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# UTILIZATION OF MARBLE-CEMENT POWDER MODIFIED WITH GRAPHITE CARBON PARTICLES ON CONCRETE CONSTRUCTION FOR BUILDINGS IN SEASIDE AREAS

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**Abstract**

This research aims to utilize marble industrial waste which is not utilized optimally and reduce air pollution as a result of cement production in cement industrial factories which produce a lot of CO2 emissions. The results of this research indicate that the use of 25 % Graphite Carbon Marble Particle Powder, to replace 25 % of the cement volume in making concrete with quality plans K-250 or fc' 20,75 MPa. The results obtained are higher concrete quality than the quality of each concrete planned for the DCT type = 22,39 MPa > 20,75 MPa, DCL type = 22,76 MPa > 20,75 MPa, WCT type = 22,14 MPa > 20,75 MPa and WCL type = 22,89 MPa > 20,75 MPa. The compressive strength testing process is caried out based on ASTM C 39/C 39M – 05. Meanwhile for workability based on the results of the slump test, a slump value of 12 cm is obtained with the testing process referring to SNI 1972:2008 and ASTM C143/C143M-12.

*Keywords*: Graphite carbon, marble powder, compressive strength, water curing, dry curing



## 1.0 INTRODUCTION

Currently the waste problem is a world problem that will definitely have a negative impact on the environment. Increased development in the infrastructure sector demands an increase in the amount of available building materials. The development of building materials needs to be addressed by using alternative building materials so that the preservation of nature and ecosystems can be maintained [1]. The waste resulting from processing marble in marble factories in the form of marble clay powder/powder tends not to be utilized and in many countries, this waste is a problem for the factory and the surrounding community who live around the factory area.

There have been many studies conducted to find solutions for the utilization of marble clay waste. The same is true for cement factories which directly create air pollution as a result of the process of burning cement raw materials.

This research aims to provide innovations in the use of marble clay waste in substituting the use of cement so that it is hoped that the use of cement in infrastructure works and other works that use cement as a basic material can reduce its use which in turn will reduce air pollution from the combustion of cement raw materials.

Marble is formed from the recrystallization of limestone (*limestone*) because its presence is always associated with limestone, although not every time there is limestone there will be marble. The main minerals of marble are calcite or dolomite and/or silified lime, so the silica content is high. The potential for limestone reserves in Indonesia is very large, estimated at 28.678 billion tons [2].

Based on the results of the elemental test containing marble waste, the highest CaO obtained is 98.63%. The positively charged $Ca^{2+}$ ions can offset the negative charge in the clay [3].

Marble is a metamorphic rock resulting from the process of metamorphism of limestone, the process of metamorphism that occurs is influenced by temperature and pressure which can cause changes in the structure, texture and mineralogy of the limestone. The main minerals that make up marble are calcite ($CaCO_3$), dolomite and other minerals, such as clay minerals, mica, quartz, pyrite, iron oxide and graphite. Calcite as a constituent of limestone (marble protolith) undergoes recrystallization in the metamorphic process [4].

The use of marble powder waste has been used in paving block research using marble powder as a substitute for fine aggregate (100% marble powder) resulting in a compressive strength bearing capacity of 39.75 MPa, 34 MPa, 25 MPa, 20 MPa and 14 MPa respectively. – respectively at a mixture ratio of 1:2, 1:4, 1:6, 1:8 and 1:10. The compressive strength of paving blocks using marble powder as a filler for fine aggregate (50% marble powder) is 38.75 MPa, 25.50 MPa, 15 MPa, 11 MPa and 10 MPa respectively at a mixture ratio of 1: 2, 1:4, 1:6, 1:8 and 1:10 [5].

Other studies have also been carried out to see how far the marble clay waste is capable of being used as an infrastructure material. For example, in testing the mechanical properties of expansive soil and soil mixed with marble waste sand, the compressive strength has increased. In general, the increase is 0.22 kg/cm$^2$ - 0.63 kg/cm$^2$ (an average of 31.71 % for every 10 % addition of marble sand), while the shear strength is 0.17 kg/cm$^2$ - 0.27 kg/cm$^2$ (average 27.05 % for every 10 % addition of marble sand) [6].

