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AGE AND COMPRESSIVE STRENGTH OF CONCRETE FROM VARIOUS BRANDS OF PORTLAND COMPOSITE CEMENT (PCC)

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Abstract. *Recently it is provided in the construction market several types of cement such as OPC (Ordinary Portland Cement), White Cement and most recently is PCC (Portland Composite Cement). The composition of PCC cement's raw materials is Clinker, gypsum and additive materials. Additive materials used are limestone, fly ash and Trass. Unlike OPC type which does not use Fly Ash and Trass additives, in PCC it is used additives like Fly Ash and Trass where there is SiO2 compound that can increase the compressive strength. The research was carried out at the Laboratory of Civil Engineering Department of the Bali State Polytechnic using a cylindrical test object with size 15x30 cm of 20 pieces for each concrete age with a compressive strength of 25 MPa plan, tested at the age of 3, 7, 14, 21, 28, 56, and 90 days following PBI'71. The concrete strength of the concrete characteristics of the plan was achieved at the age of 56 days, with the value of the compressive characteristic of the plan reached at age 56 days with consecutive values of 25.82, 27.67, 26.80, 31.20 MPa and 28.81 MPa for Tonasa, Holcim, Bosowa, Merah Putih, and Tiga Roda cements. This value is greater than the value of compressive strength targeted based on the calculation of job mix design, in which it is 25 MPa. Conversion of Age and Compressive Strength Characteristics for the 5 (five) brands of PCC cement.*

Keywords : Concrete, PCC Cement, Age of concrete, Compressive strength of concrete

1. INTRODUCTION

1.1 Background

In public market, it is very difficult to get Portland type I (OPC) cement. The currently outstanding types are PPC (portland pozollan cement) and PCC (portland composite cement). This type of cement is currently used as an adhesive in a mixture of concrete. In the ready mix business there is also a tight competition, so in order to be able to exist they substitute cement with fly ash to get more competitive price.

Problems arised at the time of the testing of cube and cylinder test objects; that is the testing of concrete samples in various ages. The test data are often obtained at the ages 3, 7, 14 that the compressive strength of the concrete in accordance with the planned compressive strength is even greater. However, the 28-day sample test often results in a smaller value than the quality of the plan. To determine the value of compressive strength in the test at age less than 28 days converted with the coefficient of age and compressive strength quoted from PBI 71. Cube test object used in PBI 71 comes from cement of type I. Because of the controversy, the author wants to find out why such problems can happen.

1.2 Problems of the Study

The problems of this research are as follows:

a. At what age is the planned compressive strength of the concrete achieved?
b. What is the conversion rate of the compressive strength characteristic achievement in the variation of age for the concrete of the adhesives from several PCC cement brands?

1.3. Specific Aims of the Research

The expected objective of this research is to get an answer about the achievement of concrete compressive strength value in the age variation for some PCC cement brands. The value is to become a new reference in the construction industry which still uses the age conversion and concrete compressive strength value of type I cement adhesive.

2. METHOD

2.1 Materials

This research uses mixed concrete materials consisting of water, adhesives and fine aggregates. The provisions of each of these materials are described as follows.

The water used for mixing the concrete is taken from the existing water channel of the water supply company in the Materials Laboratory of the Civil Engineering Department of the Bali State Polytechnic. For hydraulic adhesive, a mixture of 5 PCC cement brands, among others: *Tonasa, Holcim, Bosowa, Merah Putih, and Tiga Roda.*

For fine aggregates, it is used natural sand derived from Karangasem in which the grain arrangement is designed to meet the gradations of zone 2 according to SNI 03-2834-2000. Coarse aggregate in the form of crushed stone with the provisions of the grain arrangement is designed to meet the gradation for the maximum grain size of 20 mm in accordance with SNI 03-2834-2000.

It was made 14 kinds of concrete with ratio in weight unit between adhesive material: fine aggregate: coarse aggregate equal to 1.00: 1,93: 2,67, with adhesive water factor = 0,52. The comparison of this mixture was obtained from the calculation of concrete mix design with f'c = 25 MPa. Types of concrete treatment are given in Table 1.

