

## **ANALYSIS OF FLEXURAL STRENGTH OF BEAM USING BAMBOO REINFORCEMENT**

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### **ABSTRACT**

Concrete is the main material in building construction made from a mixture of gravel, sand, cement, and water. This material is the most commonly used in construction. The development of concrete technology brings various innovations to improve its quality, including the addition of additional materials or substitutes such as bamboo reinforcement. Bamboo reinforcement is an alternative because of its abundant availability, easy to obtain, and economical price, thus offering a more affordable construction solution. Research has explored the use of bamboo as a substitute for steel reinforcement, considering that bamboo has a strong mechanical structure. In Indonesia, Petung, wulung, tali, and Ori bamboo are the most commonly used types. Concrete design standards and compressive strength testing are regulated by SNI, with the quality of concrete tested according to SNI 1974-2011 and the increase in concrete flexural strength measured based on SNI 4431-2011. Bamboo reinforced beams at the age of 7 days reached 25 KN, at the age of 14 days reached 28 KN and at the age of 28 days reached 29 KN. Where it can be concluded that the compressive strength of concrete increases at the age of 7 to 28 days. The bagasse reinforced beam at the age of 7 days reached 20 KN, at the age of 14 days reached 23 KN and at the age of 28 days reached 24 KN. Where it can be concluded that the compressive strength of concrete increased at the age of 7 to 28 days but the results at the age of 28 days did not reach 100%. The iron reinforced beam at the age of 7 days reached 26 KN, at the age of 14 days reached 30 KN and at the age of 28 days reached 33 KN. Where it can be concluded that the compressive strength of concrete increased at the age of 7 to 28 days. Based on the results of the study, it was found that the beam with the addition of bamboo and iron reinforcement experienced an increase in the percentage of flexural strength testing while the beam reinforced with bagasse at the age of 28 days did not reach the desired target.

**Keywords:** Concrete, Concrete Flexural Strength, Reinforcement, Bamboo

### **INTRODUCTION**

Concrete is the main material in building construction made from a mixture of gravel, sand, cement, and water. This material is the most commonly used in construction. The development of concrete technology has brought various innovations to improve its quality, including the addition of additional materials or substitutes such as bamboo reinforcement. Bamboo reinforcement is an alternative because of its abundant availability, easy to obtain, and economical price, thus offering a more affordable construction solution. Research has explored the use of bamboo as a substitute for steel reinforcement, considering that bamboo has a strong mechanical structure. In Indonesia, Petung, wulung, tali, and Ori bamboo are the types most often used. Concrete design standards and compressive strength testing are regulated by SNI,

with the quality of concrete tested according to SNI 1974-2011 and the increase in concrete flexural strength measured based on SNI 4431-2011.

## METHODS

This study applies an experimental method with a series of laboratory tests to assess and compare the results. The testing stages in this study include material analysis, making a concrete mix plan, testing concrete viscosity with a slump test, making test samples, curing concrete, and testing the compressive strength of concrete. The implementation process of this research is divided into several stages as follows:

- 1) At this stage, the provision of equipment and materials to be used in the implementation of the research is carried out;
- 2) At this stage, testing is carried out on concrete components such as:
  - a. Testing to pass the sieve;
  - b. Testing the specific gravity of aggregates;
- 3) SK SNI 03-2834-2000 is a reference for concrete mix planning (mix design).
- 4) SNI 1972-2008 is a reference for slump testing;
- 5) Concrete curing is carried out using the immersion method;
- 6) Concrete compressive strength testing is carried out at the age of 7 days, 14 days, and 28 days.

### Research Flowchart

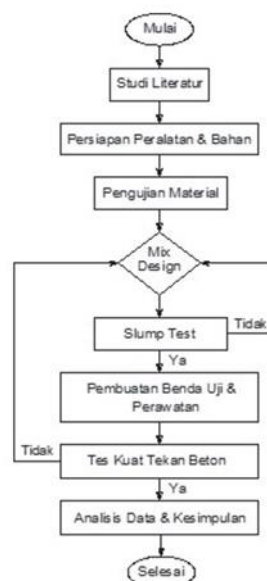


Figure 3. Research Flowchart

Before starting the research, it is important to prepare the tools and materials to be used so that the research process can run smoothly. The tools need to be cleaned from dust or dirt that may have stuck to them previously. For example, the concrete cylinder needs to be cleaned to ensure that no bolts are stuck or difficult to open when used. The walls of the concrete cylinder must also be lubricated so that the concrete that has been poured and hardened does not stick to the walls of the cylinder. Other tools such as scales, ovens, and mixers must also be prepared in the same way. Materials such as sand, crushed stone, water, and cement must be available in full throughout the research to avoid shortages. In addition, these materials must be stored in a place protected from direct weather to maintain their quality.

