Correlation of Laboratory and Field of Slab Concrete Compressive Strength

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Abstract. Concrete is construction's material that has been commonly used in the field of construction. To control the quality and quality of concrete, compressive strength of concrete is need for parameter. The aims of this study to determine the correlation of compressive strength of laboratory concrete and field concrete. The tests apply a compression strength machine for cylindrical specimens on laboratory and non-destructive test using hammer test on a concrete slab. The specimens are in the form of a cylinder of 15 × 30 cm and a concrete slab of 2 × 1 × 0.1 m. The compressive strength test was obtained at the age of 3 days, 7 days, 14 days, and 28 days with concrete curing from untreated and treated concrete. The results from this study, the compressive strength of concrete of concrete at the age of 28 days showed that normal laboratory concrete with curing still had the highest value of 25,172 MPa. Concrete with normal field with curing the value of compressive test is 22,626 MPa. The lowest value of 28 day was produced by normal field concrete without curing with an average compressive strength of 20.646 MPa, as well as for the test object in the form of a concrete slab, the highest compressive strength value was obtained on a concrete slab with curing at the age of 28 days with a value of 26.03 MPa. Both concrete slabs experienced an increase in compressive strength, but untreated concrete slab was still below the treated concrete slab. This shows that with increasing age with increasing age durability the treated concrete has higher strength.

Keywords: concrete curing · concrete compressive strength · slab · hammer test

1 Introduction

Concrete recently I one of the most frequently used material in construction, almost every aspect of development is inseparable from a concrete construction, therefore good quality concrete will greatly support structural safety for example, in the construction of roads, buildings, bridges and other construction.

The importance of the role of concrete construction requires an adequate quality of concrete, many research have been conducted to receive an alternative discovery the use of concrete in various construction fields in appropriately and efficiently, so it will be gained a better concrete quality. Concrete is a low-maintenance and longer service life compared to other materials [1].

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To support the concrete construction, components are needed that are planned, implemented, and regularly maintained in accordance with the planning and applicable regulatory standards. Each building is shaped to suit its respective environmental conditions, various conditions in the field can be a factor in decreasing the quality of the concrete itself.

Concrete strength is one of the parameters used to control the quality of a concrete. The testing method of the strength of the concrete itself is divided into *destructive testing* and *non-destructive testing* on finished constructions [2]. Destructive testing can damage the structure and requires high costs.

The process when working on concrete construction usually has more factors that affect the quality of concrete, from various ways of material preparation to concrete curing having different curings that can determine the quality of concrete [3].

The aims of this study to determine the comparison of compressive strength of concrete in laboratory and field with various curing methods using a *hammer test* on a concrete plate test object in the field and a compressive strength testing machine on a test object in the laboratory. Differences in implementation in the field of course often become one of the determining factors of a quality of concrete in concrete construction.

2 The Materials and Methods

2.1 The Materials

Cement which employed was type I with the cement brand Baturaja, coarse aggregate (crushed stone) comes from Merak, Banten and for fine aggregate (sand) from Tanjung Raja from, South Sumatera.

2.2 Test Methods

The physical properties testing of material is stage to define which aggregate is suitable with the gradation which has been determined based on Indonesian standards.

Material's physical properties testing consists of:

- Physical Examiner of Coarse Aggregate (Split Stone): SSD Specific Gravity and Absorption for aggregates [4], Content Weight [6], moisture Content [7], and Abration Test [8].
- Physical Examiner of Fine Aggregate (Sand) [5], SSD Specific Gravity and Absorption [4], content weight for fine aggregate [6], Moisture Content [7].
- Portland Cement Physical Testing: Cement Specific Gravity [9], Cement Consistency [10] and Cement Bonding Time [11].