The greater the use of marble powder in the concrete mix, the concrete slump value increases. The use of marble waste cannot be fully used as an alternative material to replace cement, but it can increase the strength of concrete when using marble waste 5 % by weight of cement [7].

Nanoparticles provide several benefits such as activation of cement hydration which can function to reduce the formation of Ca(*OH*)2, and increase strength gain. Moreover, many studies have focused on nS (*nano silicon oxide particles*/*SiO2*) to demonstrate its effectiveness in improving the strength-related properties of substituted cements [8]. Nanocarbon contains a number of properties as a filler in various types of binders used such as Portland cement, white cement, gypsum, or lime. A variety of destructive and non-destructive mechanical tests are performed, including compressive strength, flexural strength, Schmidt surface hardness, and ultrasound pulse analysis. The innovation obtained is that the ordinary binder with a compressive strength of 32.5 MPa is changed to a normal binder with a compressive strength of 42.5 MPa at 28 days only by adding nanocarbon and without increasing the cement content, which will also lead to an increase in the carbon footprint of the formulation. Therefore, continuous formulations are offered with significant strength advantages [9].

Several studies in an effort to increase the material's carrying capacity are by using carbon powder. The use of carbon powder has been performed by various researchers in the manufacture of carbon-based bricks as an addition to sand material. With reference to SNI 03-0349-1989 concerning concrete bricks for wall pairs. Mixing carbon substances in the manufacture of bricks with variations of 0%, 5%, 10%, and 15% by weight of the required sand, the cement mixture used: 25 % : 70 % : 5 %. The results of the compressive strength test on a cube sample measuring 0.15 x 0.15 x 0.15m, for normal bricks is 259.783 kg/cm$^2$. Bricks with a mixture of 5 % get a yield of 352.893 kg/cm$^2$. A mixture of activated carbon powder with 10% yielded the highest compressive strength of 393.293 kg/cm$^2$. So with the addition of 10 % carbon powder as an addition to fine aggregate (sand) is the right choice [10].

Nearly 10 % of global carbon dioxide (*CO2*) emissions come from reducing CO2 levels from the cement industry without significantly modifying the properties of concrete through the utilization of waste from other industries known as supplementary cementitious materials (*SCM*), among others evaluating the properties of Cement Concrete Limestone-Calcined Clay, silica fume, fly ash, bagasse ash and acai stone ash. [11].

In other studies using marble waste as an ingredient in concrete mixtures has also been developed. According to Elli Mercy Julmile *et al.* [12] That the effect of using silica fume and marble stone fragments as substitution materials in concrete mixtures on split tensile strength, flexural strength of concrete and compressive strength. With a design concrete quality of 25 MPa. The compressive strength value of concrete for marble fragments is 50% against Silica Fume variations of 0 %, 10 %, 12.5 % and 15 %, so the best result is the use of silica fume of 10 % with the highest value obtained 25.832 MPa.

Marble, as a widely used building decoration material, produces a significant amount of waste marble powder (WMP) during processing. The results showed that increasing the $Na_2O$ dosage shortened the setting time of the binders, reduced the fluidity, and improved the strength. Bing Liu at al [13].

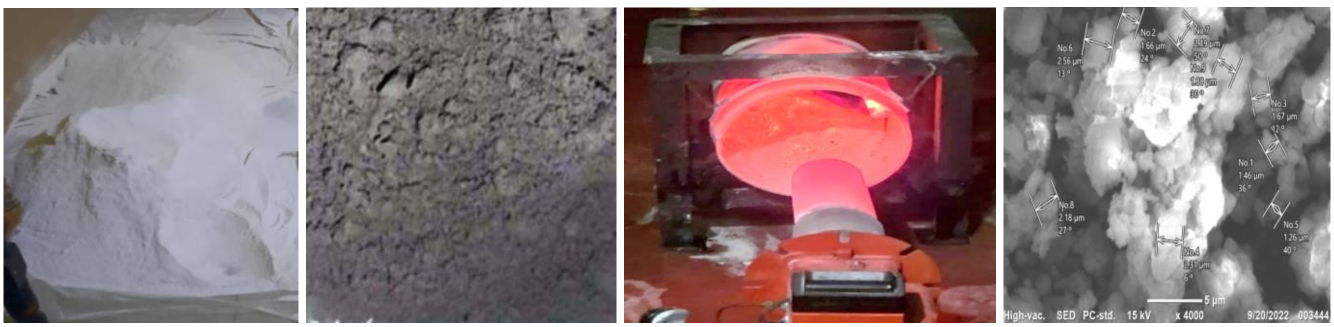
The building materials industry is always a source of waste which is most often throw out in landfills or in the nature, which has negative effects on the environment. For this purpose, in Western countries, this type of rejection is strictly prohibited and the management of solid waste, whether by valorization or recycling, remains a major concern [14].

