Compressive strength and modulus of elasticity of concrete using iron fibers

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Abstract. This paper presents the effect of using iron fiber to the value of compressive strength and modulus of elasticity of concrete. The iron fibers used in the concrete mixture are 50 mm long and 5 mm wide which is the waste of the lathe. For this purpose, there are 5 variations of concrete mixture with iron fiber content of 0%, 6%, 8%, 10% and 12% of cement weight for each mixed variation. The test specimens used are cylindrical in diameter 150 mm and 300 mm in height. The value of fresh concrete slump is set in the range 100-140 mm. The value of compressive strength and modulus of elasticity of concrete was obtained from concrete cylinder testing after 28 days of curing. The test results showed that the concrete mixture with iron fiber content of 8% yielded the highest compressive strength from the variation of the mixture of concrete using iron fiber. The value of the modulus of elasticity of the concrete obtained from the test results shows the same trend with the elasticity value calculated using the empirical equation.

1. Introduction
Concrete is a mixture of Portland cement or other hydraulic cement, fine aggregate, coarse aggregate, and water, with or without admixture [1]. Concrete is the most widely used for construction activities. It is used in buildings, dams, bridges, rigid pavements. Concrete has advantages such as basic materials that are easy to obtain, can be cast in any required shape, able to receive compressive strength with good and easy maintenance. Concrete was chosen because of the ease in the process.

At present, the knowledge of concrete composing materials is growing rapidly so that many additional or substitute materials are used such as fly ash, silica fume, slag. The addition or replacement of the main concrete material aims to improve the properties of concrete to obtain concrete that is stronger and more durable. As an effort to support sustainable development and by taking into account environmental aspects, the use of waste materials as additional or substitute materials has been widely used. This certainly brings benefits to the environment, namely reducing the source of pollution while adding value to waste. In addition to fly ash, the use of palm oil shell waste, ceramic / glass fragments, iron fiber waste provides good results to improve the properties of concrete.

Alzaed in his research used iron filling as an additional material in concrete to determine its effect on compressive strength and split tensile strength [2]. The addition of iron filling is 0%, 10%, 20% and 30% by weight of cement. The test results showed that compressive strength increased gradually when iron filling added to the concrete mix. Concrete compressive strength increased by 17% when 30% of
iron filling added to the concrete mix. However, the addition of iron filling had a minor effect on the increase of split tensile strength.

Lie et al. conduct of research by making the specimen normal concrete and concrete with mixed waste lathe with variation 0.5%, 1% and 2% [3]. The results showed for the compressive strength test of 296,354 kg/cm2, 309,825 kg/cm2, 321,371 kg/cm2, 354,086 kg/cm2 respectively for 0%, 0.5%, 1% and 2%. For tensile strength of 93,660 kg/cm2, 95 170 kg/cm2, 110.277 kg/cm2, 125,383 kg/cm2 respectively for the addition of waste lathe 0%, 0.5%, 1% and 2%.

Olutoge et al. using iron filling as partial replacement for sand with a percentage of 0% (control), 10%, 20% and 30% [4]. The results obtained showed that the maximum compressive strength on 20% replacement levels of sand with iron filling. Compressed strength obtained was 34.8 N/mm2, 36.0 N/mm2, 39.5 N/mm2, and 32.0 N/mm2 respectively for 0%, 10%, 20% and 30% replacement levels of sand with iron filling. For tensile strength of 2.36 N/ mm2, 2.66 N/mm2, 2.38 N/mm2, 2.32 N/mm2 respectively for 0%, 10%, 20% and 30% replacement levels of sand with iron filling.

Hendri using bendrat wire fiber with a diameter of 0.8 mm and a length of 30 mm in a concrete mixture with the addition of 0%, 4%, 6%, 8%, 10% and 12% fiber to the weight of cement [5]. The results showed that the use of bendrat wire fibers in a concrete mixture increased the compressive strength of concrete by 5.682% in the composition of 6% bendrat wire fiber and reduced shrinkage by 7.93% in the composition of 10% bendrat wire fiber and also the use of bendrat wire fibers reduced slump value concrete.

The objective of this research is to determine the effect of the use of iron fiber on the compressive strength and elastic modulus values of concrete. The iron fiber used is the result of the waste lathe.

2. Materials and methodology
The materials were used on this study are Portland cement, fine aggregate, coarse aggregate, water and iron fiber.

2.1. Materials

2.1.1. Cement. Portland cement is obtained by intimately mixing together calcareous and argillaceous, or other silica, alumina and iron oxide-bearing materials, burning them at a clinkering temperature and grinding the resulting clinker [6]. Cement used in this study was Gresik brand, type I (Ordinary Portland Cement/OPC) according to ASTM C150-05. In this study the chemical composition and reaction of cement was not studied. Hydraulic cement produced by grinding clinker consisting of hydraulic calcium silicates, which generally consist of one or more forms of calcium sulfate as an additive are ground together with its main ingredient [7].

2.1.2. Fine aggregate. According to SNI 03-2847-2002, fine aggregate is natural sand as a result of natural disintegration of rock or sand produced by the rock-breaking industry and has the largest grain size of 5.00 mm [8]. Fine aggregate used in this study is local aggregates from Tangkiling area of Central Kalimantan Province.

2.1.3. Coarse aggregate. SNI 03-2847-2002 states that coarse / gravel aggregates are the result of natural disintegration of rocks or in the form of broken stones obtained from the stone-breaking industry and have grain sizes between 5.00 mm - 40 mm [8]. Coarse aggregates come from the Tangkiling area of Central Kalimantan Province.

