

## **ANALYSIS OF CONCRETE COMPRESSIVE STRENGTH USING LIGHTWEIGHT BRICKS AS A PARTIAL REPLACEMENT OF FINE AGGREGATE**

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### **ABSTRACT**

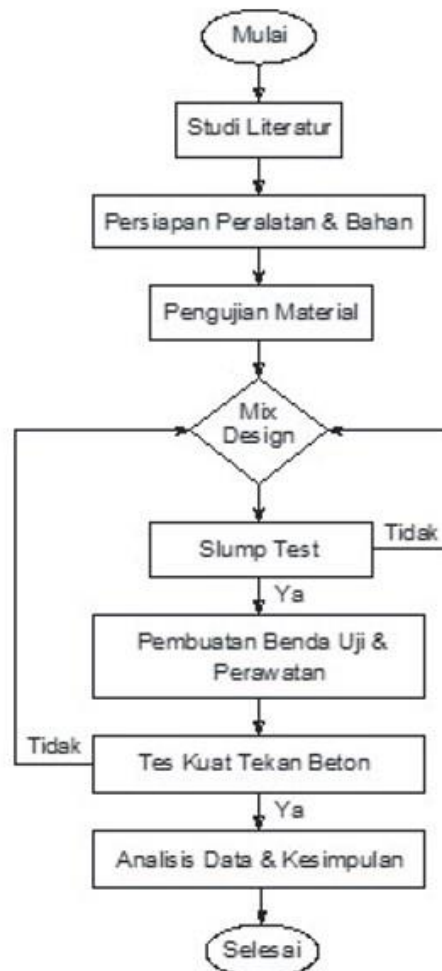
Infrastructure development is a top priority in Indonesia due to economic growth and demographic changes. With a budget of 149.81 trillion in 2021, infrastructure development is prioritized for economic recovery from COVID-19. Increased construction activities, including buildings, roads, and bridges, increase the demand for materials such as concrete, which is chosen for its strength and affordable cost. However, excessive sand mining for concrete has a negative impact on the environment. In addition, the increase in construction waste emphasizes the importance of waste management. This study explores the use of lightweight brick waste as a partial substitute for sand in concrete, focusing on its effect on the compressive strength of concrete. The following are the conclusions that can be drawn based on data analysis and discussion regarding the utilization of lightweight brick powder waste with variations of 0%, 12%, and 17% that have been explained in the previous chapter, the results of the compressive strength test on normal concrete at the age of 28 days reached 440 kN (fc'24.91), while variation 1 with 12% lightweight brick substitution reached 345 kN (fc' 19.53), and variation 2 with 17% lightweight brick substitution reached 309 kN (fc'17.49).

**Keywords:** Concrete, Concrete Compressive Strength, Lightweight Brick

### **INTRODUCTION**

Infrastructure development is a top priority in Indonesia due to economic growth and demographic changes. With a budget of 149.81 trillion in 2021, infrastructure development is prioritized for economic recovery from COVID-19. Increased construction activities, including buildings, roads, and bridges, increase the demand for materials such as concrete, which is chosen for its strength and affordable cost. However, excessive sand mining for concrete has a negative impact on the environment. In addition, the increase in construction waste emphasizes the importance of waste management. This study explores the use of lightweight brick waste as a partial substitute for sand in concrete, focusing on its effect on the compressive strength of concrete.

## METHODS

**Figure 2. Research Flowchart**

Before starting the research, it is important to prepare the tools and materials so that the process runs smoothly. The tools to be used must first be cleaned from dust or dirt. For example, the concrete cylinder needs to be cleaned to prevent the bolts from getting stuck when used. The walls of the concrete cylinder must also be lubricated so that the poured and dried concrete does not stick to the walls. Similar preparations also need to be made for other tools such as scales, ovens, and mixers. Materials such as sand, crushed stone, water, and cement must be available in full from the beginning to the end of the research to avoid shortages. In addition, these materials must be stored in a place protected from the weather to maintain their quality.

- 1) Slump testing on concrete is a measurement of the difference in concrete height that occurs immediately after the slump mold is lifted, according to SNI 1972-2008. This test assesses the water balance in the concrete mixture, with a target decrease of around  $10 \text{ cm} \pm 2$ ;
- 2) The concrete molding process is in accordance with SNI 2493-2011 which describes how to make and maintain concrete test objects in the laboratory.
- 3) Concrete maintenance is also regulated by SNI 2493-2011, which includes methods for

## RESULTS AND DISCUSSION

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

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

| Lolos Ayakan                                                                                                              |        | Berat Tak Lolos | Jumlah Tak Lolos | Jumlah Prosentase |           | 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 2 (two) methods to test the content of sand mud and clay: volume and weight.

