E-ISSN: 2528-388X
P-ISSN: 0213-762X

The Optimum Vibration of the Compressive Strength of Concrete Specimen

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Keywords:
Compressive Strength
Concrete Vibration
Vibrating Table

ABSTRACT

Concrete is the primary material in construction, so it needs further research to get good quality concrete. The quality and durability of concrete are influenced by the amount and shape of the air cavity inside the concrete. With vibrating, the air that is inside the concrete will be lost. The benefits of vibration will only be achieved if planned and implemented with a suitable method. With proper vibration, the air in the concrete will come out and make porous concrete. Reduction or removal of air cavities will make concrete mixes strong with low permeability, increasing the durability of concrete. This study aims to determine the optimum strong vibrating on the compressive strength of Fc' 21,7 Mpa concrete. Vibrating will be performed on cylinder concrete samples with a duration time of 3 minutes and with different variations in acceleration 160 m/s^2, 170 m/s^2, 180 m/s^2, 190 m/s^2, 200 m/s^2, variation velocity 140 mm/s, 150 mm/s, 160 mm/s, 170 mm/s, 180 mm/s, displacement variation 600 mm, 800 mm, 1000 mm, 1200 mm, 1500 mm. Each variation consists of 7 concrete samples. These tests were performed with methods of external vibrating by using MBT Vibrating table CO-410 in fresh concrete. Compressive strength testing is carried out at 28 days. This study shows that the optimum strong vibrating with acceleration 180 m/s^2, velocity 160 mm/s, and displacement 1000 mm with the resulting compressive strength is Fc' 23.06 MPa. So that knowing the optimum vibration strength can be the basis for the implementation of vibration to get the planned concrete quality.

1. Introductions

The construction industry is one of the industries with a high potential to improve the economy. Construction materials must be used properly and adapted to the needs. Concrete is one of the dominant materials in construction. [1] Development in construction, such as buildings, bridges, and roads, is growing rapidly, resulting in increased demand for concrete [2][3]. Concrete becomes a material in construction that is widely used because of the ease of maintaining concrete and also the concrete constituent material that is easily obtained. Concrete consists of cement, aggregate, and water. Sometimes admixture is added to or improves concrete requirements [4]. In addition to admixture, air voids in the concrete affect its quality and durability [5]-[7]. Vibration is an important casting process to ensure proper concrete consolidation. [8] Consolidation is the distribution of concrete composition materials evenly in the mixture. Consolidation in fresh concrete is important because of its effect on compressive strength [9]. Vibration can reduce the air cavity [10], so filling that space with cement or aggregating with that concrete will be high quality. [11] A 1% air cavity in concrete will reduce 6% concrete strength. [12] Reduction or removal of air cavities will make concrete mixes strong with low permeability, increasing the durability of concrete [13]. In addition to compressive strength and durability, concrete with a vibrator will increase workability compared to concrete that does not use a vibrator.[14] With proper vibration, the concrete's air will come out and make porous concrete [15].

In general, vibration is a repetitive motion over some time, with the related parameters of acceleration, velocity, and displacement [16]. For good-quality concrete, the vibration must be done properly. [17] The benefits of vibration will only be achieved if planned and implemented with the right method. One of them is about

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https://doi.org/10.21831/inersia.v18i2.54522
Received 14 November 2022; Revised 29 December 2022; Accepted 31 December 2022
Available online 31 December 2022

time and frequency. Concrete compressive strength will increase with increasing strong vibration and time vibration, but a vibration that exceeds the optimum time will make the concrete segregation. [18] in concrete, segregation or separation of aggregates must be controlled and even avoided because it will affect the strength and durability of concrete. [19] Compressive strength becomes a parameter to determine the strength or quality of concrete [20].

In general, the use of vibrators for compaction is often used for the production of cast or precast concrete [21]. Vibration methods on concrete used in the precast industry are; Internal vibration, External vibration, tamping, vacuum, and pressure. The internal vibrator produces compression waves that are repeated quickly and show the best performance at high amplitude [22]. External vibration will produce concrete with a better surface because, in its implementation, vibrations are not given directly to fresh concrete but to concrete formwork [23]. A table vibrator is one of the external vibrators widely used in the precast industry. The vibration is given to the concrete and placed under the table plate so there is no internal friction in the concrete [25]. Several studies have investigated the behavior of concrete caused by concrete vibration. However, not much has been discussed how strong it is needed to achieve optimum compressive strength.

This study aimed to determine the effect of vibration with variations in acceleration, velocity, and displacement on fc' 21.7 MPa. From knowing this, the right vibration strength will be found. Thus, the vibration process can optimize the compressive strength of concrete.

2. Method

The research is based on experimentally making test objects in the laboratory. The purpose of this experimental study is to examine how the strong influence of concrete compaction.