In recent years, the volume of waste marble powder (WMP) from ornamental stone factories has increased rapidly, causing environmental concerns of soil, water and air pollution. While some studies have explored the benefits of incorporating WMP in concrete mixtures, the lack of pertinent data and a comprehensive understanding of how WMP influences the engineering properties of concrete has hindered the large-scale applications of WMP in the concrete industry [15].

This research aims to utilize marble industrial waste that is not utilized optimally and reduce air pollution as a result of cement production in cement industry factories which produce a lot of CO2 emissions through the marble waste purification process.

## 2.0 METHODOLOGY

For the process of refining marble waste in this research using a grinder machine with a capacity of 5.5 HP equipped with a 200 micron filter. As for the combustion engine, it uses a high-pressure burner with a combustion capability of up to $2000^0$ C. To measure the temperature, it uses an Infrared Thermometer with a capacity of up to $1500^0$ C. In grouping materials in the form of coarse aggregate and fine aggregate, as well as the process of making and testing concrete samples, several pieces of equipment are used, including; Sieve shaker, Digital scales, Slump test, Molen machine Cylinder tube, and Compressive Strength machine. Figure 1 below shows the process of burning marble powder waste into graphite carbon.




(a) Marble powder (b) Marble carbon after burning (c) process of burning marble (d) Sem results marble powder

**Figure 1** Fixed-end proses of burning marble powder waste into graphite carbon

In testing the compressive strength using the standard Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens ASTM C 39/C 39M – 05 [16].

### 2.1 Research Procedure

As an initial step in managing raw materials is to carry out the process of refining marble waste. This is intended to accelerate the process of approximation of the particle size similarity with the PCC cement used. Smoothing is done using a grinder machine.

After all the marble waste material is mashed, it is then burnt to obtain carbon particles. Combustion is carried out at temperatures between $850^0$ C to $900^0$ C for 120 minutes.

After the combustion process is complete, the cooling process is then followed by the cement mixing process through a comparison formulation which includes: 0 %, 25 %, 30 %, 40 % and 50 %, each of these percentages is the weight of carbon waste marble substituted from the weight of cement plan based on the results of the mix design. The design concrete quality target is f'c 20.75 MPa. Other tests that are also carried out in this phase are structural and chemical laboratory-based tests in the form of concrete microstructure testing using a Scanning Electron Microscope (SEM).

The compressive strength test is carried out on a cylindrical sample measuring 15 x 30 cm with an age of 7, 14, 21 and 28 days.

The planning stage of the concrete mix (mix design) refers to SNI 7656-2012 [17], regarding the planning process for making normal concrete mixes. The normal concrete is the sample for comparison with the sample object of partial substitution of cement with marble waste.

The number of samples of concrete cylinders made is 240 pieces each are:

- Samples with 0 % marble waste = 48 pieces
- Samples with 25 % marble waste = 48 pieces
- Samples with 30 % marble waste = 48 pieces
- Samples with 40 % marble waste = 48 pieces
- Samples with 50 % marble waste = 48 pieces

### 2.2 Proportion of the Mixture and Curing Concrete Samples

All concrete samples that have been made are then subjected to a curing process which includes treatment by immersion in fresh water (WCT), immersion in sea water (WCL), natural curing on land / no sea air (DCT) and natural curing on the seashore (DCL).

Table 1 show the number of sample and marble powder (SSM) for partial replacement of cement into concrete specimens using curing methods which include:

WCT = water curing using fresh water
WCL = water curing using sea water
DCT = curing with land air / non sea air
DCL = dry curing with sea / seaside air

The proportion of the concrete mixture used for 1 $m^3$:

a. For normal concrete:
   Cement = 384 kg
   Sand = 692 kg
   Gravel/Split =1039 kg
   Water = 215 liters

b. For the composition of Marble Powder substitution is the percentage of cement replaced with Marble Powder Graphite Carbon:
   For 0 % = 0.00 kg
   for 25 % = 96.00 kg
   for 30 % = 115.20 kg
   for 40 % = 153.60 kg
   for 50 % = 192.00 kg

For sand, gravel/split and water it still follows the normal concrete composition. Figure 2 below shows the process of curing concrete samples.

