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Parameters of Compressive Strength of PCC Consequence Concrete the Difference in Curing Time and Specimen Shape

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Abstract: The strength of concrete is determined by its compressive strength. SNI 2847-2013 has determined that the compressive strength of concrete is obtained by using a cylindrical specimen with a diameter of 15 and a height of 30 cm (C.15) or a diameter of 10 cm and a height of 20 cm (C.10) at 28 days of age. The problem commonly encountered in the field is how to estimate the acceptable compressive strength of concrete if it has not reached the age of 28 days and with specimens that do not meet the standards set out in SNI. This study aims to obtain a correction factor for the age and shape of the test object when using a cube measuring 15x15x15 cm (K.15) and not yet reaching the age of 28 days using Portland Composite Cement (PCC). Concrete is cast using 4 forms of mold namely K15, K20, C10, and C15. Then cured until the age of 7, 14, and 28 days. At each immersion age, the compressive strength of the concrete was tested for each of the 3 specimens. The results showed that the average age factor was 0.59, 0.81, and 1 at 7, 14, and 28 days of age. While the form factor of the test object against the standard K15 form shows a value of 0.950 for K20, 1.028 for C10, and 0.813 for the C15 test object.

Keywords: Form factor; Test object age factor; PCC cement concrete

Introduction

Concrete is widely used as a building material which is obtained by mixing Portland cement, water, and aggregate in certain ratios (Polytechnic et al., 2018). The compressive strength of concrete is denoted by f'c, which is the maximum compressive stress obtained through testing in a standard procedure using a CTM (Compression Testing Machine) test tool (Widodo et al., 2017). According to SK SNI 03-xxxx-2002 RSNI 3, article 7.1 Concrete must produce an average compressive strength that meets the durability criteria with the provision that the f'c value must be based on cylinder tests that are made and tested on those that are 28 days old (Mulyadi et al., 2021). Standard cylindrical specimens in the field were initially only 15 cm x 30 cm in size. But as science and theory develop, smaller cylinder sizes are allowed. NI 2847-2013 has confirmed that the cylindrical test object that can be used is by article 5.1. For each trial mixture, at least two 150 by 300 mm cylinders or three 100 by 200 mm cylinders shall be manufactured and maintained by ASTM C192M (Suryani et al., 2018).

Cylinders shall be tested at 28 days of age or the specified test age. SNI 2847-2919 Article 5.6.3.2. Also explained that cylinders for strength tests must be printed and treated in a standard way. One way to control the quality of concrete is to test samples or specimens (Abdulla, 2022). There are two testing types: Steady Loading, controlling loading, and controlled strain rate, controlling strain. Cylinder specimens with a diameter of 150 mm and a height of 300 mm as specified in SNI 2847-2013 at the age of 28 days (Talinusa et al., 2014). The problem commonly encountered in the field is how to estimate the acceptable compressive strength of concrete if it has not reached the age of 28 days and with specimens that do not meet the standards set out in SNI. This study aims to obtain a correction factor for the age and shape of the cylindrical specimen. The compressive strength of concrete identifies the quality of a structure because the higher the desired level of structural strength, the higher the quality of the concrete

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that must be produced (Hadi, 2020). The compressive strength of concrete is denoted by f'c, namely the maximum compressive stress obtained through testing in a standard procedure using a CTM (Compression Testing Machine) test tool which provides a gradual load with a certain load-increasing speed on a cylindrical test object until it is destroyed.

Method

Research Design

This study uses experimental testing methods through laboratory testing. The research was conducted at the Laboratory of Concrete Materials and Structures, Department of Civil Engineering, Faculty of Engineering, Bosowa University using cylindrical specimens with dimensions of 15 cm x 30 cm. The research began with the manufacture of a concrete mix design using Portland cement, sand, crushed stone, and water for 20 cylindrical test samples 15x30 cm with target concrete compressive strength f'c = 20 MPa. The concrete mixture obtained is a control concrete mixture. After the concrete reaches 28 days of age, a compressive strength test is carried out. The results after going through statistical tests according to SNI 2847-2013 are declared to fulfill the requirements as concrete with a compressive strength f'c: 20 MPa. Then, using the same proportions of the mixture, cylindrical specimens were made with dimensions of 15x30 cm and 10x20 cm and cubes with dimensions of 15x15x15 cm and 20x20x20 cm. Then the compressive strength test is carried out.