From the results of the calculation of the concrete planning form, the mixture proportions for 12 normal concrete cylinders are as follows:

- Cement = 12.7 x 0.005 m^3 x 431.578 kg/m^3
  = 27.5 kg
- Water = 12.7 x 0.005 m^3 x 205 kg/m^3
  = 13.1 kg
- Sand = 12.7 x 0.005 m^3 x 485.47 kg/m^3
  = 30.1 kg
- Split = 12.7 x 0.005 m^3 x 1217.97 kg/m^3
  = 77.4 kg

From the results of the concrete calculation planning form, the ratio of the mixture for 1 piece of concrete slab with a size of 2m x 1m x 0.1m is as follows:

- Cement = 1.2 x 0.2 m 3 x 431.578 kg/m 3
  = 103.57 kg
- Water = 1.2 x 0.2 m^3 x 205 kg/m^3
  = 49.2 kg
- Sand = 1.2 x 0.2 m^3 x 485.47 kg/m^3
  = 116.51 kg
- Split = 1.2 x 0.2 m^3 x 1217.97 kg/m^3
  = 292.31 kg

The study used a cylindrical test object complete with 15 cm of diameter and 30 cm of height with a sample size of 36 concrete cylinders and a concrete slab with a size of 2 m × 1 m × 0.1 m.

There are two curings used in this study, the first is using the water curring method (wet curing) immersed in an immersion bath based on standard and the second is using the method by periodically wetting the concrete surface and covered with a material that can withstand water evaporation..

The compressive strength of concrete is doing a test with two methods, namely the direct compressive strength method which is destructive and the hammer test which is not destructive. Data analysis was obtained after the compressive strength of concrete tested.

3 Results and Discussion

3.1 Test Results

Materials research data includes testing the aggregates physical properties, this test used the aggregates which are coarse aggregate which is crushed stone, fine aggregate which is sand and physical properties of cement testing.

3.2 Physical Properties Test of Fine Aggregate

Fine Aggregates Physical Properties test is a test for aggregate according to SNI standards and which procedures contained in SNI. The tests results obtained on the material in the form of sand can be viewed in Table 1.

Table 1. Fine Aggregate Test Result

Test Type	Results	Unit	Specification
	Fine Aggregate		
	Sand		
Sieve Analysis	3.046	-	-
Bulk Specific Gravity	2.49	-	Min 2.5
SSD Specific Gravity	2.56	-	Min 2.5
Absorption	2,888	%	Max 3.0

Table 2. Coarse Aggregate Test Results

Test Type	Results	Unit	Specification
	Fine Aggregate		
	2:3		
Sieve Analysis	9.97	-	-
Bulk Specific Gravity	2.60	-	Min 2.5
SSD Specific Gravity	2.64	-	Min 2.5
Absorption	1.54	%	Max 3.0
Abration Test	0.76	%	<40

Table 3. Portland Cement Physical Properties Test Results

Test Type	Results	Unit	Specification	Explanation
Specific gravity	3.106	Kg/m^3	3–3.20	Qualify
Cement Consistency	10.65	Mm	10 ± 1 mm	Qualify
Cement Tie Time	107.12	Minute	Min 45	Qualify

3.3 Physical Properties Test of Coarse Aggregate

The procedure used according to SNI. The tests results which used the crushed stone material whose size $^2/_3$ had shown in Table 2.

3.4 Portland Cement Physical Properties Test

Portland Cement Physical Properties Test is a test for cement according to SNI standards and which procedures contained in SNI. Cement test results are shown in Table 3.

Table 4. Slump Test Results

Inspection	BN 1	BN 2	BN 3	CONCRETE SLAB
Highest point (cm)	8	8.5	9	9
Medium point (cm)	11	10.5	10	10
Low Point (cm)	12.5	12	14	11
Slump Value (cm)	10.5	10.3	11	10

