame is resistant to termites compared to the installation of a gypsum ceiling with a wooden frame (Hendrik, 2005).

On the other hand, one of the disadvantages of using gypsum board is that it is not water-resistant, even when used indoors. When exposed to water or submerged in water, this gypsum board easily absorbs water and becomes soft or even begins to crumble / fall off when exposed to water for a long time or in prolonged wet conditions (Lange, 1989).

Understanding the advantages and disadvantages of gypsum board above, manufacturers of artificial boards, especially gypsum boards, are now starting to modify the manufacture of gypsum boards by not using calcium as a whole in a gypsum board product which is coated with paper on the face and back, but adds Portland cement as a mixing material and silica sand, as well as cellulose fibres which are then processed in such a way, then dried using high pressure and temperature or using the autoclave process. Through this process, gypsum board is produced which is more resistant to water even when exposed to water directly or completely submerged. This type of gypsum board is called kalsiboard (GK) (Danar, 2016), and is used as a building material and is safe for health (this type of board does not contain asbestos at all) and is environmentally friendly and is a stable and durable product. The objectives of this research were to identify the physical properties and quality assessment of Gypsum Kalsiboard in the Ambon city market so that the physical properties of the boards and their quality are monitored and controlled.

Materials and Methods

This research was conducted at the Laboratory of Forest Products Technology, Department of Forestry, Faculty of Agriculture Pattimura University. The material used was composite board in the form of gypsum-kalsiboard panels with length of 244.0 cm, width of 122.0 cm and thickness of 3.5 mm which are sold in the Ambon city market. This study used an experimental model in a Completely Randomized Design (CRD) pattern with 10 replications. For the treatment of thickness swelling water absorption (TS & WA), 8 sample points were taken for each gypsum kalsiboard, and for density and moisture content (D & MC) 5 sample points were taken. According to Grant et.al,. (1988), the assessment control of physical properties of gypsum kalsiboard products within the limits of the quality control chart (in control chart) can be evaluated using 3-sigma control limits regarding chart X, namely through the Upper Control Limit (UCL) and Lower Control Limit (LCL), where :

$$UCL\bar{X} = \bar{X} + A_2\bar{R} \quad \text{and} \quad LCL\bar{X} = \bar{X} - A_2\bar{R}$$

Note:

$UCL\bar{X}$ = Upper Control Limit from overall average

$LCL\bar{X}$ = Lower Control Limit from overall average

$\bar{X}$ = Overall average

A_2 = 3-sigma control limit setting factor of R for control chart X. The value of the fix for subgroup 10 = 0.31

The cut pattern for the gypsum kalsiboard test is presented in Figure 1 and the procedure of physical properties test as well as quality assessment panels as shown in Figure 2.