**Table 1** Number of samples and marble powder substitution (SSM) for WCT, WCL, DCT and DC

| CONCRETE SAMPLES | WCT | | | | WCL | | | | DCT | | | | DCL | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Sampel Age (Days) | | | | | | | | | | | | | | | |
| | 7 | 14 | 21 | 28 | 7 | 14 | 21 | 28 | 7 | 14 | 21 | 28 | 7 | 14 | 21 | 28 |
| SSM- 0 % (Normal | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| SSM - 25 % | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| SSM - 30 % | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| SSM - 40 % | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| SSM - 50 % | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |

(a) Curing of Sample at sea/DCL (b) in land/airless areas/DCT (c) in sea water (WCT) (d) in fresh water (WCT)

**Figure 2** Curing process of sample concrete

## 2.3 Slump Test

To measure the workability of the concrete sample mix, the slump test method is carried out SNI 1972: 2008 [18]. And ASTM C143/C143M-12 [19]. Figure 3 shows the workability measurement process.

Slump or collapse of the concrete mix is the most widely known for monitoring the workability of concrete. The workability of fresh concrete is related to the flow and cement water factor in the micro planes between the cement paste and aggregate during preparation, transportation, and vibration when placing the concrete into the formwork [20].

**Figure 3** Measurement of workability with a slump test

### 2.4 Compressive Strength of Concrete

The compressive strength of concrete is the maximum force per unit area acting on concrete. The compressive strength test of concrete is carried out based on SNI 03-1974-1990 (BSN 1990). The compressive strength of concrete is obtained by the formula:

$$fc' = P / A \quad (1)$$

Information: $fc'$ = compressive strength (MPa)
$P$ = Maximum load force (N)
$A$ = Surface area ($mm^2$)

In this research, the design quality of concrete compressive strength is K-250 or fc' 20.75 MPa. Compressive strength testing using a Compressive Strength Digital machine. The number of test object samples consisted of: 48 pcs DCT type, 48 pcs DCL type, 48 pcs WCT type and 48 pcs WCL type, so that the total number of samples is 240 pcs.

## 3.0 RESULTS AND DISCUSSION

### 3.1 Compressive Strength

Compressive strength testing is carried out on concrete samples that have gone through various concrete curing methods which include: water curing using fresh water (WCT), water curing using sea water (WCL), dry curing with sea / seaside air (DCL) and dry curing with land air / non sea air (DCT). Based on the four sample treatment methods, hereinafter referred to as the WCT type, WCL type, DCL type and DCT type.

Each of them carried out a comparison of the quality of its compressive strength carrying capacity. The design concrete quality is K-250 or fc' 20.75 MPa. The following are the results of each sample test obtained.

Comparison of the compressive strength of DCT type concrete samples against normal concrete (N) with Carbon Graphite marble powder substituted concrete of 25 %, 30 %, 40 % and 50 %.

From the results of the test analysis, the empirical fact is obtained that all samples of the test object continued to experience an increase in the quality of compressive strength as the sample age increased. The significance of the concrete samples at the age of 28 days from the results of the mix design using the K-250 or fc' 20.75 MPa quality reference can be shown in Table 2 below. As for each sample of Marble Powder substitution results after being processed into Carbon Graphite Particles can be described as follows:

- Substitution 0 % (normal concrete) = 26.47 MPa > 20.75 MPa
- Substitution 25 % = 22.39 MPa > 20.75 MPa
- Substitution 30 % = 16.56 MPa < 20.75 MPa
- Substitution 40 % = 12.63 MPa < 20.75 MPa
- substitution 50 % = 07.59 MPa < 20.75 MPa

**Table 2** Comparison of the quality DCT type compressive strength results on all types of Graphite Carbon marble powder substitution

| Concrete Samples | DCT Type (MPa) | | | |
|---|---|---|---|---|
| **Samples Age** | **7** | **14** | **21** | **28** |
| Substitution 50 % | 7.12 | 7.14 | 7.20 | 7.59 |
| Substitution 40 % | 7.62 | 10.70 | 10.60 | 12.63 |
| Substitution 30 % | 12.21 | 13.21 | 14.94 | 16.56 |
| Substitution 25 % | 8.87 | 17.23 | 20.90 | 22.39 |
| Substitution 0 % | 17.30 | 22.73 | 25.62 | 26.47 |

To find out a comparison of the quality DCT type compressive strength results on all types of Graphite Carbon marble powder substitution as shown in Figure 4 below.

