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Compressive strength of high-strength concrete with cornice adhesive as a partial replacement for cement

Compressive strength of high-strength concrete with cornice adhesive as a partial replacement for cement

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Abstract. Concrete was made from a mixture of water, cement, and aggregate with a ratio depending on the type of concrete. The purpose of this study was to determine the effect of using Cornice Adhesive as a partial replacement of cement on the compressive strength. Variations of cornice adhesive used were 0%, 5%, 10%, and 15% replacing cement. The compressive strength test was used to evaluate the mechanical characteristics of the concrete produced at 3 days, 7 days, 14 days, and 28 days. The results showed that cornice adhesive makes a positive contribution to the weight loss of concrete and can be used to reduce the weight of the structure. Although for the compressive strength value of the concrete mixture using Cornice Adhesive as a partial replacement of cement with variations of 5%, 10%, and 15% at the age of 3 days, 7 days, and 28 days could not exceed normal concrete (0% cornice adhesive). However, the biggest increase in compressive strength value from 3 days to 28 days is using a concrete mixture with a variation of 10% cornice adhesive as a replacement for cement, up to 70.4% increase.

1. Introduction

Concrete is a construction material that is currently very commonly used. Concrete is very closely related in various aspects of human life, especially in the field of development. Production of Portland cement as a material for making concrete is still the material most widely used by humans after water. [1]. Many studies have been carried out to obtain an alternative discovery of the use of concrete construction in various fields appropriately and efficiently, so that a better quality of concrete will be obtained in order to meet the needs of the community for structural and infrastructure facilities [2-4].

Refers with the development of knowledge and technology, the quality of concrete is developed and improved to be even better to create high-quality and even very high-strength concrete. Influencing factors the success of making high-quality concrete are condition of cement, water-cement factor, quality of coarse and fine aggregates, types of additives or substitutes used, correct and standardized manufacturing processes, and strict supervision and control [5].

In general, concrete can be obtained by mixing fine aggregate, coarse aggregate, cement and water. However, in this study, we will be tried to add other materials as a partial replacement for cement. The material is Cornice Adhesive [6,7].

Cornice Adhesive is a building material with a plaster powder texture and has a strong adhesion function to repair cracked, uneven, rough and smooth wall surfaces. In previous studies, Cornice Adhesive was used as a filler in Asphalt Concrete Wearing Course mixtures and the results revealed that

Cornice Adhesive is a non-plastic material, does not contain organic matter, in terms of grain size meets the requirements as a filler material, and can improve characteristics asphalt concrete wearing layer [8,9].

In addition to research on the use of Cornice Adhesive as a filler in asphalt mixtures, Cornice Adhesive is also used for organic soil stabilization. The results of the study stated that Cornice Adhesive can improve the characteristics of organic soil [10]. The purpose of this study was to determine whether the use of Cornice Adhesive as a partial replacement of cement can increase the compressive strength of concrete.

2. Materials and Methods

2.1. Physical Properties of Aggregate

Table 1 and Table 2 showed the results of testing the characteristics of the fine aggregate (2 mm - 5 mm) and the characteristics of the coarse aggregate (10 mm - 20 mm), respectively. As shown in Table 1, the water content was 3.95%, bulk density, saturated surface dry density and apparent density were 2.30, 2.35, and 2.43, respectively. Water absorption was 2.14%. As shown in Table 2, the water content was 3.16%, bulk density, saturated surface dry density and apparent density were 2.50, 2.55, and 2.63, respectively. Water absorption was 2.00%. Based on the test results of the characteristics of fine aggregate and coarse aggregate, it is known that all test results meet the specifications required by the Indonesian National Standard.