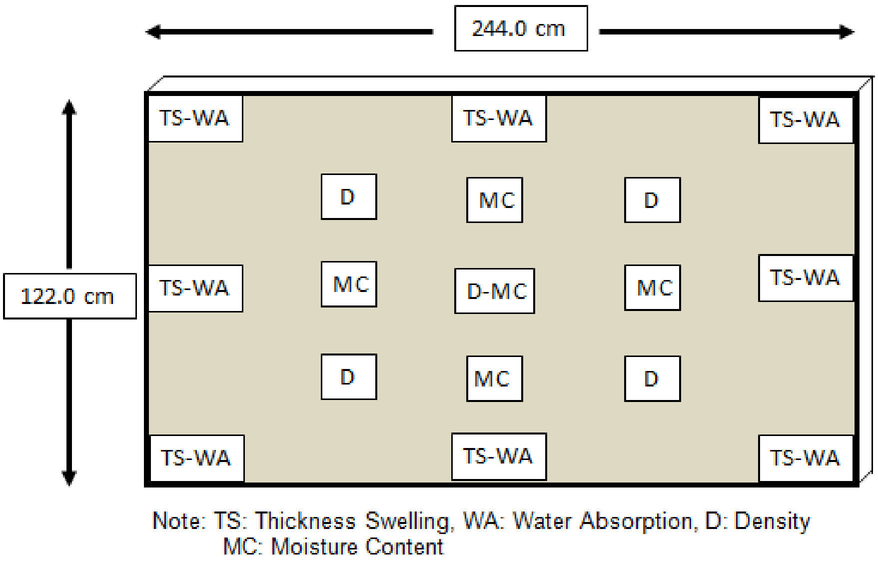

Figure. 1. The cut pattern for the gypsum kalsiboard test

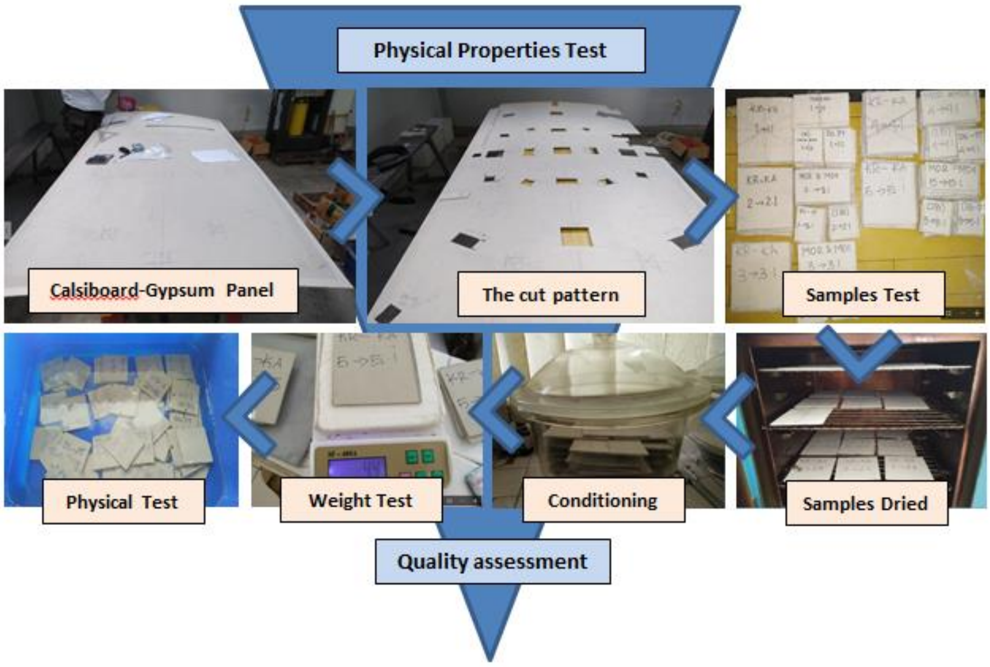

Figure. 2. The Procedure of physical properties test and quality assessment of gypsum kalsiboard

Results and Discussion

Identification of Gypsum Kalsiboard

The gypsum kalsiboards were observed in this study have characteristic white to gray color, with a flat, smooth surface with an average production standard size of 244.0 cm (length), 122.0 cm (wide) and 3.5 mm (thickness). The edge of the board is cut flat, with a right angle (90°) on all four sides. The average weight of gypsum kalsiboards were 6 kg. These panels also have the characteristics of a hard and rigid board, which if dropped or hit hard, will result in cracks and breaks at the end to the center of the board. Gypsum kalsiboard cannot be bent and are allowed to bend excessively. In the example of the application board observed in the room where the board was sold during the research, the gypsum kalsiboard panel is a board suitable for indoor ceiling applications or wall partitions and is applied using 2 – 3.5 cm nails if the installation frame uses a wooden frame. In the use of gypsum kalsiboard, the connection between the boards is left open (visible joint). When applied, the gypsum kalsiboard is not glued or joined using a compound but screwed to the metal frame because its thickness is only 3.5 mm.

The physical Properties and Quality Control Assessment

The results of the physical properties test of gypsum kalsiboard showed that the average of overall density was about of 1.41 g/cm^3, moisture content of 9.12%, water absorption of 25.21% and thickness swelling about of 1,91%. The complete of the physical properties was presented in Table 1.