2.1 Material

Concrete material must meet the material requirements to achieve the planned quality. The concrete must be tested in civil engineering laboratories to meet the material requirements.

a) Cement

Cement in the concrete mixture serves as a binder for aggregate materials. The adhesive used is (PCC type I refresh to ASTM C150 [25].

b) Aggregate

Fillers in concrete mixes derived from natural materials are called aggregates which refer to ASTM C33 [26]. Approximately aggregate occupies 70% of the volume of concrete [27]. The aggregates used in this study are coral and sand [28] The coarse aggregate, taken from the village of Kedak Kediri in East Java with a maximum size 20 mm, with the amount of mud in coarse aggregate as much as 1.41%. In the coarse leaching aggregate, remove fine aggregate particles, which can affect the concrete properties [29]. The fine aggregate is taken from the Brantas River in Kediri, East Java, with a maximum size 2 mm with an amount of mud in fine aggregate of 4.3%. All aggregate is free from organic substances [30].

Figure 1. (a) Coarse aggregate ; (b) Fine aggregate; (c) water

The proportion of water in the concrete is vital to be considered to provide adequate workability during the mixing or casting process. [31] the water used is clean water pH 7 taken in the university's civil engineering laboratory.

2.2 Mix Proportions Concrete

The determination of mixing proportions refers to 7656-2012. Each variation in this study has 7 test specimens, so there are a total of 35 test specimens.

Table 1. Quantity of materials for 1 m3 fc' 21,7 Mpa

Materials	Cement (kg)	Fine aggregates (kg)	Coarse aggregates (kg)	Water (Lt)
Quantities per (m^3)	384	692	1039	215

Table 2. Quantity of materials for 0.045 m^3 fc' 21,7 Mpa

Materials	Cement (kg)	Fine aggregates (kg)	Coarse aggregates (kg)	Water (Lt)
Quantities per (0.045m^3)	17.09	30.80	46.25	9.57

2.3 Mixing and Casting

Concrete mixing is done using an electric concrete mixer (Figure 2). The pouring of fresh concrete into the mold is divided into three layers, with each layer compaction of the cornering method 25 times using an iron bar. The specimen used was cylindrical with a diameter of 15 x 30 cm. As soon as it is put into the mold, fresh concrete is vibrated using a vibrating table to remove the culture cavity inside the concrete. The concrete then it is cured ASTM C31 after 24 hours [32]-[33]. The compressive strength test was carried out when the concrete was 28 days old. After compressive strength testing, visual observations were made about cracks that occur and also air cavities in hard concrete

Figure 2. (a) Concrete mixer (b) Cylinder mold

2.4 Vibration

There are many methods used in vibrating concrete to remove air cavities that are in concrete. One method used in this study is the external vibrating method using an MBT vibrating table for vibrating concrete. Vibration Meter GM63B (Figure 3) for reading acceleration, velocity, and displacement with frequency 1kHz [32] [34] [35] Vibration strength variation with variations in acceleration 160 m/s^2, 170 m/s^2, 180 m/s^2, 190 m/s^2, 200 m/s^2, variation velocity 140 mm/s, 150 mm/s, 160 mm/s, 170 mm/s, 180 mm/s, displacement variation 600 mm, 800 mm, 1000 mm, 1200 mm, 1500 mm.

Figure 3. (a) MBT vibrating table CO-410; (b) Vibration Meter GM63B

2.5 Compressive Strength Test

Tested according to ASTM C39 / C39M [36] Concrete strength is the ability of concrete to withstand a large load with a certain compressive force. Before testing the compressive strength, the surface of the test specimen must be leveled so that the load is evenly distributed. If the load is not evenly distributed, it will result in reduced compressive strength. Figure 4 is a compressive strength test machine with type TC-325 Tatonas, 150 tons with 220 VAC power.

Figure 4. Universal Testing Machine type TC-32

3. Result

3.1 Slump

The result of slump determines the level of concrete workability that is done. the planned slump reduction rate is 12 ± 2 cm.

Figure 5. Slump Test

From the picture above show the decrease that occurs includes slump collapse with slump value obtained is 12 cm

3.2 Acceleration Effects

Acceleration is the change in velocity per unit of time. The result compressive strength of concrete and the acceleration are described as follows.

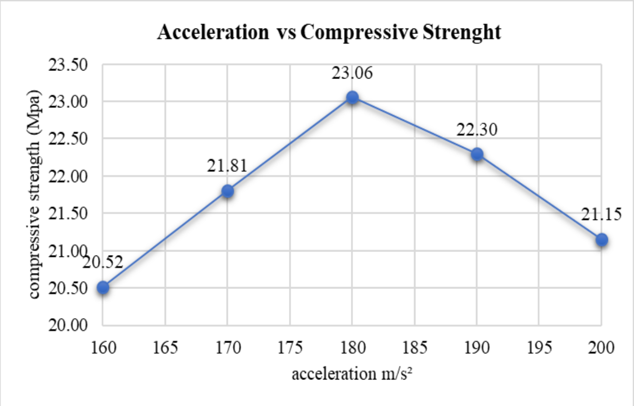

Figure 6. Effect of velocity on strength

The compressive strength of concrete reaches the planned target with a given acceleration of more than 160 m/s^2. The highest compressive strength obtained is 23.06 Mpa with an acceleration of 180 m/s^2. When the vibrational acceleration level is increased, the compressive strength of the concrete also increases. But after reaching the optimum point, the compressive strength decreases with the vibration acceleration.

