Porosity Analysis and Compressive Strength of Normal Concrete with Synthetic Wood Waste Filler Additives

Wahyu Kartini¹, Sumaidi²
¹,² Civil Engineering Department, Universitas Pembangunan Nasional “Veteran” Jawa Timur, Surabaya, Indonesia

wahyu.ts@upnjatim.ac.id

Abstract. To improve the quality of normal concrete often used additional materials such as fillers, to reduce the cavities in the concrete (porosity). Fillers can fill pores in concrete due to gaps from aggregates, if the empty space is reduced, the compressive strength value of the concrete will increase because the cavities in the concrete can result in cracks during loading. The filler used is synthetic wood waste from PT Dominic NISI which makes multiboard from cement. Synthetic wood fillers are not reactive with water, because the silica content in this filler comes from cement which has been reactive when making synthetic wood, therefore this filler is only as a filler in concrete. The optimal value of porosity testing was 9.774% with variations in the addition of 15% synthetic wood waste filler, has decreased porosity by 7.914% compared to concrete without synthetic wood waste filler. While the optimal value of compressive strength with the addition of synthetic wood waste filler at 10% variation of 41.594 MPa, an increase of 27.09% compared to concrete without synthetic wood waste filler.

Key Words: concrete, filler, porosity, compressive strength

1. Introduction
Concrete is a mixture of coarse aggregates and fine aggregates as fillers, cement and water as adhesives and or without additives. Normal concrete is concrete which has a specific gravity between 2100-2550 kg/m³ with a water cement ratio (f/a/s) between 0.4 - 0.6.[1]-[12]

Concrete manufacturing often utilizes waste material as an additive to influence the mechanical properties of concrete, including by adding filler. Filler is a material that passes the sieve no. 200 (75 μm) has a smaller size than sand, so that it can fill the concrete pores. The function of the filler is to fill the cavities between aggregates, expected to increase density and reduce permeability of the mixture. The filler content in concrete will affect the mixing process, spread and compaction. In addition, the filler also affects the elasticity of the mixture and its sensitivity to water.

Porosity is the percentage of empty spaces or the amount of pore content contained in concrete and one of the factors that influence the strength of concrete. Concrete pores usually contain air or contain interconnected water and are called concrete capillaries. Besides concrete porosity arises because the pores or cavities that are in the aggregate granules formed by the presence of air trapped in the granules when forming or decomposing minerals. Aggregate gradation also affects the value of
concrete porosity because with a uniform size the porosity will be even greater while the non-uniform size of the concrete porosity decreases.

The compressive strength of concrete is the crushed load divided by the cross-sectional area of the test object, using a compressive testing machine. The strength of concrete is influenced by aggregate, mortar and bonding between mortar and aggregate strength. While the parameters that influence the final strength of concrete include water cement ratio (w/c ratio), air content, raw material characteristics, and comparison of the amount of cement with aggregate.

2. Data, Methodology, and Variables

2.1. Research Data

The filler is used as an additional material in research from synthetic wood waste from PT Dominic NISI Mojosari which produces various kinds of sills, doors and multiboard made from cement and coconut fiber. Synthetic wood filler waste from waste materials that are not used because the process of destruction of waste naturally takes place slowly, so that the pile of waste can disturb the surrounding environment and have an impact on human health. In this study planned to use normal concrete.

2.2. Methodology

The variation of adding synthetic wood waste filler is 0%; 5%; 10%; and 15% to determine the optimum compressive strength and porosity that can be achieved, and water cement ratio used is 0.45.

Material testing using ASTM includes moisture, specific gravity, water absorption, volume weight, organic matter content, sludge cleanliness test, sieve analysis.

Mix design using the ACI method, concrete compressive strength test specimens using a cylinder 15 cm x 30 cm are 3 specimens per variation. Concrete porosity test specimens use a cylinder 10 cm x 20 cm by 3 specimens per variation. Concrete strength and porosity tests were carried out at 28 days.

3. Result and Discussion

3.1. Material Analysis

Aggregate analysis test, specimens making and test were carried out at the Laboratory of Materials and Construction of Civil Engineering UPN "Veteran" Jawa Timur, and chemical composition analysis of synthetic wood fillers was carried out at Chemical Engineering ITS Surabaya.

3.1.1 Aggregate Specifications

The results of aggregate analysis tests shown in Table 1.

| Table 1. Specification of Aggregate Characteristics |
|-----------------------------------------------|
| Specific Gravity(gr/cm³) | water Absorption (%) | Moisture (%) | Organic Content | Cleanliness of Sludge (%) |
|--------------------------|------------------------|--------------|-----------------|--------------------------|
| Fine Aggregate           | 2.713                  | 0.929        | 1.615           | Clear Yellowish          | 3.45                     |
| Coarse Aggregate         | 2.235                  | 2.093        | 2.495           | -                        | -                        |