Tabel 1. The average measurement of Physical Properties of Gypsum kalsiboard

Gypsum Kalsiboard Samples	Physical Properties			
	Density (gr/cm^3)	Water Content (%)	Water Absorption (%)	Thickness Swelling (%)
1	1.46	8.37	17.75	1.476
2	1.42	10.14	23.24	1.653
3	1.42	8.15	26.10	1.959
4	1.42	9.62	26.18	1.959
5	1.37	8.83	29.17	1.878
6	1.42	8.71	23.71	2.078
7	1.41	9.63	27.37	1.679
8	1.42	9.34	27.88	1.892
9	1.40	9.25	26.60	2.288
10	1.39	9.18	24.06	2.267
Average	**1.41**	**9.12**	**25.21**	**1.91**

The density of gypsum kalsiboard were obtained from samples measuring 10 x 10 cm which in air dry conditions and their weight as well as volume were be measured. The density of gypsum kalsiboard ranges from the smallest value of 1.37 g/cm^3 to the highest value of 1.46 g/cm^3 while the overall average value of 1.41 g/cm^3. The density of gypsum kalsiboard is high when compared to other inorganic boards such as ordinary gypsum board and also the density is not too varied, indicating that the weight of the gypsum kalsiboard is high with the volume dividing factor, especially the low thickness (3.5 mm). Figure 3 shows the average density of gypsum kalsiboard samples. The results of the analysis of variance showed that the values of the density of the gypsum kalsiboard were not significantly different.

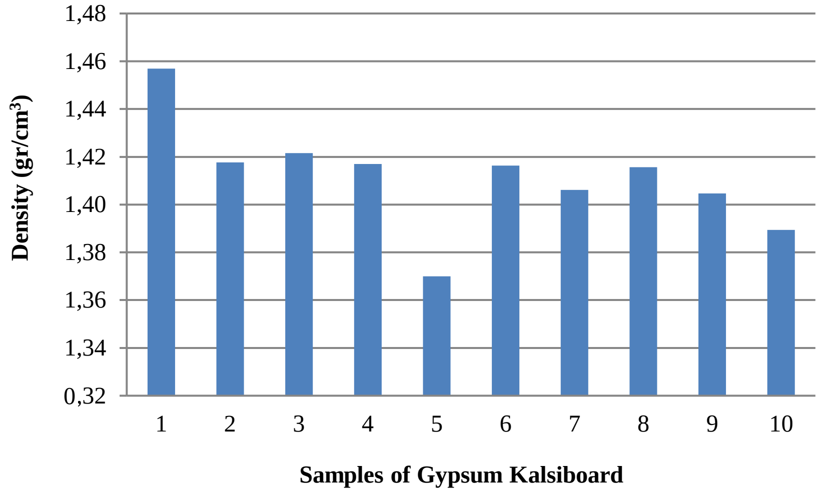

Figure 3. The average density of gypsum kalsiboard

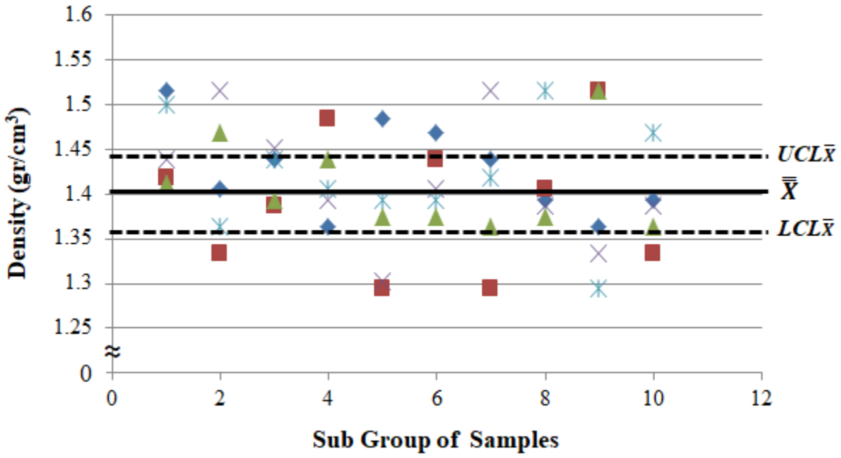

Figure 4. Control chart quality of GK-Density

In quality control assessment as depicted in the quality control chart in Figure 8 shows that based on the Indonesian National Standard SNI No. 03-6434-2000 concerning Gypsum Board which requires a density tolerance of 0.40 g/cm³ to 1.50 g/cm³, gypsum Kalsiboard products have a density that is still within the tolerance limit. However, if observed in more detail on the quality control chart, there are several points that are above the upper control limit (UCL) of the overall average of density which is 13 points and those below the lower control limit (LCL) are 7 points. These result indicated that although the density of products were still within the tolerance limits according to SNI, it has a high range or diversity from the overall average density of products, so it would be better in the production process the amount and weight of raw materials need to be considered in order to produce a product with a uniform density, besides, being necessary in the manufacturing process, the compression of the board at the time of production at the factory must be set with the same compression pressure on all parts of the board with a stable temperature.