**Table 2 Sand Mud Analysis Test**

| 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 $((A) - (B) / A) \times 100 \%$ | 1,54        | 1,68  |
|                                                                                                  | <b>Kandungan lumpur rata-rata (%)</b>            | <b>1,61</b> |       |
| Temuan pengujian : <b>1,61%</b> 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 split analysis for the split stone used in this test, which has a maximum size 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 Concrete Slump Test Analysis**

| Desain Campuran                                                                 | Nilai Slump | Satuan    |
|---------------------------------------------------------------------------------|-------------|-----------|
| Beton f'c 25 Mpa.                                                               | 8           | cm        |
| Beton f'c 25 MPa variasi 10% limbah serbuk bata ringan sebagai substitusi pasir | 10          | cm        |
| Beton f'c 25 MPa variasi 15% limbah serbuk bata ringan sebagai substitusi pasir | 11          | cm        |
| <b>Rata-rata</b>                                                                | <b>9,7</b>  | <b>cm</b> |



**Figure 3. Normal Concrete Slump Test**

**Table 8 Compressive Strength Analysis Test of 7-Day-Old Cylinder Concrete Load**

| No | Benda Uji | Tanggal Pembuatan | Tanggal Pengujian | Umur Benda Uji (hari) | Berat Benda Uji (kg) | Aktual Kuat Tekan kN | Rata-rata Kuat Tekan kN | Rata-rata Kuat Tekan kN |
|----|-----------|-------------------|-------------------|-----------------------|----------------------|----------------------|-------------------------|-------------------------|
| 1  | fc'25     | 27 Mei 2024       | 3 Juni 2024       | 7                     | 11,85                | 265                  | 266                     | 60,18%                  |
| 2  | fc'25     | 27 Mei 2024       | 3 Juni 2024       | 7                     | 12,1                 | 274                  |                         |                         |
| 3  | fc'25     | 27 Mei 2024       | 3 Juni 2024       | 7                     | 11,7                 | 260                  |                         |                         |
| 1  | 12% BR    | 6 Juni 2024       | 13 Juni 2024      | 7                     | 11,8                 | 195                  | 207                     | 46,83%                  |
| 2  | 12% BR    | 6 Juni 2024       | 13 Juni 2024      | 7                     | 11,85                | 221                  |                         |                         |
| 3  | 12% BR    | 6 Juni 2024       | 13 Juni 2024      | 7                     | 11,85                | 206                  |                         |                         |
| 1  | 17% BR    | 13 Juni 2024      | 20 Juni 2024      | 7                     | 11,55                | 211                  | 206                     | 46,61%                  |
| 2  | 17% BR    | 13 Juni 2024      | 20 Juni 2024      | 7                     | 11,7                 | 229                  |                         |                         |
| 3  | 17% BR    | 13 Juni 2024      | 20 Juni 2024      | 7                     | 11,6                 | 178                  |                         |                         |

**Table 9 Compressive Strength Analysis Test of 14-Day-Old Cylinder Concrete Load**

| No | Benda Uji | Tanggal Pembuatan | Tanggal Pengujian | Umur Benda Uji (hari) | Berat Benda Uji (kg) | Aktual Kuat Tekan kN | Rata-rata Kuat Tekan kN | Rata-rata Kuat Tekan kN |
|----|-----------|-------------------|-------------------|-----------------------|----------------------|----------------------|-------------------------|-------------------------|
| 1  | fc'25     | 27 Mei 2024       | 10 Juni 2024      | 14                    | 11,95                | 367                  | 372                     | 84,16%                  |
| 2  | fc'25     | 27 Mei 2024       | 10 Juni 2024      | 14                    | 12,16                | 372                  |                         |                         |
| 3  | fc'25     | 27 Mei 2024       | 10 Juni 2024      | 14                    | 11,9                 | 377                  |                         |                         |
| 1  | 12% BR    | 6 Juni 2024       | 20 Juni 2024      | 14                    | 11,8                 | 297                  | 298                     | 67,42%                  |
| 2  | 12% BR    | 6 Juni 2024       | 20 Juni 2024      | 14                    | 11,85                | 303                  |                         |                         |
| 3  | 12% BR    | 6 Juni 2024       | 20 Juni 2024      | 14                    | 11,95                | 294                  |                         |                         |
| 1  | 17% BR    | 13 Juni 2024      | 27 Juni 2024      | 14                    | 11,55                | 237                  | 263                     | 59,50%                  |
| 2  | 17% BR    | 13 Juni 2024      | 27 Juni 2024      | 14                    | 11,88                | 266                  |                         |                         |
| 3  | 17% BR    | 13 Juni 2024      | 27 Juni 2024      | 14                    | 11,74                | 287                  |                         |                         |