- 1) Slump testing on concrete is a measurement of the decrease in concrete height that occurs immediately after the concrete mold is lifted, according to SNI 1972-2008. This test is carried out to assess the water balance in the concrete mixture, with a target decrease of around 10 cm  $\pm$  2;

- 2) The concrete molding process is in accordance with SNI 2493-2011 which describes the method of making and curing concrete test objects in the laboratory. This process involves the formation of cylindrical concrete which will be tested for its compressive strength;
- 3) Concrete curing is also regulated by SNI 2493-2011, which includes methods for maintaining concrete characteristics through the curing process;
- 4) The purpose of this test is to determine the compressive strength of the concrete samples that have been made, for application in the field according to established procedures.

## RESULTS AND DISCUSSION

The results of the material inspection, which include aggregate test analysis, fresh concrete, and hardened concrete, were obtained from the Concrete Technology Laboratory at Krisnadwipayana University, Jakarta. The results of the test and analysis are then displayed in this chapter in the form of graphs and tables.

**Table 1 Results of Sand Gradation Analysis Test**

| Lolos Ayakan                                                                                                              |        | Berat Tak Lolos (gr) | Jumlah Tak Lolos (gr) | Jumlah Presentase |           | Tidak Lolos Kumulatif (%) |
|---------------------------------------------------------------------------------------------------------------------------|--------|----------------------|-----------------------|-------------------|-----------|---------------------------|
| SNI (mm)                                                                                                                  | ASTM   |                      |                       | Tak Lolos (%)     | Lolos (%) |                           |
| 9,52                                                                                                                      | 3/8 in | 0                    | 0                     | 0,00              | 100,00    | 0,00                      |
| 4,75                                                                                                                      | NO.4   | 30                   | 30                    | 3                 | 97        | 3                         |
| 2,36                                                                                                                      | NO.8   | 70                   | 100                   | 10                | 90        | 10                        |
| 1,18                                                                                                                      | NO.16  | 142                  | 242                   | 24,2              | 75        | 24,2                      |
| 0,6                                                                                                                       | NO.30  | 128                  | 370                   | 37                | 63        | 37                        |
| 0,3                                                                                                                       | NO.50  | 133                  | 503                   | 50,3              | 49,7      | 50,3                      |
| 0,15                                                                                                                      | NO.100 | 277                  | 780                   | 78                | 22        | 78                        |
| 0,075                                                                                                                     | NO.200 | 220                  | 1000                  | 100               | 0         | 100                       |
| Jumlah                                                                                                                    |        | 1000                 |                       | 100               |           | 202,5                     |
| Modulus Kehalusan                                                                                                         |        |                      |                       |                   |           | 2.025                     |
| Hasil analisis uji modulus Kehalusan = $202,5 / 100 = 2.025$<br>Sesuai spek SNI-S-04-1989-F nilai modulus pasir 1,50-3,80 |        |                      |                       |                   |           |                           |

There are two methods that can be used to test the content of mud and clay in sand, namely the volume method and the weight method.

**Table 2 Average Content of Sand Mud**

| No                                                                                                  | Uraian                                      | Hasil |       |
|-----------------------------------------------------------------------------------------------------|---------------------------------------------|-------|-------|
| 1                                                                                                   | Mangkuk                                     | 1     | 2     |
| 2                                                                                                   | Sebelum dicuci, berat kering (A) gram       | 500   | 500   |
| 3                                                                                                   | Setelah dicuci, berat pasir kering (B) gram | 492,3 | 491,6 |
| 4                                                                                                   | Kandungan lumpur ((A) – (B) / A) x 100 %    | 1,54  | 1,68  |
|                                                                                                     | Kandungan lumpur rata-rata (%)              | 1,61  |       |
| Temuan pengujian : 1,61% kandungan lumpur                                                           |                                             |       |       |
| Nilai kadar pasir < 5% adalah nilai maksimum yang diperbolehkan oleh spesifikasi SNI S. 04. 1989. F |                                             |       |       |

The results of the specific gravity and absorption test of concrete sand for concrete mixtures are shown in Table 3 below.