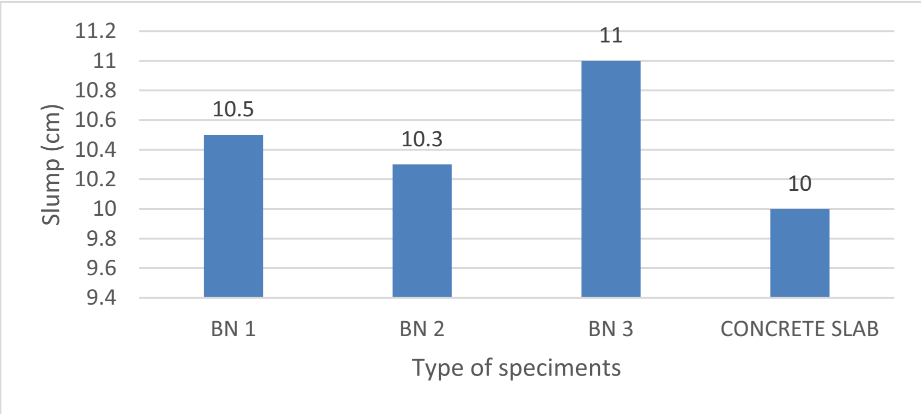

Fig. 1. Slump Value

3.5 Slump Test Results

Testing process for fresh concrete is carried out during the casting process, where the concrete has not yet experienced setting time. Fresh concrete testing is carried out through the slump test. The slump test value represents the workability of concrete made, where the higher value of the slump test, the better the workability value. Slump test is carried out for each sample of the test object. The results of slump test can be viewed in Table 4.

From the data in Table 4, a graph of the slump value is obtained as shown in Fig. 1.

The graph shows that the slump value has increased and decreased in different castings. The slump test value obtained when testing concrete on normal laboratory concrete mixes is 10.5 cm, for normal field concrete casting with maintenance it is 10, 3 cm, for normal field concrete without curing it is 11 cm and for plates concrete is 10 cm, in terms of increasing or decreasing does not occur with a constant value. The greater the slump value, the easier the workability process, but this is inversely proportional to the relationship between the value of slump test and the quality of the resulting concrete. The higher value of the slump test the lower value of the compressive strength of concrete produced also the lower the quality of the concrete. The results from the slump value taken, it can be concluded that the slump has met the plan, which is 6 cm–18 cm.

Table 5. Concrete Cylinder Compressive Strength Results

Test Object Age (Day)	Average Compressive Strength of Test Object (MPa)		
	BN 1	BN 2	BN 3
3	9.14	9.33	8.96
7	15.56	14.71	12.63
14	20.93	19.70	17.25
28	25,17	22.63	20.65

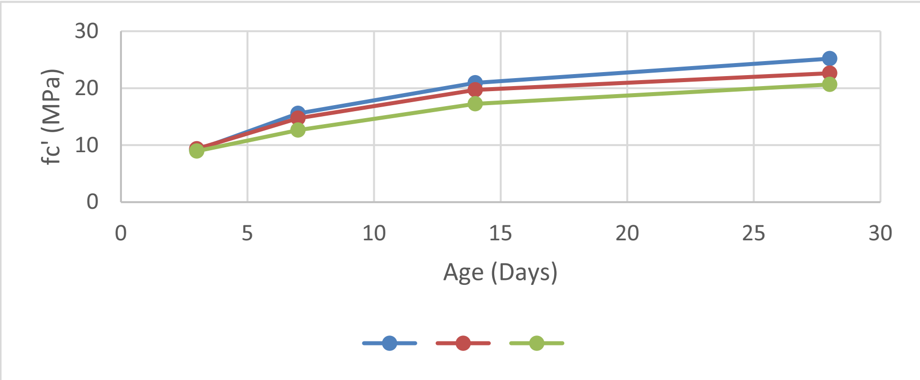

Fig. 2. Comparison Graph of Average Compressive Strength Values

3.6 Test Results of Compressive Strength in Cylindrical Concrete

Since forming and maintaining the test object, after that is doing the compressive strength testing of the test object. The concrete test object that was taken by the compressive strength test is the object at the age 3,7,14 and 28 days with the planned concrete quality being fc' 22.5 with 36 samples of cylindrical specimens. Compressive strength data viewed in Table 5.