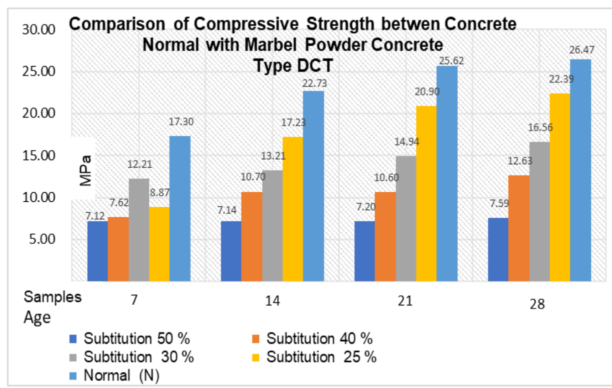



**Figure 4** Comparison of the quality DCT type compressive strength results on all types substitution of Graphite Carbon marble powder

From the table 2 and Figure 4 above, it shows that normal concrete or concrete without substitute Graphite Carbon Marble Powder, the compressive strength quality is above the planned concrete quality and for the Graphite Carbon Marble Powder concrete quality with a substitution value of 25% cement replacement, it has reached a quality of compressive strength which is also above the design quality, namely fc' = 22.39 MPa > 20.75 MPa or 8% above the design concrete quality. As for each of the other substitution compositions it is still below the design concrete quality.

Comparison of the compressive strength of DCL type concrete samples `substituted concrete of 25 %, 30 %, 40 % and 50 %.

The results of data analysis on the DCL type on concrete samples aged 28 days with comparison of normal concrete quality is fc' 20.75 MPa. This can be shown in Table 3 below. As for each sample of Marble Powder substitution results after being processed into Graphite Carbon Particles can be described as follows:

- Substitution 0 % (normal concrete) = 23.0 MPa > 20,75 MPa
- Substitution 25 % = 22.76 MPa > 20.75 MPa
- Substitution 30 % = 15.27 MPa < 20.75 MPa
- Substitution 40 % = 10.70 MPa < 20.75 MPa
- Substitution 50 % = 07.89 MPa < 20.75 MPa

**Table 3** Comparison of the quality DCL type compressive strength results on all types of Graphite Carbon marble powder substitution

| Concrete Samples | DCL Type (MPa) | | | |
|---|---|---|---|---|
| **Samples Age** | **7** | **14** | **21** | **28** |
| Substitution 50 % | 4.28 | 5.69 | 6.68 | 7.89 |
| Substitution 40 % | 7.91 | 10.11 | 11.52 | 10.70 |
| Substitution 30 % | 11.65 | 11.88 | 15.22 | 15.27 |
| Substitution 25 % | 9.33 | 17.87 | 21.41 | 22.76 |
| Substitution 0 % | 17.01 | 22.08 | 22.19 | 23.08 |

To find out a comparison of the quality DCL type compressive strength results on all types of Graphite Carbon marble powder substitution as shown in Figure 5 below.

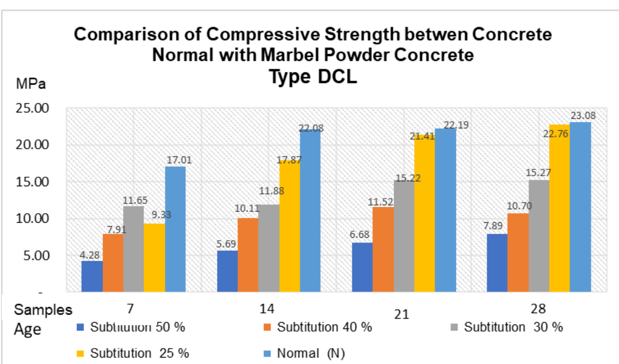



**Figure 5** Comparison of the quality DCL type compressive strength results on all types substitution of Graphite Carbon marble powder

Figure 5 and Table 3 above show that the DCL type is normal concrete or concrete without substitution (0%) Graphite Carbon Marble Powder, the compressive strength is above the planned concrete quality and for Graphite Carbon Marble Powder concrete quality, the cement substitution value is 25%. has achieved compressive strength which is also above the design quality, namely fc' = 22.76 MPa > 20.75 MPa or 10.1% above the design concrete quality. As for the composition of each of the other substitutions, it is still below the planned concrete quality.