**Table 10 Compressive Strength Analysis Test of 28-Day-Old Cylinder Concrete Load**

| No | Benda Uji | Tanggal Pembuatan | Tanggal Pengujian | Umur Benda Uji (hari) | Berat Benda Uji (kg) | Aktual Kuat Tekan kN | Rata-rata Kuat Tekan kN | Rata-rata Kuat Tekan kN |
|----|-----------|-------------------|-------------------|-----------------------|----------------------|----------------------|-------------------------|-------------------------|
| 1  | fc'25     | 27 Mei 2024       | 24 Juni 2024      | 28                    | 11,85                | 445                  | 440                     | 99,55%                  |
| 2  | fc'25     | 27 Mei 2024       | 24 Juni 2024      | 28                    | 12,1                 | 439                  |                         |                         |
| 3  | fc'25     | 27 Mei 2024       | 24 Juni 2024      | 28                    | 11,7                 | 436                  |                         |                         |
| 1  | 12% BK    | 6 Juni 2024       | 4 Juli 2024       | 28                    | 11,8                 | 358                  | 345                     | 78,05%                  |
| 2  | 12% BK    | 6 Juni 2024       | 4 Juli 2024       | 28                    | 11,85                | 347                  |                         |                         |
| 3  | 12% BK    | 6 Juni 2024       | 4 Juli 2024       | 28                    | 11,85                | 329                  |                         |                         |
| 1  | 17% BK    | 13 Juni 2024      | 11 Juli 2024      | 28                    | 11,55                | 296                  | 309                     | 69,91%                  |
| 2  | 17% BK    | 13 Juni 2024      | 11 Juli 2024      | 28                    | 11,7                 | 308                  |                         |                         |
| 3  | 17% BK    | 13 Juni 2024      | 11 Juli 2024      | 28                    | 11,6                 | 323                  |                         |                         |

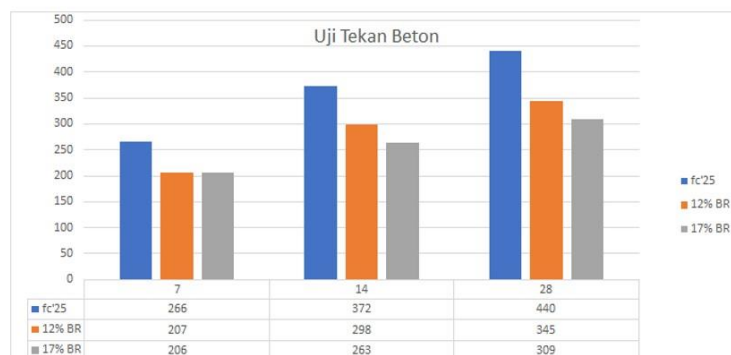


**Figure 4. Normal Concrete Compression Test Bar Diagram, Variation 1 & Variation 2**

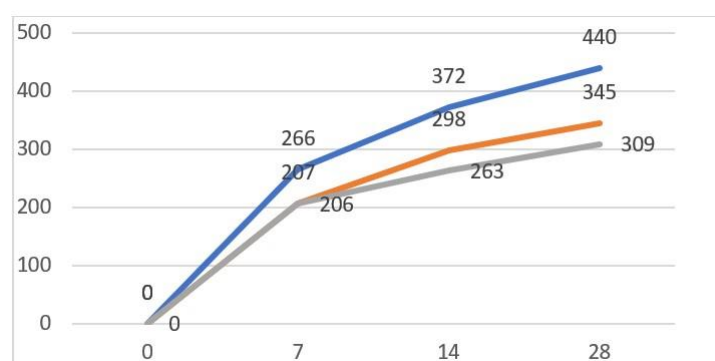


**Figure 5. Normal Concrete Compression Test Graph, Variation 1 & Variation 2**

## CONCLUSIONS

The following are the conclusions that can be drawn based on data analysis and discussion regarding the utilization of lightweight brick powder waste with variations of 0%, 12%, and 17% that have been explained in the previous chapter, the results of the compressive strength test on normal concrete at the age of 28 days reached 440 kN (fc'24.91), while variation 1 with 12% lightweight brick substitution reached 345 kN (fc' 19.53), and variation 2 with 17% lightweight brick substitution reached 309 kN (fc'17.49).

## REFERENCES

- Taqwa, I., Rumbyarso, Y. P. A., & Darmiyanti, L. (2024). ANALYSIS OF LIGHTWEIGHT BRICK WASTE FOR PARTIAL SUBSTITUTION OF FINE AGGREGATE ON CONCRETE COMPRESSIVE STRENGTH. *INTERNATIONAL JOURNAL OF MULTI SCIENCE*, 4(02), 34-41.
- Rumbyarso, Y. P. A. (2022). Analysis Of Compressive Strength Of Concrete By Using Slag Circum As A Concrete Aggregate Mix. *International Journal Of Multi Science*, 2(12), 35-46.
- Abdillah, S. R., Zulfikar, S., & Prima, Y. (2023). PENGARUH LIMBAH CANGKANG KERANG SEBAGAI SUBSTITUSI AGREGAT HALUS TERHADAP KUAT TEKAN BETON. *Jurnal Sipil Krisna*, 9(1), 39-48.