Based on data from the compressive test of the concrete cylinder sample in Table 5, a comparison graph of the average compressive strength of normal concrete with different curings is made in Fig. 2.

Compressive strength of concrete at the age of 28 days shows that normal laboratory concrete by immersing it in water still has highest average compressive strength value of 25.71 MPa. Normal field concrete with curing got an average compressive strength value of 22.626 MPa. The lowest value was produced by normal field concrete without curing with an average compressive strength value of 20.646 MPa, when compared with results of normal laboratory concrete, which was 25.172 MPa, there was a decrease of 2.546 MPa or worth 10.114% of the compressive strength of normal concrete in field with curing and is 4.526 MPa or 17.980% of the value of the compressive strength of normal concrete in the field without curing.

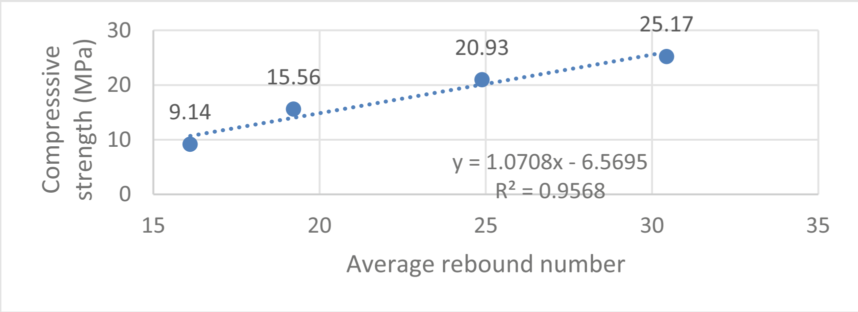

Fig. 3. Correlation between R and fc' cylinder field with Curing

The study results indicate that curing by covering the concrete with burlap sacks and regular watering provides higher strength with increasing time (durability). The possibility of maintaining temperature stability, and changes in humidity inside and outside the concrete because the concrete is protected from contamination by external influences, while the hydration process can run well by doing regular watering. In the field, both methods of curing by watering and closing wet burlap sacks can be carried out, in addition to maintaining the concrete quality, it also increases the concrete strength by increasing the age of the concrete, while the immersion curing of concrete should be obtained in the laboratory.

3.7 The Results of Concrete Plate Compressive Strength Test

After reaching the design age, the compressive strength of the concrete slab was tested using *a hammer test t* at the age of 3,7,14, and 28 days. This test purposes to see the difference in compressive strength of concrete from several methods of treated concrete slabs and untreated concrete slabs, the compressive strength value is formed the results of the linear regression equations that have been obtained in Fig. 3 and Fig. 4.

From Fig. 3 and Fig. 4 it can be explained the relationship between the reflected number (R) and the cylinder fc'.

There are 4 types of age with different averages which in the hammer test chart has provisions only for concrete aged 14 days–28 days, therefore this graph is made to get the fc' (MPa) value by connecting the reflected number (R) hammer test with a value of fc' (MPa) of cylindrical concrete which produces a linear regression equation $y = 1.0706x-6.5661$ for treated concrete slabs and $y = 0.9032x-4.6454$ for untreated concrete slabs.

From this regression equation, the fc' value of the equation shows the compressive strength value of the concrete slab. The compressive strength value of the concrete slab viewed in Table 6.

Based on Table 6, There is a graph for showing the average compressive of concrete slabs at the age of 3, 7, 14, and 28 days. Comparison graph of the concrete slab can be viewed in Fig. 5.