Moisture content is one of the physical properties of gypsum kalsiboard which indicates the water content of the board is in equilibrium with the surrounding environment. As shown on the Figure 5, the average water content values of the gypsum kalsiboard was ranged from the smallest 8.15% and the largest 10.14% with an overall average value of 9.12%. The average value of the moisture content of the gypsum kalsiboard meets the standard limits required by SNI (≤ 14%). The results of the analysis of variance showed that the values of the moisture content of the gypsum kalsiboard were not significantly different.

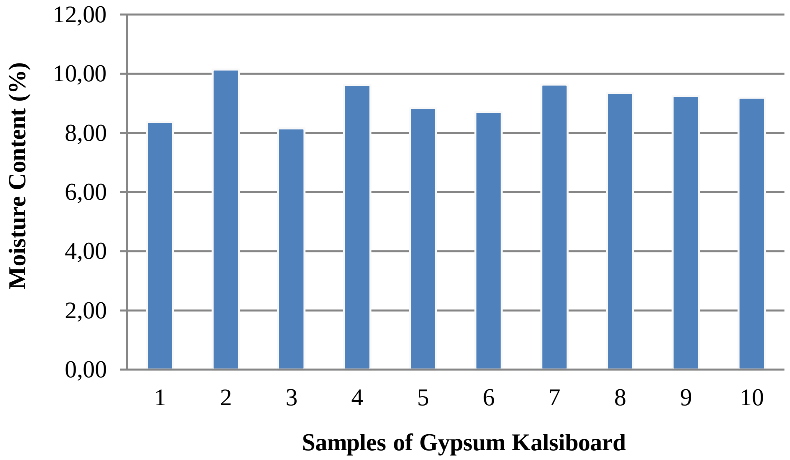

Figure 5. The average moisture content of gypsum kalsiboard

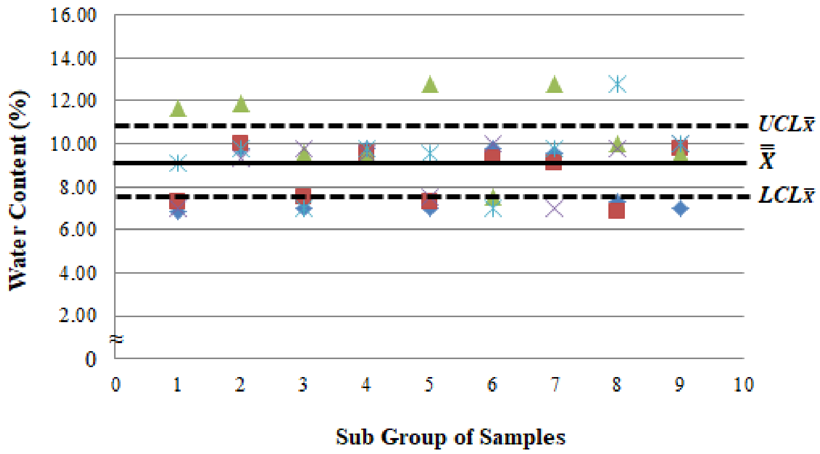

Figure 6. Control chart quality of GK-Moisture Content

In the quality control chart as shown in Figure 6, there were several points above the upper control limit (UCL) of the overall mean of moisture content which were 5 points and those below the lower control limit (LCL) were 9 points. The condition of the points that were outside the control limits indicates that the gypsum kalsiboard has diversity from the average water content which is still high in variation. Base on this condition, it was better when marketing the gypsum kalsiboard products, the boards must be stored in a dry place with air temperature surrounding 26ºC and at normal humidity to avoid large variations in water content mentioned.

Furthermore, the water absorption capacity of the gypsum kalsiboard is the amount of water absorbed by the product compared to its initial mass after immersion in 24 hours which is expressed in percentage. Water absorption occurs because of the adsorb force which is a molecular attraction due to the hydrogen contained in the material.