Comparison of the compressive strength of WCT type concrete samples against normal concrete (N) with Graphite Carbon marble powder substituted concrete of 25 %, 30 %, 40 % and 50 %.

The results of data analysis on the WCT type on concrete samples aged 28 days with comparison of normal concrete quality is fc' 20.75 MPa. This can be shown in Table 4 below. As for each sample of Marble Powder substitution results after being processed into Graphite Carbon Particles can be described as follows:

- Substitution 0 % (normal concrete) = 21.79 MPa > 20.75 MPa
- Substitution 25 % = 22.14 MPa > 20.75 MPa
- Substitution 30 % = 14.27 MPa < 20.75 MPa
- Substitution 40 % = 11.27 MPa < 20.75 MPa
- Substitution 50 % = 07.69 MPa < 20.75 MPa

**Table 4** Comparison of the quality WCT type compressive strength results on all types of Graphite Carbon marble powder substitution

| Concrete Samples | WCT Type (MPa) | | | |
|---|---|---|---|---|
| **Samples Age** | **7** | **14** | **21** | **28** |
| Substitution 50 % | 6.20 | 6.70 | 7.18 | 7.69 |
| Substitution 40 % | 8.05 | 9.73 | 8.85 | 11.27 |
| Substitution 30 % | 10.06 | 13.64 | 13.26 | 14.27 |
| Substitution 25 % | 9.45 | 17.31 | 21.23 | 22.14 |
| Substitution 0 % | 14.66 | 18.24 | 20.83 | 21.79 |

To find out a comparison of the quality WCT type compressive strength results on all types of Graphite Carbon marble powder substitution as shown in Figure 6 below.

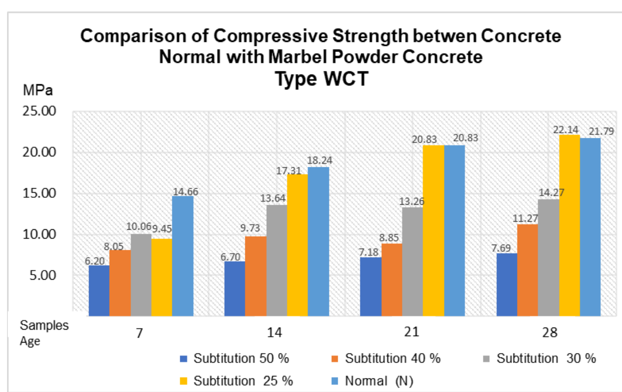



**Figure 6** Comparison of the quality WCT type compressive strength results on all types substitution of Graphite Carbon marble powder

Figure 6 and Table 4 above show that the WCT type is normal concrete or concrete without substitutes (0 %) Graphite Carbon Marble Powder, the compressive strength is above the quality of the planned concrete and for the quality of Graphite Carbon Marble Powder concrete, the substitution value is 25 % cement replacement. has achieved compressive strength quality which is also above the design quality, namely fc' = 22.14 MPa > 20.75 MPa or is 7 % above the design concrete quality. As for each of the other substitution compositions it is still below the design concrete quality.

Comparison of the compressive strength of WCL type concrete samples against normal concrete (N) with Carbon Graphite marble powder substituted concrete of 25 %, 30 %, 40 % and 50 %.