From Fig. 5 it can be said that both concrete slabs both experienced an increase in compressive strength, but the untreated concrete slab was still below the treated concrete

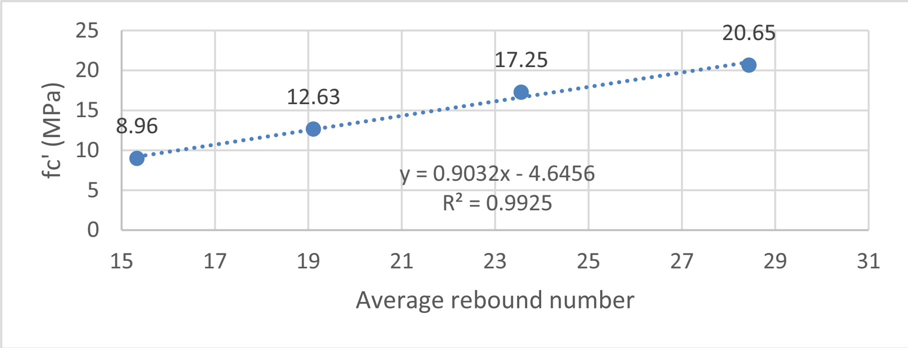

Fig. 4. Correlation between R and fc' Cylinder Field Without Curing

Table 6. Compressive Strength Value of Concrete Slab

Age Test Object (Day)	**Average Compressive Strength of Concrete Slabs (MPa)**	
	Concrete Slab (Cured)	Concrete Slab (Uncured)
3	10.68	9.2
7	14.01	12.62
14	20.08	16.63
28	26.03	21.03

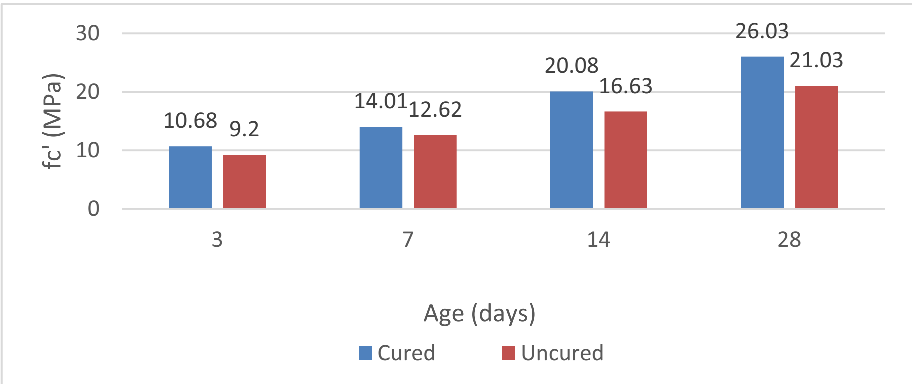

Fig. 5. Graph of Comparison of Test Results of Average Compressive Strength of Concrete Slabs in Different Curings

slab, this indicates that treated concrete is better than untreated concrete. The highest compressive strength value in concrete slab with curing at the age of 28 days with a value of 26.03 MPa and a decrease of 19% compared to concrete slab without curing, while at the age of 14 days there was a decrease of 17.1% and at the age of 7 days it decreased by 9, 9% and for the age of 3 days a decrease of 13.8%.

The possibility of maintaining temperature stability, and changes in humidity inside and outside the concrete because the concrete is protected from contamination by external influences, while the hydration process can run well by doing regular watering.

4 Conclusion

The results from this research, analysis, and discussion which have been performed, can be conclude by these following conclusion:

1. The compressive strength value of field concrete with curing and field concrete without curing that testing 28 days is still below the compressive strength of concrete which followed by curing at laboratory with a decrease of 10.114% for field concrete with curing and 17.980% for field concrete without curing.
2. The concrete's compressive strength at age of 3 days did not have a significant difference because the concrete was still wet and still in the process of hardening.
3. The compressive strength value of the concrete slab each increased but the concrete slab without curing was still under the treated concrete slab, at the age of 28 days the compressive strength value of the treated concrete slab was 26.03 MPa when compared to the untreated concrete slab, it decreased 19%.
4. In the concrete slab test object, there is a difference between the results of compressive strength value of concrete which test by engine test and the hammer test, so to determine the compressive strength value of concrete, a multiplier or constant is needed. From the regression result analysis, it was found that the correlation value between the hammer test and the compressive test (MPa) was obtained.

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