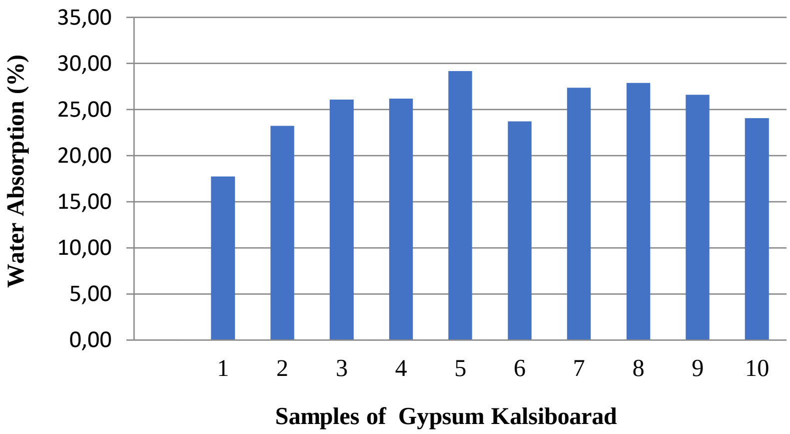

Figure 7. The average water absorption capacity of gypsum kalsiboard

The absorption capacity of gypsum kalsiboard obtained from a sample measuring 5x5 cm which was weighed initial and after immersion for 24 hours showed that the average value of the water absorption test of gypsum kalsiboard which ranged from the smallest of 17.75% and the largest of 29.17% with overall average value of 25.21% which meets the standard limits required by SNI (≤ 30%). The average water absorption capacity distributions of gypsum kalsiboard are presented in Figure 7.

In the quality control chart as shown in Figure 8, there were several points that are above the upper control limit (UCL) of the overall mean of water absorption capacity which were 8 points and those below the lower limit (LCL) were 3 points. Although the general average water absorption of gypsum kalsiboard was 25.21%, the absorption capacity of this board was still within the tolerance limits for an inorganic board because the condition of the board does not show significant changes such as those related to thickness expansion, indicating that the board was quite stable after 24 hours of immersion. Apart from this, the absorption of gypsum kalsiboard was also influenced by the shape of the surface of the board, which is because the surface of the board were smooth and slippery; gives an indication that the pores of the board was very small, and this has an effect on the least amount of water entering the surface of the board.

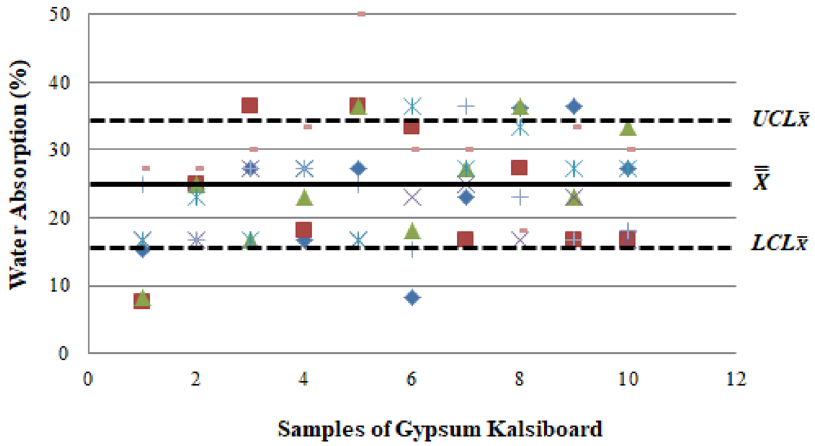

Figure 8. Control chart quality of GK-Water Absorption Capacity

The thickness swelling of gypsum kalsiboard was obtained from samples measuring 5x5 cm which were air-dried and measured the thickness of 4 sides before and after immersion for 24 hours. Figure 9 shows the average value of the thickness swelling test of gypsum kalsiboard were ranged from the smallest of 1.47% and the largest of 0.28% with a general average value of 1.91%. This value meets the standard limits required by SNI (≤ 10%). These boards have very small thickness swelling because the manufacturing process goes through perfect compression so that it does not return to its initial dimensions when submerged in water, besides, being influenced by the type of adhesive and raw materials as well as the process of applying pressure during forging. It was also reported by Subiyanto (1998) that in the manufacture of composite boards, thickness expansion is influenced by the amount of compression given to the product during the pressing/pressure process and the adhesive that glues the board materials.