Aggregate Test Results

Fine and fine aggregate testing refers to the test standards in Table 1.

Table 1. Aggregate Test Method

Test Type	Testing Standards
Sieve analysis of coarse and fine aggregates	SNI ASTM C136 :2012
Aggregate moisture content	SNI 1969:2008
Aggregate Weight	SNI-03-4804-1998
Specific gravity and absorption	
- Fine Aggregate	SNI 1970: 2016
- Coarse Aggregate	SNI 1969:2008
Material that passes sieve #200	SNI-03-4804-1998

Slump Testing

The slump test is a method used to determine the level of workability of concrete. This is indicated by how much water has been used in the mixture. The stiffness of the concrete mix must be matched to the product quality requirements, so the yield (Kumar, 2022). The slump test is a measure of the behavior of an inverted concrete cone that is compacted under the action of gravity. This measures the concrete's consistency or wetness, which then provides an overview of the workability conditions of the concrete mix (Figure 1).

Concrete Specimens

In this study, 4 test objects were used: 1. Cylinder 150 x 300 mm, 2. Cylinder 100 x 200 mm. 3. 150 x 150 x 150mm cube and 4, 200 x 200 x 200 mm cube.

Concrete Curing

Methods for making and treating specimens refer to SNI 2493-2011. Specimens. The test object is immersed in a water bath. The curing time was varied, namely 7 days, 14 days, and 28 days.

Result and Discussion

Aggregate Test Results

The results of fine aggregate and coarse aggregate testing can be seen in Tables 2 and 3.

Table 2. Fine Aggregate Test Results

Aggregate Characteristics		Test Result
Sieve analysis		Getaway %
Filter number	#.4	100.00
	#.8	87.84
	#.16	75.29
	#.30	55.30
	#.50	37.16
	#.100	18.25
	#200	1.26
Sludge levels		3.15
Water content		4.45
Fill weight		
- Free		1.67 gr/cm^3
- solid		1.76 gr/cm^3
Absorbs		0.77%
Specific weight		
- bulk-specific weight		2.62
- SD-specific weight		2.64
Apparent specific weight		2.67

Aggregate functions as a filler in mortar or concrete mixtures. This aggregate occupies approximately 70% of the volume of mortar or concrete (Nasrulloh et al., 2018). Even though it is only as a filler material, aggregate is very influential on the properties of the concrete, so the selection of aggregate is an important part in making concrete. Based on the gradation of sand and crushed stone 1-2 cm, with a ratio of 60:40. The most important property of an aggregate (stones, gravel, sand and others) is crush strength and impact resistance, which can affect its bond with the paste cement, porosity and water absorption characteristics which affects the resistance to the process winter time freezing and chemical aggression, and resistance to shrinkage (Wardi et al., 2022).

Table 3. Coarse Aggregate Test Results

Aggregate Characteristics		Test Result
Sieve analysis		Getaway %
Filter number	3/4″	100.00
	1/2″	26.07
	3/8″	7.71
	#.4	1.81
	#.8	0.25
	#.16	0.23
	#.50	0.18
	#.100	0.17
	#200	0.12
Sludge levels		0.79
Water content		0.56
Fill weight		
- Free		1.65 gr/cm^3
- solid		1.78 gr/cm^3
Absorbs		2.34%
Specific weight		
- bulk-specific weight		2.48
- SSD Specific weight		2.54
Apparent specific weight		2.64

To produce concrete with good cohesiveness, aggregate gradation is required the good one. The aggregate gradation is the size distribution aggregate grain hardness (Tumingan et al., 2017). The gradation is taken from sieving results. How to distinguish the type of aggregate the most done is with based on the size of the particles tested through sieving analysis. The aggregate have large granules coarse aggregate whose size is greater than 4.75 mm or retained on sieve no. 4 in the form crushed stone (split) and gravel. While details (Sulianti et al., 2018). The fine aggregates are called fine aggregates has a size smaller than 4.75 mm or passes filter no. 4 in the form of sand and fine materials pass other filters. aggregates used in concrete mixes are usually smaller than 40 mm. Aggregate that is larger than 40 mm in size is used for other civil works, for example for road works, earth retaining embankments, and others (Maldonado Bandala et al., 2018). Fine aggregate is usually called sand and coarse aggregate is called gravel, split, crushed stone, and others (Tomayahu, 2016). The combined gradation curve is obtained as shown in Figure 1.

