The Effect of Bioconc Against Compressive Strength of Paving Concrete Combining Natural Materials

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Abstract. The use of additive concrete mixtures is commonly used to increase the concrete compressive strength. This study aims to see the effect of using Bioconc additives in combination with natural ingredients in increasing concrete compressive strength and reducing the use of cement. Natural materials used in concrete mixtures are fibers and coconut shells, bamboo and snail shells. The specimens measuring 15 cm x 15 cm x 15 cm with the percentage composition of each natural ingredient is 10% in coarse aggregate substitution and the addition of 500 ml/m³ of the Bioconc concrete mixture to the target K300 (24.9 MPa). Reduction of cement use 10% (R10), 15% (R15), 25% (R25) as much as each percentage is 5 pcs and tested at 28 days. The compressive strength results obtained from testing the average specimen of each natural material and the optimum percentage of cement reduction for fibers and coconut shell R10 = 26.27 MPa, R15 = 23.92 MPa, R25 = 19.39 MPa, Roptimum = 13%; bamboo R10 = 26.83 MPa, R15 = 22.59 MPa, R25 = 16.52 MPa, Roptimum = 12%; Snail Shell R10 = 17.89 MPa, R15 = 14.68 MPa, R25 = 12.35 MPa, Roptimum = 9%. While for the absorption of the average of each natural material for fibers and coconut shell = 2.28%, bamboo = 2.67%, and Snail Shell = 1.71%. Based on the results obtained with the target of K300 concrete compressive strength it can be concluded that the optimum cement reduction with substitution of natural fibers and coconut shell material is equal to 13% and for the average absorption is bamboo natural material substitution of 2.67%.

1. Introduction
The use of additive materials in concrete mixtures is commonly used to improve the quality of concrete mixtures, reduce hydration, reduce shrinkage cracks, increase shear stress, and others. The additive materials include Superplasticizer, Fly Ash, Silicafume and Bio Enzyme (Bioconc). The use of Bioconc provides an advantage especially is the reduction of cement usage and increasing compressive strength in concrete because the microbes in Bioconc will close the pores so that the concrete becomes denser as shown in Figure 1. Bioconc effect on the percentage reduction in cement use in concrete with a mixture of natural ingredients combined but still meeting the desired compressive strength will be described in this study [1].
2. Bioconc and job mix design
Bioconc is a liquid bio-technology product, made from natural/organic materials, denaturing proteins, surfactant biopolymers and organic minerals fermented by microbes. Bioconc microbes will produce crystals that act as adhesives or bonding agents. In a concrete mixture, Bioconc will fill the space between sand and rock where this space is usually filled by Portland Cement, because the size of the microbial Bioconc is so small that it is able to fill all the gaps and cavities perfectly, then the gluing surface area becomes greater so the strength of concrete also increased.

Bioconc increases the mechanical properties of Concrete by increasing the compressive strength of Concrete by up to 30%, so that for the same quality of concrete it can be carried out efficiency by reducing the volume of cement to 30% of normal job mix. Biocon is an environmentally friendly product, non-toxic and safe for humans and other living organisms that are associated with concrete additive processes. The advantage of using Bioconc as an additive: (i) Reducing cement content, (ii) Hydrative heat, (iii) Reducing shrinkage cracks, (iv) Improve compressive strength, (v) Increase bending strength, (vi) Increasing shearing strength, and (vii) Self-healing concrete.

2.1. Normal mix design modification
Concrete mix planning is carried out based on modifications to the mix design of SNI 7394-2008 using Bioconc as shown in Table 1 [2-4].

| No | Material Mix SNI 7394-2008 | N Unit | Job Mix Modification with Bioconc and Cement Reduction Factor (R%) |
|----|-----------------------------|--------|---------------------------------------------------------------|
| 1  | Cement                      | A kg   | A [1-R%]                                                      |
| 2  | Water                       | B kg   | B [1-R%]                                                      |
| 3  | Gravel                      | C kg   | C +{(A+B).R%.[D/(C+D+E)]}                                     |
| 4  | Sand                        | D kg   | D +{(A+B).R%.[D/(C+D+E)]}                                     |
| 5  | Bioconc                     | E ml   | 500 ml                                                        |
|    | Total Weight                |        | A + B + C + D + E + 500 ml                                    |

2.2. Mix design test objects
Based on the target compressive strength of K300 kg/cm², the composition of the mixture of normal concrete is required in combination with natural fibers and coconut shell, bamboo, and snail shells, each with 10% substitution on coarse aggregates as in Table 2 with specimens measuring 15 cm x 15 cm x 15 cm 5 pcs.
Table 2. Job mix modification with Bioconc.

| No | Material Mix   | Percentage of Cement Reduction |
|----|---------------|-------------------------------|
|    |               | 10   | 15   | 25   |
| 1  | Cement (kg)   | 10.5 | 9.9  | 8.8  |
| 2  | Water (kg)    | 4.7  | 4.4  | 3.9  |
| 3  | Gravel (kg)   | 25.3 | 25.8 | 26.9 |
| 4  | Sand (kg)     | 16.5 | 16.8 | 17.5 |
| 5  | Bioconc (ml)  | 12.2 |      |      |

Total Weight = 69.1

3. Methodology
Materials that form concrete for the manufacture of test objects need to be carried out several analyzes in order to meet the requested requirements and test objects that have met the age of 28 days are tested using Compressing Testing Machine (CTM) [5-6].