In the quality control chart as shown in Figure 10, there are several points that are above the upper control limit (UCL of the overall mean of thickness swelling) which were 8 points and those below the lower control limit (LCL) were 8 points. Although the raw material for making gypsum kalisboard was solid cellulose fiber which tends to have high water absorption and this can affect the thickness of the board, it can be seen that the solid cellulose fiber was covered on its surface by a fine mixture of silica sand (gypsum solids) so that it absorbs water by the board becomes small and has no significant effect on changes in the dimensions of the board, especially the thickness swelling of the gypsum kalsiboard. A low expansion value of board thickness is expected from a gypsum kalsiboard product so that it can show high dimensional stability. The results of the analysis of variance showed that the value of the water absorption capacity and thickness swelling of the gypsum kalsiboard were not significantly different.

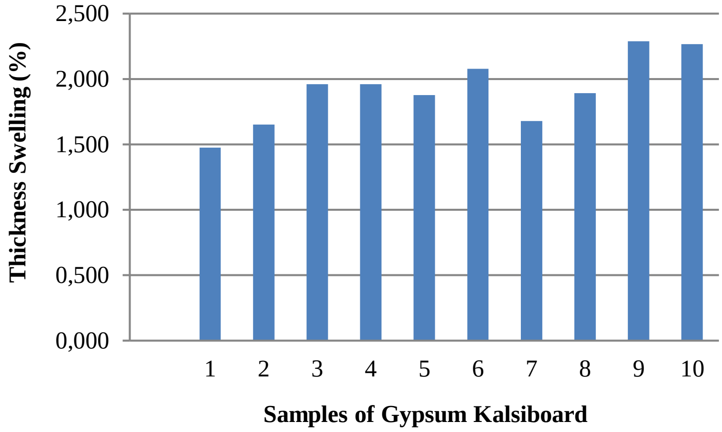

Figure 9. The average thickness swelling of gypsum kalsiboard

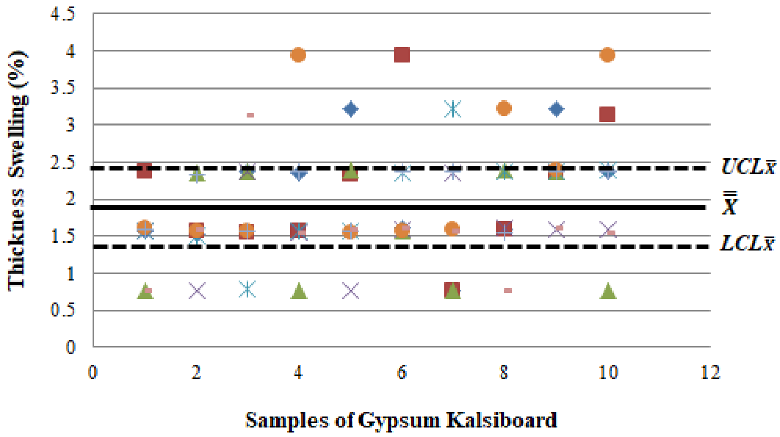

Figure 10. Control chart quality of GK-Thickness Swelling

Conclusion

The physical properties test of gypsum kalsiboard showed that the average of overall density was about of 1.41 g/cm^3, moisture content of 9.12%, water absorption of 25.21% and thickness swelling about of 1.91% which meets the standard limits required by SNI No. 03-6434-2000. Although by quality assessment there were several points that are above the upper control limit (UCL) and below the lower control limit (LCL), the physical properties values of this board was still within the tolerance limits because the condition of the board does not show significant changes such as those related to water absorption and thickness swelling, indicating that the board was quite stable and high dimensional stability after 24 hours of immersion.

Conflict of interest

The authors declare that there is no any competing interest (e.g., financial, professional, or personal relationships relevant to the work).

Contribution of Author

RSM (PhD of Wood Based Panels / Bio-composite Materials) designed the study, developed the methodology, analysed data, made the interpretations and approved the final version of the manuscript.

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