2.1.4. Water. Water is needed in the process of making concrete so that chemical reactions occur with cement, to wet the aggregate and to lubricate the mixture so that it is easy to process. Water used for manufacture and maintenance of concrete must not contain oil, alkaline acids, salts, organic ingredients or other materials that damage concrete and or reinforcing steel [9].
2.1.5. *Iron fiber*. The iron fiber used in the concrete mixture is 50 mm long and 5 mm wide which is a lathe waste.

| Properties          | Fine aggregates | Coarse aggregates |
|---------------------|-----------------|-------------------|
| Fineness modulus    | 3.48            | 7.67              |
| Sieve analysis      | Zona II         | Zona II           |
| Specific gravity    | 2.48            | 2.61              |
| Absorption          | 2.71            | 2.66              |
| Moisture content    | 2.05            | 1.14              |

2.2. *Mix proportions of concrete*

The concrete mix design based on SNI 03-2834-2000 (Procedures for Making a Normal Concrete Mixture Plan). The concrete mix proportion used was 1 (cement) : 1.57 (fine aggregate) 2.09 (coarse aggregate) and a water/cement ratio of 0.52. Five variations of composition in the mixture were made with the variation set of 0%, 6%, 8%, 10% and 12% of the weight of cement. Table 2 shows the mix proportions for each m3 of concrete.

| Material (kg/m³) | 0  | 6  | 8  | 10 | 12 |
|------------------|----|----|----|----|----|
| Cement           | 441.18 | 441.18 | 441.18 | 441.18 | 441.18 |
| Fine aggregates  | 691.50 | 691.50 | 691.50 | 691.50 | 691.50 |
| Coarse aggregates| 922.64 | 922.64 | 922.64 | 922.64 | 922.64 |
| Water            | 229.69 | 229.69 | 229.69 | 229.69 | 229.69 |
| Iron fiber       | -   | 26.47 | 35.29 | 44.12 | 52.94 |

2.3. *Manufacturing, curing and testing*

Each variation of the concrete mix is made of a concrete specimen cylinder with a diameter of 150 mm and height of 300 mm. Each variation consists of five test objects. Before casting all specimens, slump test was adopted to measure the workability of concrete. The value of fresh concrete slump is set in the range 100-140 mm. Curing of test specimens is carried out by soaking in water for 28 days with the aim that the drying process occurs evenly. The Universal Testing Machine (UTM) was used for testing the object.

3. *Result and discussion*

3.1. *Compressive strength*

The Compressive strength testing is carried out at the age of 28 days. The compressive strength tests results are presented in Table 3.

| % iron fiber | Average Density (kg/m³) | Average Compressive Strength (MPa) |
|--------------|-------------------------|-----------------------------------|
| 0            | 2442.80                 | 22.40                             |
| 6            | 2319.27                 | 14.60                             |
| 8            | 2432.13                 | 19.98                             |
| 10           | 2362.99                 | 13.59                             |
| 12           | 2474.79                 | 15.35                             |
The control mix concrete with 0% of iron fibers has greater compressive strength of 22.40 MPa. For concrete with iron fibers, concrete with 8% of iron fibers being the highest compressive strength of 19.98 MPa, so it can be used as structural concrete.

3.2. Modulus of elasticity
The elastic modulus value is based on the shortening of the test object due to loading at certain intervals. The elastic modulus test uses the same test object with compressive strength testing. The elastic modulus test results are presented in table 4.

| % iron fiber | Average modulus of elasticity (MPa) |
|--------------|------------------------------------|
| 0            | 25827                              |
| 6            | 16076                              |
| 8            | 21550                              |
| 10           | 12854                              |
| 12           | 16417                              |

Based on table 4, The control mix concrete with 0% of iron fibers has greater modulus of elasticity. For concrete with iron fibers, concrete with 8% of iron fibers being the highest modulus of elasticity. Table 5 shows the comparison of the elastic modulus obtained from the empirical formula testing and calculation.

| % iron fiber | Compressive Sternght (MPa) | Modulus of Elasticity (MPa) |
|--------------|----------------------------|----------------------------|
|              |                           | Exp. $E=4700\sqrt{f'c}$   | $E=0.043w^{1.5}\sqrt{f'c}$ |
| 0            | 22,40                     | 25827                      | 22244                      | 24571                      |
| 6            | 14,60                     | 16076                      | 17959                      | 18352                      |
| 8            | 19,98                     | 21550                      | 17959                      | 22950                      |
| 10           | 13,59                     | 12854                      | 17326                      | 18208                      |
| 12           | 15,35                     | 16417                      | 18414                      | 20741                      |
The elastic modulus value obtained from the test results has the same tendency as the elasticity value calculated based on the formula. Based on table 5, the compressive strength is proportional to the modulus of elasticity.

4. Conclusion

- The concrete with 0% iron fibers has greater compressive strength and modulus of elasticity.
- Iron fibers usage, with 8% being the highest compressive strength of concrete with iron fibers.
- The concrete with 8% iron fiber produces compressive strength of more than 17.5 MPa so that it can be used as structural concrete.
- The elastic modulus values of concrete with iron fiber 0%, 6% and 8% of the test results have the same tendency as the calculation of the empirical formula.
- The compressive strength is proportional to the modulus of elasticity.

Acknowledgments

The authors thankfully acknowledge the financial support from Palangka Raya University.

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