**Table 3 Results of Specific Gravity & Absorption Test of Sand**

| Berat Jenis dan Penyerapan Pasir Bogor |                                                  |        |                              |           |
|----------------------------------------|--------------------------------------------------|--------|------------------------------|-----------|
| No.                                    | Uraian                                           | Satuan | Rumus                        | Percobaan |
| 1                                      | Bobot pasir kering mutlak (BK)                   | Gr     | -                            | 473,1     |
| 2                                      | Bobot partikel pasir (SSD)                       | Gr     | -                            | 500       |
| 3                                      | Bobot piknometer ditambah Air ditambah Pasir(BT) | Gr     | -                            | 970       |
| 4                                      | Bobot Piknometer ditambah Air (B)                | Gr     | -                            | 667       |
| 5                                      | Bobot jenis curah                                | -      | $BK / (B - SSD - BT)$        | 2,317     |
| 6                                      | Bobot jenis SSD                                  | -      | $SSD / (B + SSD - BT)$       | 2,538     |
| 7                                      | Bobot jenis semu                                 | -      | $BK / (B + BK - BT)$         | 2,668     |
| 8                                      | Daya serap air                                   | %      | $(SSD - BK) / BK \times 100$ | 5,686     |

Table 4 to Table 6 shows the coarse aggregate analysis for split stone used in this test, with a maximum dimension of 4 cm.

**Table 4 Split Sieve Analysis Results Test**

| Berat Jenis dan Penyerapan Pasir Bogor |                                                  |        |                         |           |
|----------------------------------------|--------------------------------------------------|--------|-------------------------|-----------|
| No.                                    | Uraian                                           | Satuan | Rumus                   | Percobaan |
| 1                                      | Bobot pasir kering mutlak (BK)                   | Gr     | -                       | 473,1     |
| 2                                      | Bobot partikel pasir (SSD)                       | Gr     | -                       | 500       |
| 3                                      | Bobot piknometer ditambah Air ditambah Pasir(BT) | Gr     | -                       | 970       |
| 4                                      | Bobot Piknometer ditambah Air (B)                | Gr     | -                       | 667       |
| 5                                      | Bobot jenis curah                                | -      | $BK / (B + SSD - BT)$   | 2,317     |
| 6                                      | Bobot jenis SSD                                  | -      | $SSD / (B + SSD - BT)$  | 2,538     |
| 7                                      | Bobot jenis semu                                 | -      | $BK / (B + BK - BT)$    | 2,668     |
| 8                                      | Daya serap air                                   | %      | $(SSD - BK) / BK * 100$ | 5,686     |

**Table 5 Results of Specific Gravity and Split Absorption Tests**

| Uji Analisis Berat Jenis dan Daya Serap Air Split |                                  |        |                         |                    |
|---------------------------------------------------|----------------------------------|--------|-------------------------|--------------------|
| No                                                | Keterangan                       | Satuan | Rumus                   | Hasil Uji Analisis |
| 1                                                 | Bobot agregat kering mutlak (BK) | gr     | -                       | 4895,5             |
| 2                                                 | Bobot split (SSD)                | gr     | -                       | 5000               |
| 3                                                 | Bobot split di dalam air (BA)    | gr     | -                       | 3047               |
| 4                                                 | Bobot jenis curah                | -      | $BK / (SSD - BA)$       | 2,507              |
| 5                                                 | Bobot jenis SSD                  | -      | $SSD / (SSD - BA)$      | 2,560              |
| 6                                                 | Bobot jenis semu                 | -      | $BK / (BK - BA)$        | 2,648              |
| 7                                                 | Daya serap air                   | %      | $(SSD - BK) / BK * 100$ | 2,135              |

**Table 6 Split Wear Test Results**

| Uji Analisis Berat Jenis dan Daya Serap Air Split |                                  |        |                         |                    |
|---------------------------------------------------|----------------------------------|--------|-------------------------|--------------------|
| No                                                | Keterangan                       | Satuan | Rumus                   | Hasil Uji Analisis |
| 1                                                 | Bobot agregat kering mutlak (BK) | gr     | -                       | 4895,5             |
| 2                                                 | Bobot split (SSD)                | gr     | -                       | 5000               |
| 3                                                 | Bobot split di dalam air (BA)    | gr     | -                       | 3047               |
| 4                                                 | Bobot jenis curah                | -      | $BK / (SSD - BA)$       | 2,507              |
| 5                                                 | Bobot jenis SSD                  | -      | $SSD / (SSD - BA)$      | 2,560              |
| 6                                                 | Bobot jenis semu                 | -      | $BK / (BK - BA)$        | 2,648              |
| 7                                                 | Daya serap air                   | %      | $(SSD - BK) / BK * 100$ | 2,135              |