Table 1. Types of Concrete Treatment

Age	**The Code of the Test Object**
	TONASA
3	TNS 3
7	TNS 7
14	TNS 14
21	TNS 21
28	TNS 28
56	TNS 56
90	TNS 90
	HOLCIM
3	HLC 3
7	HLC 7
14	HLC 14
21	HLC 21
28	HLC 28
56	HLC 56
90	HLC 90
	BOSOWA
3	BSW 3
7	BSW 7
14	BSW 14
21	BSW 21
28	BSW 28
56	BSW 56
90	BSW 90
	MERAH PUTIH
3	MRP 3
7	MRP 7
14	MRP 14
21	MRP 21
28	MRP 28
56	MRP 56
90	MRP 90
	TIGA RODA

Age	The Code of the Test Object
3	TGR 3
7	TGR 7
14	TGR 14
21	TGR 21
28	TGR 28
56	TGR 56
90	TGR 90

2.1 Research Method

The implementation of the research is divided into several stages: preparation, manufacture of test specimens, specimen treatments, data collection and data analysis.

Preparatory steps include the preparation of tools, inspection of materials including the making of the implementation schedule. Equipment used such as mixer, cylinder mold 30 mm x 150 mm, vibrating machine, place of care and press test equipment. The feasibility of carrying out the research condition is checked.

Examination of the material concerning the examination of the characteristics of the basic materials used in the study such as specific gravity, unit weight, the design of fine aggregate gradation and coarse aggregate which will be used in any mixture and others.

Mixing of materials is done by using mixing machine 'Mixer' by following the standard procedure. In this study, un-mixed aggregates were prepared under SSD conditions. The number of specimens prepared according to the age of the test and the number of specimens per test.

Power measurements were performed at ages of 3, 7, 14, 21, 28, 56 and 90 days using each 20 (twenty) cylinders 30 mm x 150 mm for each type of cement and test life. Thus the required test piece for each treatment is 140 (one hundred and forty) pieces, so the total of 30 mm x 150 mm total cylinders made entirely is 280 (two hundred and eighty) pieces. The specimens were left in the mold for 24 hours and then opened from the mold for further maintenance. Treatment is carried out by placing test specimens in a room protected from direct sunlight up to the time specified for testing: 3, 7, 14, 21, 28, 56 and 90 days.

The test is done at the material laboratory of Civil Engineering Department of Bali State Polytechnic. The data collected are crushed loads for compressive strength. All of it is obtained from the test results of the cylindrical test object in accordance with the specified test age. Before testing the specimens were weighed and measured on the sides. From the information of compressive strength values, produced for each group of specimens and each subsequent age of testing, it is done an analysis to obtain the age and strength relationship of concrete made with mixed adhesive of PCC and PPC and concrete with Cement Type I adhesive.

For the purposes of drawing conclusions, the discussion involving the tested parameters and related theories in the literature is carried out. To facilitate an understanding of the discussion, the test results will be displayed in the form of tables and curves.

3. RESULTS AND DISCUSSION

3.1 Examination of Concrete Materials

The results of inspection of materials obtained from laboratory experiments shall be in accordance with the requirements of the concrete-forming material specified in the applicable concrete guidelines. This data will then be used in calculating the concrete mix design.

a. Fine aggregates

From the results of sand examination in the laboratory, sand data obtained as follows: (more data can be seen in appendix A-1)

1) Density of sand in state of SSD = 2.56 water absorption = 4.69% and volume weight 1,578 gr / cc
2) Gradation of fine aggregate designed according to SNI 03-2834-2000 goes into the gradation of zone 2 (Figure 4.1) with the fineness modulus (Fm) = 2.79.
3) Sandblood content = 1.44%, which means that sand is eligible for concrete mixtures according to SNI 03-4142-1996 that fine aggregates for concrete mixtures should not contain more than 5% sludge against dry weight.

b. Coarse aggregates

From the examination of crushed stone in the laboratory, it is obtained data as follows: (more data can be seen in Appendix A-2)

1) Weight of the crushed stone is in state of SSD = 2.32 water absorption = 3.93% and weight of volume 1.210 gr / cc

2) Gradation of coarse aggregate is designed according to SNI 03-2834-2000 with grain diameter of 20 mm (Figure 4.2), from this gradation it is obtained the fineness modulus = 6.55.
3) The level of crushed stone slurry obtained from the examination results is 0.3%. This value indicates that the crushed stone is eligible for the concrete mixture. In accordance with SNI 03-4142-1996, the crushed stone shall not contain more than 1% sludge.
4) The wear resistance is 35.56% which means that in accordance with the requirements of SNI 03-2417-1991, coarse aggregates shall not lose weight more than 50% when using a Los Angeles worn machine.

c. Cement

PCC cement is used in this study. The examination of the cement includes the volume, and from the examination it was found that the average cement volume was 1,235 g / cm3.