The results of data analysis on the WCL type on concrete samples aged 28 days with comparison of normal concrete quality is fc' 20.75 MPa. This can be shown in Table 5 below. As for each sample of Marble Powder substitution results after being processed into Graphite Carbon Particles can be described as follows:

- Substitution 0 % (normal concrete) = 28.00 MPa > 20.75 MPa
- Substitution 25 % = 22.89 MPa > 20.75 MPa
- Substitution 30 % = 16.69 MPa < 20.75 MPa
- Substitution 40 % = 12.17 MPa < 20.75 MPa
- Substitution 50 % = 08.30 MPa < 20.75 MPa

**Table 5** Comparison of the results of the quality WCL type compressive strength on all types of Carbon Graphite marble powder substitution

| **Concrete Samples** | **WCL Type (MPa)** | | | |
|---|---|---|---|---|
| **Samples Age** | **7** | **14** | **21** | **28** |
| Substitution 50 % | 4.38 | 6.29 | 7.66 | 8.30 |
| Substitution 40 % | 7.37 | 9.89 | 8.74 | 12.17 |
| Substitution 30 % | 10.76 | 12.07 | 15.98 | 16.69 |
| Substitution 25 % | 8.83 | 16.65 | 22.02 | 22.89 |
| Substitution 0 % | 20.03 | 20.28 | 21.88 | 23.63 |

To find out a comparison of the quality WCL type compressive strength results on all types of Graphite Carbon marble powder substitution as shown in Figure 7 below.

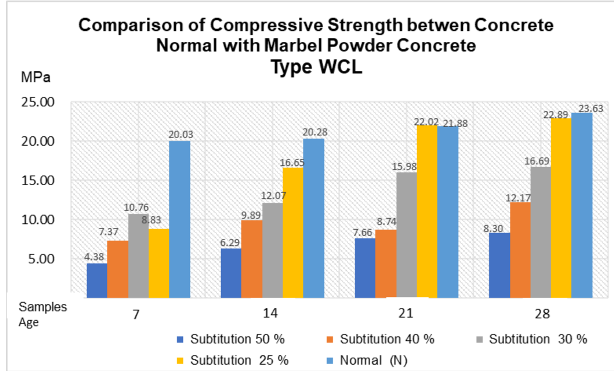



**Figure 7** Comparison of the quality WCL type compressive strength results on all types substitution of Graphite Carbon marble powder

Figure 7 and Table 5 above show that the WCL type is normal concrete or concrete without substitution (0 %) Graphite Carbon Marble powder, the compressive strength is above the quality of the planned concrete and for the quality of Graphite Carbon Marble Powder concrete, the substitution value is 25% cement replacement. has achieved compressive strength quality which is also above the design quality, namely fc' = 22.89 MPa > 20.75 MPa or is 10.35% above the design concrete quality. As for each of the other substitution compositions it is still below the design concrete quality.

From the results of the analysis of points 3.1.1 to 3.1.4 on the quality of concrete that meets the requirements for the approach to Mix Design Concrete Quality Plan fc' 20.75 MPa, it can be stated as follows:

a. For subtitution concrete 0 % (normal concrete/ N)
   - DCT Type = 26.47 MPa > 20.75 MPa
   - DCL Type = 23.00 MPa > 20.75 MPa
   - WCT Type = 21.79 MPa > 20.75 MPa
   - WCL Type = 28.00 MPa > 20.75 MPa
b. For subtitution concrete 25 % Graphite Carbon Particle Marble Powder.
   - DCT Type = 22.39 MPa > 20.75 MPa
   - DCL Type = 22.76 MPa > 20.75 MPa
   - WCT Type = 22.14 MPa > 20.75 MPa
   - WCL Type = 22.89 MPa > 20.75 MPa

The results of this study indicate that the use of 25% Graphite Carbon Marble Particle Powder, to replace 25% by volume of cement in making concrete with design quality K-250 or fc' 20.75 MPa. Obtained concrete quality higher than the concrete quality plan. Figure 8 below shows sample samples for the WCL and DCL types during the pressure test process.

**Figure 8** The compressive test process for DCT, DCL, WCT and WCL types of concrete samples

## 4.0 CONCLUSION

From the conditions mentioned above, it shows that by using Graphite Carbon Particle Marble Powder in reducing the amount of cement in construction work by 25% of the volume of cement planned for concrete in buildings both on the seaside or temperate areas without the influence of sea air including those touching directly with the seawater or fresh water, the concrete quality can still be achieved according to the quality plan. Thus it can be stated that the use of marble waste is a real step in saving the environment by suppressing the use of cement so that CO2 emissions from cement factories can also be reduced.

## Conflicts of Interest

The author(s) declare(s) that there is no conflict of interest regarding the publication of this paper.

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