**Table 7 Summary of Flexural Strength Test Results for Normal Beams**

| No | Kode Benda Uji | Umur (Hari) | Slump (Cm) | Berat Benda Uji (Kg) | Beban (KN) |
|----|----------------|-------------|------------|----------------------|------------|
| 1  | K-300 / Fs 35  | 7 Hari      | 12         | 32.50                | 18         |
| 2  | K-300 / Fs 35  | 14 Hari     | 12         | 32.55                | 21.5       |
| 3  | K-300 / Fs 35  | 28 Hari     | 12         | 32.35                | 26         |

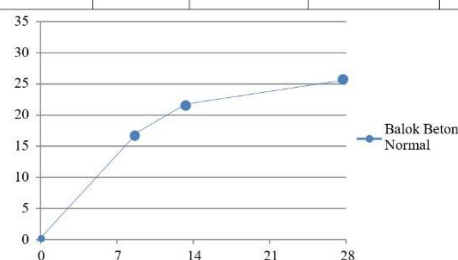


**Figure 4. Graph of Flexural Strength Test Results of Beam**

**Table 8 Summary of Flexural Strength Test Results of Beam + Bamboo Reinforcement**



**Figure 5. Graph of Flexural Strength Test Results of Beam + Bamboo Reinforcement**  
**Table 9 Summary of Flexural Strength Test Results of Beam + Bagasse Reinforcement**

| No | Kode Benda Uji | Umur (Hari) | Slump (Cm) | Berat Benda Uji (Kg) | Beban (KN) |
|----|----------------|-------------|------------|----------------------|------------|
| 1  | K-300 / Fs 35  | 7 Hari      | 10         | 32.35                | 20         |
| 2  | K-300 / Fs 35  | 14 Hari     | 10         | 32.45                | 23         |
| 3  | K-300 / Fs 35  | 28 Hari     | 10         | 32.40                | 24         |

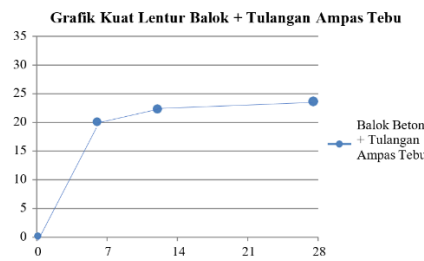


**Figure 6. Graph of Flexural Strength Test Results of Beam + Bagasse Reinforcement**  
**Table 10 Summary of Flexural Strength Test Results of Beam + Iron Reinforcement**

| No | Kode Benda Uji | Umur (Hari) | Slump (Cm) | Berat Benda Uji (Kg) | Beban (KN) |
|----|----------------|-------------|------------|----------------------|------------|
| 1  | K-300 / Fs 35  | 7 Hari      | 10         | 32.55                | 26         |
| 2  | K-300 / Fs 35  | 14 Hari     | 10         | 32.65                | 30         |
| 3  | K-300 / Fs 35  | 28 Hari     | 10         | 32.80                | 33         |

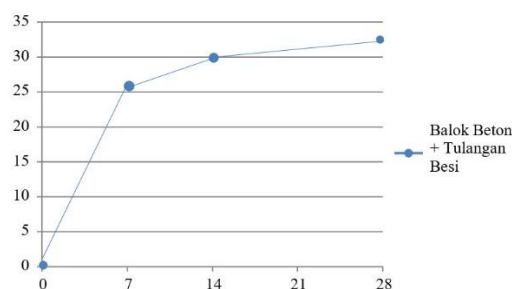


**Figure 7. Graph of Flexural Strength Test Results for Beam + Iron Reinforcement**

## CONCLUSIONS

Bamboo reinforced beams at the age of 7 days reached 25 KN, at the age of 14 days reached 28 KN and at the age of 28 days reached 29 KN. Where it can be concluded that the compressive strength of concrete increased at the age of 7 to 28 days. Bagasse reinforced beams at the age of 7 days reached 20 KN, at the age of 14 days reached 23 KN and at the age

of 28 days reached 24 KN. Where it can be concluded that the compressive strength of concrete increased at the age of 7 to 28 days but the results at the age of 28 days did not reach 100%. Iron reinforced beams at the age of 7 days reached 26 KN, at the age of 14 days reached 30 KN and at the age of 28 days reached 33 KN. Where it can be concluded that the compressive strength of concrete increased at the age of 7 to 28 days. Based on the research results, it was found that the beams with the addition of bamboo and iron reinforcement experienced an increase in the percentage of flexural strength testing, while the beams reinforced with bagasse at the age of 28 days did not reach the desired target.

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