3.2 Results of Concrete Examination

a. Value of slump

The slump value test is intended to determine the degree of viscosity of the concrete mix which can further illustrate the workability of the concrete mixture. The slump test results obtained can be seen in the following table 3.1 below.

Table 3.1 The value of concrete mixture slump

Age	**The Code of the Test Object**	**VALUE SLUMP CM**
	TONASA	
3	TNS 3	4,00
7	TNS 7	3,00
14	TNS 14	3,00
21	TNS 21	5,00
28	TNS 28	3,00
56	TNS 56	3,00
90	TNS 90	3,00
	HOLCIM	
3	HLC 3	5,00
7	HLC 7	3,00
14	HLC 14	3,00
21	HLC 21	4,00
28	HLC 28	3,00
56	HLC 56	4,00
90	HLC 90	5,00
	BOSOWA	
3	BSW 3	4,00
7	BSW 7	3,00
14	BSW 14	3,00
21	BSW 21	3,00
28	BSW 28	6,00
56	BSW 56	5,00
90	BSW 90	4,00
	MERAH PUTIH	
3	MRP 3	3,00
7	MRP 7	4,00
14	MRP 14	4,00
21	MRP 21	4,00
28	MRP 28	3,00
56	MRP 56	3,00
90	MRP 90	3,00
	TIGA RODA	
3	TGR 3	3,00
7	TGR 7	3,00
14	TGR 14	3,00

Age	The Code of the Test Object	VALUE SLUMP CM
21	TGR 21	6,00
28	TGR 28	3,00
56	TGR 56	5,00
90	TGR 90	3,00

From table 3.1 it can be seen that the slump value occurring is still within the required interval of 30 mm - 60 mm, so mixing and molding of concrete can be continued.

b. Characteristic of Concrete Compressive Strength

The calculation of the compressive strength applies equations 2.1 and 2.2. The average compressive strength (Rm) is the amount of the compressive strength of the test objects divided by the amount of the test objects/ specimens (20 objects). The characteristic compressive strength of concrete (f'c) is calculated using the equation 2.3 described in chapter II. The calculation use simple statistic analysis in accordance to formula in PBI'71 article 4.5 (1) (2) pages 39 and 40.

The compressive strength value of the concrete characteristics for each treatment of the adhesive for each test age is shown in Table 3.2

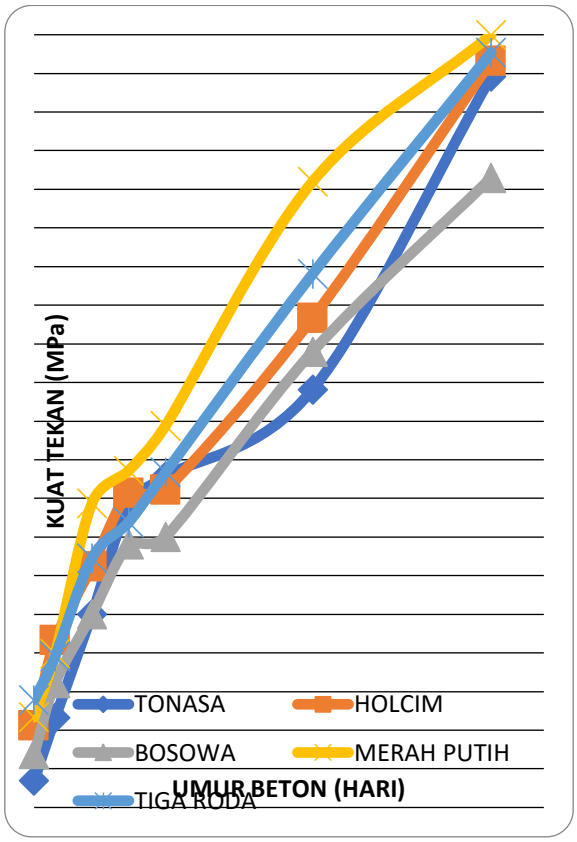
c. Conversion Rate of Age and Concrete Compressive Strength

After obtaining the result of value of concrete characteristic compressive strength for each cement, then the results are inserted into the table of concrete compressive strength recapitulation in the variation of age (3, 7, 21, 28, 56, and 90 days), then it is calculated the age conversion rate to concrete compressive strength age 56 days, shown in table 3.2 and figure 3.1.