3.1. Material testing for coarse and fine aggregate
Testing of coarse aggregate and fine aggregate is based on SNI 03-2834-2000 for gradation requirements and SNI S-04-1989-F for material specification criteria requirements. The coarse aggregate gradation requirements are shown in Table 3, while for fine aggregates in Table 4 [7-8]. Coarse aggregates must meet the following criteria:

- The coarse aggregate must consist of hard and non-porous grains.
- It is eternal, meaning it is not broken or destroyed by the effects of the weather.
- Coarse aggregates must not contain more than 1% sludge, if the mud content exceeds 1% then coarse aggregates must be washed.
- Coarse aggregates must not contain substances that are alkaline reactive.
- Fine modulus of grain between 6 - 7.1 with grain variations according to the standard gradation.

Table 3: Coarse aggregate gradation limits.

| Sieve size (mm) | Percentage of Passed (%) | Gradation of Aggregates |
|-----------------|--------------------------|-------------------------|
|                 |                          | 40 mm | 20 mm | 10 mm |
| 76              | 100                      | -     | -     |
| 38              | 95-100                   | 100   | -     |
| 19              | 35-70                    | 95-100| 100   |
| 9.6             | 10-40                    | 30-60 | 50-85 |
| 4.8             | 0-5                      | 0-10  | 0-10  |

Meanwhile, fine aggregates must meet the following criteria:

- The fine aggregate consists of sharp and hard grains.
- Fine aggregate beads must be eternal, meaning they are not broken or destroyed by the influence of the weather.
- The fine aggregate does not contain more than 5% sludge, if it exceeds the fine aggregate it must be washed.
- Fine aggregates do not contain much organic matter
- Fine grain modulus between 1.5 - 3.8 with grain variations according to the standard gradation.
Table 4. Fine gradient aggregate limits.

| Sieve Size | Percentage of Passed (%) |
|------------|--------------------------|
|            | Area I | Area II | Area III | Area IV |
| 10         | 100    | 100     | 100      | 100     |
| 4.8        | 90-100 | 90-100  | 90-100   | 95-100  |
| 2.4        | 60-95  | 75-100  | 85-100   | 95-100  |
| 1.2        | 30-70  | 55-90   | 75-100   | 90-100  |
| 0.6        | 15-34  | 35-59   | 60-79    | 80-100  |
| 0.3        | 5-20   | 8-30    | 12-40    | 15-50   |
| 0.15       | 0-10   | 0-10    | 0-10     | 0-15    |

3.2. Curing treatment
Curing is generally understood as a concrete treatment, which aims to keep the concrete from losing water too quickly, or as an action to maintain the humidity and temperature of the concrete, as soon as the concrete finishing process is complete and the total time setting is reached. The relationship graph of concrete age is shown in Figure 2 [9-11].

Figure 2. Relationship graph of concrete age with curing time.

3.3. Compressive strength test
The compressive strength is the ability of concrete to accept the compressive force of broad unity. Concrete compressive strength identifies the quality of a structure. The higher the level of the desired structural strength, the higher the quality of the concrete produced. For testing the compressive strength of concrete, a test object in the form of a concrete cube with a size of 15 x 15 x 15 cm is pressed with a load until it collapses. The compressive stress on the concrete equal to the load divided by the cross-sectional area of concrete, so that it is formulated as [12-13]:

$$
\sigma_c = \frac{P}{A}
$$

where $\sigma_c$ = concrete compressive stress (kg/cm²), $P$ = the maximum load (kg), and $A$ = concrete cross-sectional area (cm²)
3.4. Water absorption testing
Measurement of absorptive capacity is the comparison percentage between the difference between wet weight and dry weight, in accordance with the provisions stated in SNI 03-0691-1996. The sample that has been measured is the dry weight and soaked for 24 hours and then measured the wet weight [14].

$$W_d = \frac{W_b - W_k}{W_k} \times 100$$

(2)

where $W_d = $ water absorption, $W_k = $ dry sample weight (g), and $W_b = $ wet sample weight (g).

4. Results and discussion
The test results at the age of 28 days from Compressing Testing Machine have been tabulated in Table 5 for a combination of fibers and coconut shell, Table 6 combination of bamboo, Table 7 combination of snail shells.