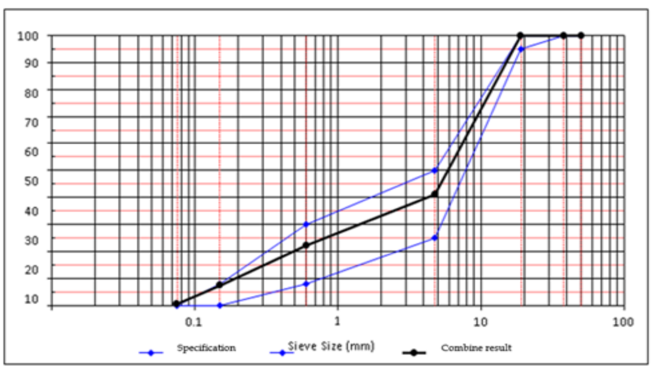

Figure 1. Combine gradation curve

Aggregate gradation is one of the properties that really determines the performance/durability of the road. Each type of road pavement has a gradation certain aggregates that can be seen in each road pavement material specifications.

Effect of Age Testing

Cube test object 15 x 15 x 15 cm

Table 4. Effect of Age Testing

Time (Days)	Press Hard (MPa)	Age Factor
7	13.41	0.59
14	18.37	0.81
28	22.677	1.00

Cube test object 20 x 20 x 20 cm

T[illegible]5. Effect of Age Testing

Time (Days)	Press Hard (MPa)	Age Factor
7	12.67	0.59
14	17.75	0.83
28	21.33	1.00

Cylinder test object D10 X 20 cm

Table 6. Effect of Age Testing

Time (Days)	Press Hard (MPa)	Age Hactor
7	14.01	0.60
14	18.68	0.80
28	23.35	1.00

Cylinder test object D15 x 30 cm

Table 7. Effect of Age Testing

Time (Days)	Press Hard (MPa)	Age Factor
7	10.76	0.57
14	16.42	0.88
28	18.68	1.00

The age factor presented in table 4 shows that the age factor of 14 days is 0.8–0.9 for the four test object forms, similar to the factor shown in PBI '71. As for the age of 7 days, the age factor is 0.65–0.75 higher than the test results which show a value of 0.59–0.60. This is because the cement used is different from the type of cement specified by PBI '71. Several studies have been carried out to correlate cylinder compressive strength with cubic compressive strength, among others, carried out by Neville, using cylindrical compressive strength as a standard then giving a correlation number for cubic compressive strength (Novianto et al., 2018).

Effect of Specimen Shape

Age 7 days

Table 8. Effect of Specimen Shape

Test Object Shape	Press Hard (MPa)	Form Factor
Cube 15 x 15 x 15 cm	13.41	1.00
Cube 20 x 20 x 20cm	12.67	0.94
Cylinder D10x20 cm	14.01	1.04
Cylinder D15x30 cm	10.76	0.80

Age 14 days

Table 9. Effect of Specimen

Test Object Shape	Press Hard (MPa)	Form Factor
Cube 15 x 15 x 15 cm	18.37	1.00
Cube 20 x 20 x 20cm	17.75	0.97
Cylinder D10x20 cm	18.68	1.02
Cylinder D15x30 cm	14.91	0.80

Age 28 days

Table 10. Effect of Specimen

Test Object Shape	Press Hard (MPa)	Form Factor
Cube 15 x 15 x 15 cm	22.677	1.00
Cube 20 x 20 x 20cm	21.33	0.94
Cylinder D10x20 cm	23.35	1.03
Cylinder D15x30 cm	18.68	0.82

The form factor of the test object is taken using a 15x15x15 cm cube as a standard. The test results show that the difference is not significant with the form factor stated in PBI '71. The strength of the concrete produced have varying tendencies mix to mix. Testing against the quality of the mix done from an object standard test cube (15 x 15 x 15) cm or (20 x 20 x 20) cm and specimens cylinder (15 x 30) cm. Analysis of the strength of the test object from a foundry designation that value distribution is related to probability theory (likelihood), so have a normal or Gaussian distribution (Doda, 2018).