Table 3.2 Conversion Rate of Age and Concrete Compressive Strength

Age	The Code of the Test Object	Compressive Strength MPa	Age Conversion Rate
	TONASA		
3	TNS 3	15,69	0,61
7	TNS 7	17,32	0,67
14	TNS 14	20,00	0,77
21	TNS 21	22,81	0,88
28	TNS 28	23,57	0,91
56	TNS 56	25,82	1,00
90	TNS 90	33,92	1,31
	HOLCIM		
3	HLC 3	17,12	0,62
7	HLC 7	19,32	0,70
14	HLC 14	21,23	0,77
21	HLC 21	23,14	0,84
28	HLC 28	23,22	0,84
56	HLC 56	27,67	1,00
90	HLC 90	34,32	1,24
	BOSOWA		
3	BSW 3	16,38	0,61
7	BSW 7	18,22	0,68
14	BSW 14	20,00	0,75
21	BSW 21	21,81	0,81
28	BSW 28	22,00	0,82
56	BSW 56	26,80	1,00
90	BSW 90	31,30	1,17
	MERAH PUTIH		
3	MRP 3	17,34	0,56
7	MRP 7	18,98	0,61

Age	The Code of the Test Object	Compressive Strength MPa	Age Conversion Rate
14	MRP 14	22,87	0,73
21	MRP 21	23,72	0,76
28	MRP 28	24,88	0,80
56	MRP 56	31,20	1,00
90	MRP 90	35,00	1,12
	TIGA RODA		
3	TGR 3	17,78	0,62
7	TGR 7	18,91	0,66
14	TGR 14	21,45	0,74
21	TGR 21	22,38	0,78
28	TGR 28	23,67	0,82
56	TGR 56	28,81	1,00
90	TGR 90	34,54	1,20



Picture 3.1 Age and Compressive Strength of Concrete

From Table 3.2 and Figure 3.1, it can be seen some behaviors of Concrete with PCC Adhesive as follows:

1) At the age of 3, 7, 14, 21, 28, and 56 days the value of characteristic compressive strength achieved by concrete from 5 brands of cement tends to increase.
2) The planned characteristics compressive strength were achieved at age 56 days with values of 25.82, 27.67, 26.80, 31.20 MPa and 28.81 MPa for cements of *Tonasa, Holcim, Bosowa, Merah Putih, and Tiga Roda*. This value is greater than the value of compressive strength of the targeted plan of the calculation of job mix design (25 MPa).

3) At the age of 90 days, the compressive strength value of all concrete characteristics increased by about 20% of the compressive strength at the age of 56 days.
4) The sequence of the compressive strength from the highest to the lowest: *Merah putih, tiga roda, holcim, tonasa, bosowa.*
5) From Table 3.2, it can be seen that when using the age conversion of compressive strength of PC1 concrete characteristics, then at age 3 and 7 days it will be produced higher compressive strength of PCC concrete characteristics than the planned compressive strength of concrete (25 MPa). But at the ages of 14, 21, and 28 days, it is produced lower compressive strength characteristic than the planned compressive strength. This is the answer to the field practitioner's question as to why at the early age of the test, the specimens they tested produced a compressive strength higher than the compressive strength required in the RKS.

4. CONCLUSION AND SUGGESTION

4.1 Conclusion

From the above data can be concluded several things as follows:

a. The material of sand and gravel concrete formers meets the applicable requirements; sand enter zone 2 mud content below 5%, gradation gravel max 20 mm, mud content is below 12%.
b. The slump value of a concrete mixture is obtained in a range that meets the requirements of 30 mm-60 mm
c. The targeted characteristics compressive strength is achieved at age 56 days, all brands of cement
d. Conversion Rate of Age and Characteristics Compressive Strength for adhesives from 5 (five) PCC cement brands are as listed in table 3.2.

4.2 Suggestion

Suggestions which may be given in connection with this research are as follows:

a. To reduce the confounding variables, it is necessary to make a gradation of coarse and fine aggregate.
b. The slump value occurring is set to almost the same for each concrete slab.
c. It is needed to do research on the percentage value of pozolan content in PCC or PPC cement
d. It is needed to be researched after 90 days of age, e.g. 120 days and 180 days, seeing a tendency to increase the compressive strength of concrete is quite high at the age of 90 days.

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