Table 1 Properties of fine aggregate

Properties	Testing Result	Specification (Indonesian National Standard)
Water content (%)	3.95	0.5 – 5.0
Volume weight (loose condition) (kg/l)	1.30	1.2 – 1.9
Volume weight (dense condition) (kg/l)	1.38	
Sludge content (%)	0.90	0.2 – 6.0
Bulk specific gravity	2.30	
Saturated surface dry specific gravity	2.35	1.6 – 3.1
Apparent specific gravity	2.43	
Water absorption (%)	2.14	0.1 – 5.0%

Table 2 Properties of coarse aggregate

Properties	Testing Result	Specification (Indonesian National Standard)
Water content (%)	3.16	0.5 – 5.0
Volume weight (loose condition) (kg/l)	1.32	1.2 – 1.9
Volume weight (dense condition) (kg/l)	1.48	
Sludge content (%)	0.50	0.2 – 2.0
Bulk specific gravity	2.50	
Saturated surface dry specific gravity	2.55	1.6 – 3.1
Apparent specific gravity	2.63	
Water absorption (%)	2.00	0.1 – 5.0%
Abrasion (%)	28.43	Max. 40%

2.2. Physical Properties of Portland Composite Cement

High strength concrete mixture blended production in this research was used Portland composite cement (PCC). A national cement factory was produced Portland composite cement (PCC) and meet ASTM

blended cement standard and SNI Type IP (Portland-pozzolan cement). The results of research by Tjaronge et al (2014), stated that there was a hydration process and produced tobermorite in self-compacting concrete for the development of compressive strength and time to harden concrete using Portland composite cement (PCC). Table 3 shows the physical properties of Portland composite cement.

Table 3 Physical properties of PCC

Material Properties	Standard Method (SNI 15-7064-2004)	Result
Water content, (%)	12 max.	11.5
Smoothness	280 min.	382
Expansion, %	0.8 max.	-
Compressive strength		
a. 3 days (kg/cm^2)	125 min.	185
b. 7 days (kg/cm^2)	200 min.	163
c. 28 days (kg/cm^2)	250 min.	410
Time hardening (Vicat test)		
a. Initial hardening, minute	45 min.	132.5
b. Final hardening, minute	375 min.	198
False bond time	50 min	-
Hydration temperature 7 days, cal/gr		65
Normal consistency, (%)		25.15
Specific gravity		3.13

2.3. Research Design

In carrying out this research, researchers must first know the procedures for carrying out research in the laboratory starting from the preparation of tools and materials. After the tools and materials are available, the characteristics of the materials used are checked. If the inspection does not meet the requirements of the standard method used, a more accurate re-examination will be carried out to find results according to the required value. However, if the material inspection meets the reference requirements, a trial mix design will be carried out for normal concrete. After the mix design is obtained, mixing fresh concrete is done by checking the slump value in order to determine the thickness of the concrete produced and determine the quality of the concrete plan. The quality of the concrete plan in this study was 40 MPa at the age of 28 days. The mould used in the manufacture of the test object is a 15 cm x 30 cm cylindrical mould. The next process after removing the test object from the mould is immersing the test object into a soaking tub for 3 days, 7 days, 14 days, and 28 days. Then the test object is removed from the soaking tub to dry the day before testing the compressive strength of the concrete. After the test is complete, the data obtained is processed to determine how much the compressive strength of the concrete of the specimens is with variations in the use of cornice adhesives of 0%, 5%, 10%, and 15% to partially replace composite Portland cement.

2.4. Compressive Strength Test

Refers to SNI 03-6825-2002 [11], the compressive strength test should exert a continuous monotonous pressure at constant speed on the test element between two load bars, which creates a compressive load on the applied pressure test element. Compressive strength test equipment was used to produce compressive stress. Compressive strength measured based on the peak load received divided by the cross-sectional area of the concrete core specimen. Figure 1 shows the equipment for the compressive strength test. The stage of testing the compressive strength of the test object is intended to determine the characteristic compressive strength of the test object, starting from the preparation of the test object. The stages of testing the compressive strength of concrete are carried out as follows:

1. Remove the test object from its treatment (soaking tub according to the design age).
2. Dry the test object.
3. After the test object is dry, place the test object right on the axis. Press the test object and the pressing base must be completely clean.
4. The application of pressure to the concrete test object is carried out constantly and continuously so that the test object reaches the moment of breaking or cracking (the manometer needle does not move up).