### Table 5. Compressive strength test combining coconut shell and fiber.

| % of Cement Reduction | No | Strength of 28 day (MPa) | Average (MPa) |
|------------------------|----|--------------------------|---------------|
|                        | 1  | 25.97                    |               |
|                        | 2  | 26.67                    |               |
| 10                     | 3  | 26.98                    | 26.72         |
|                        | 4  | 26.61                    |               |
|                        | 5  | 25.10                    |               |
| 15                     | 1  | 24.57                    |               |
|                        | 2  | 25.67                    |               |
|                        | 3  | 23.61                    | 23.92         |
|                        | 4  | 23.10                    |               |
|                        | 5  | 22.64                    |               |
| 25                     | 1  | 18.89                    |               |
|                        | 2  | 19.54                    |               |
|                        | 3  | 19.45                    | 19.39         |
|                        | 4  | 20.20                    |               |
|                        | 5  | 18.87                    |               |

### Table 6. Compressive strength test combining bamboo.

| % of Cement Reduction | No | Strength of 28 day (MPa) | Average (MPa) |
|------------------------|----|--------------------------|---------------|
|                        | 1  | 26.89                    |               |
|                        | 2  | 26.64                    |               |
| 10                     | 3  | 27.27                    | 26.83         |
|                        | 4  | 26.75                    |               |
|                        | 5  | 26.61                    |               |
| 15                     | 1  | 22.84                    |               |
|                        | 2  | 21.65                    |               |
|                        | 3  | 22.27                    | 22.59         |
|                        | 4  | 22.75                    |               |
|                        | 5  | 23.44                    |               |
| 25                     | 1  | 17.03                    |               |
|                        | 2  | 16.62                    |               |
|                        | 3  | 16.20                    | 16.52         |
|                        | 4  | 16.55                    |               |
|                        | 5  | 16.20                    |               |
Table 7. Compressive strength test combining snail shell.

| % of Cement Reduction | No | Strength of 28 day (MPa) | Average (MPa) |
|------------------------|----|--------------------------|---------------|
| 10                     | 1  | 17.03                    |               |
|                        | 2  | 18.73                    |               |
|                        | 3  | 17.89                    | 17.89         |
|                        | 4  | 17.61                    |               |
|                        | 5  | 18.17                    |               |
| 15                     | 1  | 14.76                    |               |
|                        | 2  | 14.59                    |               |
|                        | 3  | 15.19                    | 14.68         |
|                        | 4  | 14.62                    |               |
|                        | 5  | 14.22                    |               |
| 25                     | 1  | 12.54                    |               |
|                        | 2  | 12.99                    |               |
|                        | 3  | 11.87                    | 12.35         |
|                        | 4  | 11.76                    |               |
|                        | 5  | 12.60                    |               |

It can be summarized the average yield of each natural ingredient substitution in each percentage of cement reduction planned as shown in Table 8.

Table 8: Summary of average results of the compressive strength.

| % of Cement Reduction | Coconut Shell and Fiber (MPa) | Bamboo (MPa) | Snail Shell (MPa) |
|------------------------|-------------------------------|--------------|-------------------|
| 10                     | 26.27                         | 26.83        | 17.89             |
| 15                     | 23.92                         | 22.59        | 14.68             |
| 25                     | 19.39                         | 16.52        | 12.35             |

Then Table 6 is graphed as shown in Figure 3, based on the concrete quality target of K300 kg/cm² (24.9 MPa), the intersection between the lines of each natural material substitution and the concrete quality target line is the optimal value point.

Figure 3. The optimum value reduction of cement each natural materials.
Table 9 can be described as in Figure 4, where by drawing the line based on the optimum cement reduction value up to the absorption line of each substitution of natural ingredients and drawing horizontally to the percentage absorption value, the optimal value of absorption is obtained.

Table 9. Summary of average absorption results test.

| % of Cement Reduction | Coconut Shell and Fiber (MPa) | Bamboo (MPa) | Snail Shell (MPa) |
|------------------------|-------------------------------|--------------|-------------------|
| 10                     | 2.03                          | 2.58         | 2.01              |
| 15                     | 2.50                          | 2.69         | 2.25              |
| 25                     | 3.02                          | 2.73         | 2.61              |

**Figure 4.** The optimum absorption value is based on the optimum value of cement reduction each natural materials.

5. Conclusion

Based on the results of the compressive strength test it is known that bamboo substitution has the highest average compressive strength of 26.83 MPa, followed by substitution of fibers and coconut shells of 26.27 MPa, and substitution of snail shells of 17.89 MPa. Compressive strength with substitution of snail shells for all cement reduction percentages of 10%, 15%, and 25 does not meet the K300 concrete quality target (24.9 MPa). From Figure 3, it is known that by drawing the concrete quality target line 24.9 MPa horizontally cutting the compressive strength lines of each natural material substitution, the optimal value of the percentage of cement reduction that meets the requirements is 13% for bamboo and 12% for fibers and coconut shell. By drawing a vertical line from the optimal value for substitution of fibers and bamboo coconut shell by 13% in Figure 4 (absorption), the optimum absorption value is 2.28%, while for bamboo substitution the optimum absorption value is 2.67%.

6. References

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[3] Gardjito E, Fauzi A R, Limantara A D, Purnomo Y C S, Subiyanto B and Ridwan A 2018 The use of waste disposal of woven result of bamboo for mixed standard mix design paving block No. Figure 1 1-8
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