3.3 Velocity Effects

With variations in velocity 140 mm/s, 150 mm/s, 160 mm/s, and 170 mm/s, produce compressive strengths of 20.52 MPa, 21.81 MPa, 23.06 MPa, 22.30 MPa, 21.15 MPa, respectively.

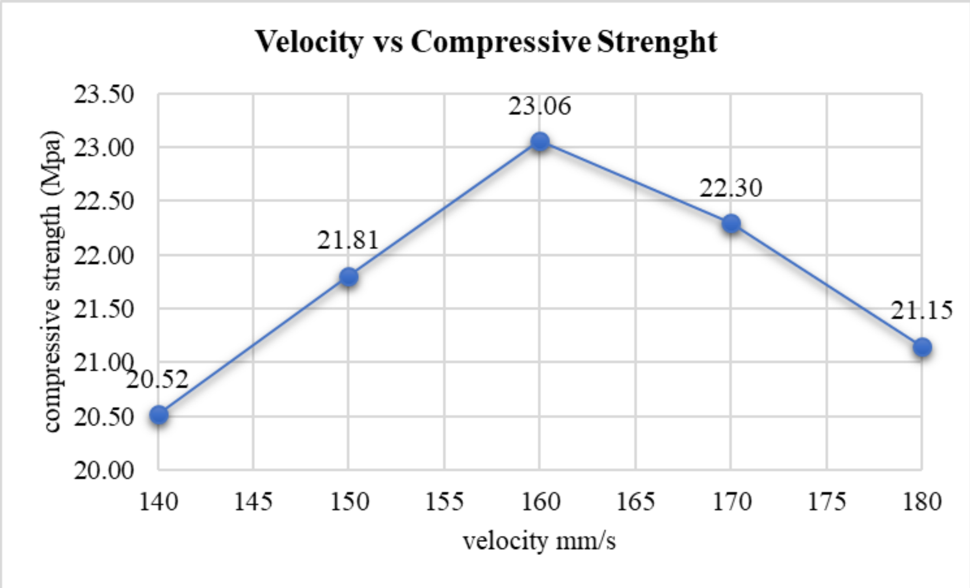

Figure 7. Effect of velocity on strength

The highest compressive strength faced at velocity 160 mm/s, in Figure 7, shows that an increase in compressive strength occurs when velocity increases, but the compressive strength decreases after achieving optimum velocity.

3.3 Displacement Effects

Displacement indicates the magnitude of the distance of the vibrating system from the condition balance. The image below is presented the relationship between the compressive strength of concrete and the displacement of 28-days.

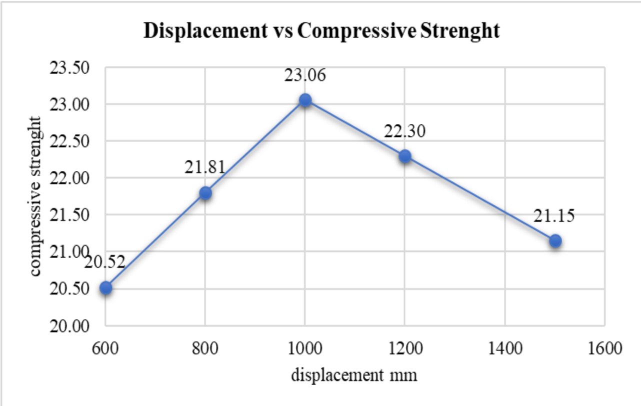

Figure 8. Effect of displacement on strength

The results show that compressive strength is reached with a given displacement of more than 600 mm. The highest compressive strength obtained is 23.06 Mpa with removal of 1000 mm. when the vibrational displacement level is increased, the compressive strength of the concrete also increases. But after reaching the optimum point, the compressive strength decreases with the displacement of vibration.

3.3 Visual

Figure 9a shows the outside appearance of the concrete after removing it from the formwork. From the image, air spaces are still evenly present in the concrete. Figure 9b shows the cracking pattern that occurred after the compressive strength test of the destruction in the concrete showed the destruction parallel to the vertical axis.

Figure 9. (a) Concrete air void (b) After compressive strength test

Figure 9 shows the air cavity and physical appearance in the concrete. from the picture can be seen that there are still air cavities that are in the concrete evenly with a very small size. But there is no segregation or aggregate separation.

Figure 10. Air cavity pattern in concrete

4. Conclusion

According to the compressive strength results, Compaction using a vibrating table is able to compact concrete well. This is indicated by the increase in concrete strength. The highest compressive strength achieved was 23.06 MPa with variations in acceleration, velocity and displacement of 180 m/s^2, 160 m/s, 1000 mm, respectively. a decrease in compressive strength will occur after vibration reaches optimum acceleration, velocity, and displacement. this shows that excessive vibration will result in a decrease in compressive strength. So that knowing the optimum vibration strength can be the basis for the implementation of vibration to get the planned concrete quality.

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