Mechanical Properties Characterization of Marble and Resin Composite Materials

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Abstract – The process of forming furniture and house construction, the marble used produces a lot of waste in the form of marble powder. One solution offered to overcome this problem is to make a composite of marble’s powder and resin. The purpose of this study was to determine the tensile strength and hardness of resin composites and marble’s powder and determine the optimal value of the composition between marble’s powder and resin. These composites were then tested to obtain mechanical properties such as yield strength, elastic modulus and hardness. Fracture surface observation by using SEM on the specimens was also conducted. The results showed that the optimal composition for composites is the composition between 60/40 and 70/30.

Keywords: Composite materials, Marble, Resin, SEM

1. Introduction
Marble is a rough crystalline rock derived from limestone or dolomite. Pure white marble and mainly compose of calcite minerals [1]. In general, marble is used for interior or exterior design of a house or building. In addition, marble can also be used as raw material for crafts or sculpture.

Aceh province is a producer of marble stone, especially in the district South Aceh (Tapaktuan). At this time, marble in this area is widely used as flooring, household appliances, and so on. The process of producing raw materials into products causes a lot of waste. Gradually, this waste will accumulate and should be reduced by the waste into useful products [2]. One solution is to make the marble powder waste into a composite material. This composite can later be used into form and needed by the community.

Several studies related to marble powder have been carried out. Sugianto Danu et al [3] conducted a study by utilizing marble waste into composites after adding polyester polymer as a matrix and abaca fiber as reinforcing material with the drying process using γ Co 60 radiation and peroxide catalyst. Mahayatra et al [4] conducted a study to determine the effect of variations in marble particle size on the mechanical properties of composites. Tjaronge M. Andi Mizwar et al [5] conducted a study on the utilization of marble mud, Styrofoam waste and coal fly ash for the manufacturing of hollow concrete bricks. Rania A. Hamza et al [6] conducted a study comparing the mechanical strength of marble and granite powders. Husaini et al [7] have conducted research on the mechanical properties of composite Marble/Resin only in the composition of 50/50.

Purposes of this study is to determine the mechanical properties of marble and resin composites in four types of compositions. The method used to find mechanical properties in this research are by applying tensile and hardness testing. The results of this test is the comparison of each composition. At the end, the results is to obtain the best compositions of resin composite and marble’s powder. It was found that the composition with optimal tensile strength and hardness is occurred in between the compositions from 60/40 to 70/30.
2. Basic Concept
Marble is a rough crystal stone derived from limestone or dolomite. Pure white marble and mainly composed of calcite minerals. Marble is a rock from the process of metamorphism or transition from limestone. The effect of temperature and pressure produced by endogenous forces causes recrystallization of these rocks to form foliation or not foliation.

The resin produced from polymerization addition process on heating with an amino catalyst. These resins have wide uses in the chemistry, mechanical and civil industries as adhesives, coating paints, cord printing and molded objects. The most produced epoxy resin is from bisphenol A and epiklohidrin. Composites are materials that are composed of a mixture of two or more materials with different chemical and physical properties, and produce a new material that has different properties with its constituent materials.

3. Methodology
This research uses several supporting tools. For the manufacture of specimens, a mold made of acrylics is used as shown in figure 1.

![Figure 1. Acrylic molds used in the experiment.](image)

Marble powder is obtained by sieving powder using a 150 μm (0.15 mm) mesh sieve. The equipment used to make composites can be seen in Figure 2. Making composites is done in ways: Pour resin into a measuring cup. Then pour it into a container. Next enter the marble powder that has been sifted and measured using a measuring cup little by little into a container that already contains resin using a spoon. Next add enough catalyst (ratio 1:10 with resin) and stir it slowly so that the marble powder can be mixed perfectly using the stirrer. The volume composition between marble powder and resin is planned as shown in table 1.

| No | Resin (%V) | Marble Powder | Identification |
|----|------------|---------------|----------------|
| 1  | 50         | 50            | 50/50          |
| 2  | 60         | 40            | 60/40          |
| 3  | 70         | 30            | 70/30          |
| 4  | 80         | 20            | 80/20          |

Apply wax to the mold specimen using a brush, then pour the composite mixture that has been mixed evenly throughout the specimen mold. The composite mixture on the mold is then dried at room temperature for 3 days. After dried, the composite is removed from the mold and then the surface is smoothed using sandpaper. After that, clean the mold using 96% alcohol. Figure 2 shows the equipment and materials used in the experiment.
Figure 2. Equipment and materials used.

Tensile testing were carried out for 3 pieces of specimens for each composition. Examples of specimens to be tested can be seen in Figure 3.

Figure 3. Tensile test specimen.

This tensile test uses the ASTM D 638-03 tensile testing standard [8]. In addition to the tensile test, specimens were also subjected to a hardness test as shown in Figure 4. Testing of this hardness uses the ASTM standard D 785-03 [9]. After all tests have been completed, then the fracture surface of the tensile test was observed using a SEM (Scanning Electron Microscope).

Figure 4. Hardness test specimens.

4. Results and Discussion

4.1 Tensile strength

The tensile test results, can be seen in figure 5, where the greatest yield stress occurs in the composition of 70/30. The overall results of tensile testing can be seen in table 2.
Figure 5. Tensile test result.

Table 2. Yield stress $\sigma_y$ and modulus young $E$ obtained from tensile test each composition.

| No | Composition | $\sigma_y$ (MPa) | $E$ (MPa) |
|----|-------------|------------------|-----------|
| 1  | 50/50       | 663              | 39        |
| 2  | 60/40       | 1051             | 4375      |
| 3  | 70/30       | 1077             | 3474      |
| 4  | 80/20       | 879              | 3381      |

4.2 Hardness test

The hardness test was carried out on specimens by taking 3 sampling points. Hardness test using the Rockwell method with an R scale (HRR). The test results are shown in Figure 6.

Figure 6. Hardness value for each composition.

The results of the hardness test can be seen in table 3 below. The results of this test are compared with the hardness of marble stone averaging 126.75 HRR.
Table 3. Hardness value for each composition.

| No | Composition | Hardness (HRR) |
|----|-------------|----------------|
| 1  | 50/50       | 93.99          |
| 2  | 60/40       | 105.2          |
| 3  | 70/30       | 108.24         |
| 4  | 80/20       | 111.71         |

4.3 Observation using SEM
Observations using SEM were carried out on broken surfaces of specimens from tensile test. Figure 7 shows the results of the fracture of the specimen after experiencing a load of drag on the composition 50/50. In the previous study, the propagation of crack propagation in ABS resin and PC/ABS blends was also observed with SEM [10-12].

![Figure 7. Fracture result of the specimens after tensile testing on a composite with composition of 70/30](image)

This 70/30 composition has a lower hardness compared to 80/20 composition but has a higher hardness than 50/50 or 60/40 composition. SEM observation (figure 8) shows that the marble powder is spread evenly in all parts of the resin and the surface is rougher than the other compositions.

![Figure 8. SEM image on the fracture surface on the specimens with the composition 70/30](image)

5. Conclusion
The results of testing and SEM observations, provide several conclusions: the largest value of yield stress, \( \sigma_y = 10.77 \text{ MPa} \), obtained by 70/30 composition. The largest Young’s modulus value, \( E = 43.75 \text{ MPa} \), obtained by 60/40 composition and the greatest value of hardness (111.71 HRR), obtained by 80/20 composition. The composition with optimal tensile strength and hardness is between the compositions from 60/40 to 70/30.
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