3.1.2 Spesifikasi Filler

Testing of synthetic wood filler based on XRF (X-Ray Fluorance) namely the analysis of chemical composition, concentration of the elements contained in a sample obtained results as in Table 2.
Table 2. Chemical Composition and Concentration of Filler Elements

| Element     | Norm C (wt %) | Compound | Stoich C (wt %) | Norm Stoich C (wt %) |
|-------------|---------------|----------|-----------------|----------------------|
| Rhodium     | 0.00          |          | 0.00            | 0.00                 |
| Sulfur      | 17.98         | SO3      | 11.57           | 44.89                |
| Continued   |               |          |                 |                      |

| Element     | Norm C (wt %) | Compound | Stoich C (wt %) | Norm Stoich C (wt %) |
|-------------|---------------|----------|-----------------|----------------------|
| Oxygen      | 45.07         |          | 0.00            | 0.00                 |
| Titanium    | 0.09          | TiO2     | 0.04            | 0.14                 |
| Aluminium   | 1.04          | Al2O3    | 0.50            | 1.96                 |
| Silicon     | 3.69          | SiO2     | 2.03            | 7.89                 |
| Magnesium   | 0.47          | MgO      | 0.20            | 0.78                 |
| Calcium     | 30.63         | CaO      | 11.04           | 42.85                |
| Iron        | 1.02          | Fe2O3    | 0.37            | 1.45                 |
| Manganese   | 0.02          | MnO      | 0.01            | 0.03                 |
| Total       | 100           |          | 25.77           | 100                  |

Source: Micro XRF Tornado ITS

3.2. Porosity Testing Results

Porosity testing was carried out on 3 cylindrical of 10 cm x 20 cm specimens for each variation. The results of the average porosity testing of concrete with variations in the addition of filler can be seen in Table 3. and Figure 1.

Table 3. Porosity Test Results

| Filler Variations | Porosity (%) | Decreases in Porosity (%) |
|-------------------|--------------|---------------------------|
| 0%                | 10.614       | 0.000                     |
| 5%                | 10.402       | 2.002                     |
| 10%               | 10.223       | 3.684                     |
| 15%               | 9.774        | 7.914                     |

Source: Calculation

Figure 1. Porosity Values with Filler Variations

From Figure 1. shows the results of concrete porosity testing with w/c ratio 0.45 at 28 days. The higher the addition of filler variations in concrete, the porosity value decreases compared to concrete without.
the addition of synthetic wood waste filler. The greatest decrease in porosity occurs in a variation of 15% which is 7.914% of concrete without the addition of synthetic wood waste filler. This is because fillers occupy empty spaces or pores in concrete due to water capillaries, cavities in the aggregates and gaps that arise between the aggregates. Fillers are able to fill concrete pores because the grains are smaller than sand which is 75 µm so that they can occupy spaces that cannot be filled by sand and broken stones.

3.3. Compressive Strength Test Results

Compressive strength testing is performed on 3 cylindrical of 15 cm x 30 cm specimens for each variation. Average compressive strength of concrete with w/c ratio 0.45 at 28 days obtained the results as in Table 4 and Figure 2.

| Filler Variations | Compressive Strength (Mpa) | Increased Compressive Strength (%) |
|-------------------|---------------------------|-----------------------------------|
| 0%                | 32.728                    | 0.000                             |
| 5%                | 33.482                    | 2.305                             |
| 10%               | 41.594                    | 27.090                            |
| 15%               | 35.274                    | 7.781                             |

Source: Calculation

Figure 2. Compressive Strength with Filler Variation

From Figure 2, shows that with the addition of filler variations, the compressive strength value of concrete has increased compared to concrete without the addition of synthetic wood waste filler. The greatest increase in compressive strength occurred in the 10% variation of 27.09% of concrete without the addition of synthetic wood waste filler. Concrete with the addition of synthetic wood waste filler has a non-uniform gradation, which will affect the density of the concrete so that the strength of the concrete increases. This was also seen with the addition of a 10% filler, a decrease in porosity of 3.684% which caused the concrete to become denser, so the compressive strength of the concrete
increased. However, the addition of excess filler can cause a decrease in compressive strength as in the variation of the addition of 15% filler decreased by 15.194 compared to the variation of adding 10% filler. This decrease is caused by the excess synthetic wood waste filler absorbing some of the water that should be used for the hydration reaction between cement and water. The process of the formation of C-S-H (Calcium Silicate Hydrate or CaOSiO2H2O) which functions as a binder will be hampered, resulting in C-S-H produced to be reduced. The remaining synthetic wood waste filler is can reduce bonding between the aggregate and cement paste, so that its strength is reduced.

4. Conclusion
The higher the addition of filler in concrete, the porosity value decreases compared to concrete without the addition of synthetic wood waste filler. The optimal porosity value is in the variation of 15% which is 9.774%, has decreased porosity by 7.914% compared to concrete without synthetic wood waste filler.

While the addition of filler in concrete, will increase the compressive strength compared to concrete without the addition of synthetic wood waste filler. The optimal compressive strength value of concrete is obtained at a variation of 10% by 41.594 Mpa, an increase of 27.09% compared to concrete without synthetic wood waste filler.

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