The long-term performance of concrete structures is affected to a large extent by the properties and behaviour of concrete at early age. However, the fundamental mechanisms affecting the early-age behaviour of concrete have not yet been fully understood. This is due to the various highly interrelated factors influencing it, and the complexity of testing techniques needed for its investigation. With modern developments in concrete technology, it has become essential to evaluate the influence of these interrelated factors and their implications for the service life of concrete structures (Mazumder et al., 2020).

Concrete Compression Test Results

The compressive strength of concrete is the magnitude of the load unity area, which causes objects concrete crushing test when loaded with force certain press generated by the machine press (SNI 03-1974-1990) (Pratama et al., 2016). Concrete compression test results (Figure 2).

Based on Figure 2 it can be seen that the 28-day-old specimen has the highest weight, which is 23.35 MPa with a test cylinder size of D10 x 20 cm. The lowest compressive strength is 10.76 MPa with a cylindrical object shape test of D15 x 30 cm. The compressive strength of concrete is the main parameter that must be known and can provide an overview of almost all of the other mechanical properties of concrete (Polii et al., 2015). Even in concrete there is a tensile stress small, it is assumed that all compressive stresses are supported by the concrete. Concrete with good performance can see from the compressive strength produced. The higher the compressive strength produced, the concrete have good quality concrete (Supriadi et al., 2017). Factors affecting the strength of concrete are the proportions of the mix, mixing during the manufacture, manufacture, compaction and curing of the concrete itself.

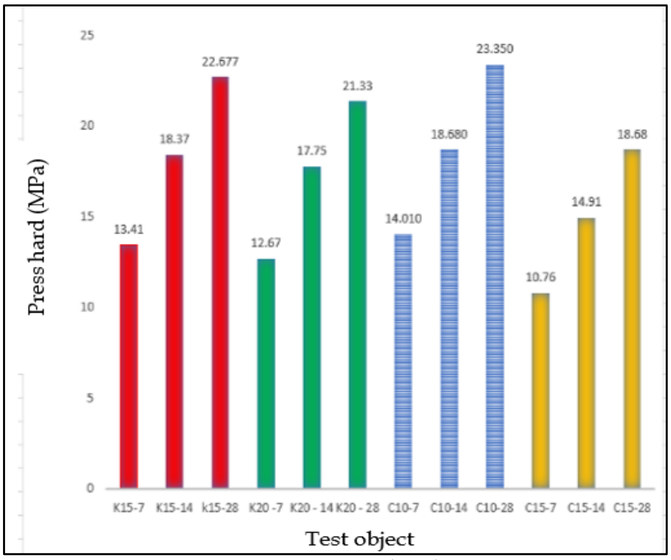

Figure 2. Press hard

Compressive strength is the ability of concrete to accept a broad unit compressive force. Concrete compressive strength identify the qualities of a structure. The higher the desired structural strength, the higher also the quality of the concrete produced (Khunt et al., 2022). The compressive strength value of concrete is obtained from the standard test. The test object used is cylindrical in shape. The standard specimen dimensions are 300 mm high and 150 in diameter mm. The test procedure that is generally used is the ASTM C39-86 standard. Press each the specimen is determined by the highest compressive stress (fc') achieved by the 28-day-old specimen due to the compressive load during the experiment.

Characteristic strength, compressive strength, stress and strain, shrinkage and creep, reaction to temperature, durability and water resistance (Hashempour et al., 2014). Of all these properties the most important is the compressive strength of concrete because it is an illustration of the quality of concrete that has to do with the concrete structure (Mohammed Redha, 2019). Each concrete, high-temperature curing after precuring does not have any adverse effect on the nonevaporable water content, compressive strength, permeability to chloride ions, and the connected porosity of concrete at late ages compared with standard curing (Jin, 2017). Modern construction methods often result in concrete structures bearing loads at an early age, which is different from the stress condition under the standard curing in the laboratory (Xue et al., 2021).

Conclusion

A correction factor for the age and shape of the test object when using a cube measuring 15x15x15 cm (K.15) and not yet reaching the age of 28 days using Portland Composite Cement (PCC).

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