Figure 1 Compressive strength test equipment

3. Results and Discussion

3.1. Combined Aggregate Gradation

Based on the results of the coarse aggregate gradation test, it can be seen that the coarse aggregate falls into zone I where the results of the grain size gradation examination are 10 mm, in zone II the coarse aggregate enters the grain size of 20 mm while in zone III it does not enter the lower threshold and threshold. upper limit. Therefore, it can be concluded that the maximum grain size of coarse aggregate is 20 mm. Where, coarse aggregate is included in zone II because the results obtained are between the upper and lower limits. For the gradation of fine aggregate, it shows that the gradation of fine aggregate is in zone III. Table 4 shows the combined aggregate gradation used in this research.

Table 4 Combined aggregate gradation

Number of sieve	**Fine aggregate**	**Coarse aggregate**	**Aggregate percentage**		**∑ aggregate**
	% passed		**31%**	**69 %**	
1 ½” (38.1mm)	100	100	31	69	100
¾” (19.1mm)	100	97.8	31	67.48	98.48
Number of sieve	Fine aggregate	Coarse aggregate	Aggregate percentage		∑ aggregate
	% passed		31%	69%	
3/8” (9.52mm)	100	38.9	31	26.84	57.84
No. 4 (4.75mm)	100	0	31	0	31
No. 8(2.36mm)	97	0	30.07	0	30.07

Number of sieve	Fine aggregate	Coarse aggregate	Aggregate percentage		∑ aggregate
	% passed		31%	69 %	
No. 16 (1.18mm)	82.5	0	25.575	0	25.57
No. 30 (0.60mm)	68	0	21.08	0	21.08
No. 50 (0.30mm)	35	0	10.85	0	10.85
No. 100 (0.15mm)	6	0	1.86	0	1.86
No. 200 (0.75mm)	1	0	0.31	0	0.31
PAN	0	0	0	0	0

3.2. Mixtures Design

Based on the results of combining aggregates, the mixtures design used in this study was calculated based on the DOE method. Table 5 and Table 6 show the mixtures design used in this study, namely normal concrete and concrete using cornice adhesive as a partial replacement of composite Portland cement with a variation of cornice adhesive content of 5%, 10%, and 15% in units of 1 m3, respectively.

Table 5 Mixtures design of normal concrete (0% cornice adhesive)

Materials	Weight of materials (1 m^3)
Portland Composite Cement	4.20 kg
Water	1.30 kg
Fine aggregate	2.77 kg
Coarse aggregate	6.18 kg

Table 6 Mixtures design of normal concrete using cornice adhesive

Materials	Cornice adhesive (%)/Weight of materials (1 m^3)		
	5	10	15
Portland Composite Cement	3.99 kg	3.78 kg	3.57 kg
Water	1.30 kg	1.30 kg	1.30 kg
Fine aggregate	2.77 kg	2.77 kg	2.77 kg
Coarse aggregate	6.18 kg	6.18 kg	6.18 kg
Cornice adhesive	0.21 kg	0.42 kg	0.63 kg

3.3. Physical Properties of Fresh Concrete

Testing the physical characteristics of fresh concrete was carried out by the slump test. Table 7 shows the results of the slump test on concrete without and with 5%, 10%, and 15% cornice adhesive as a partial substitute for composite Portland cement. The results of the slump test without cornice adhesive was 90 mm while the concrete mixture using cornice adhesive as a substitute for Portland cement composite 5%, 10% and 15% were 100 mm, 80 mm and 90 mm, respectively.

Table 7 Slump test of fresh concrete

Variation of Specimens	Slump (mm)
Normal concrete (0% cornice adhesive)	90
Concrete with 5% cornice adhesive	100
Concrete with 10% cornice adhesive	80
Concrete with 15% cornice adhesive	90

3.4. Weight of Concrete

Table 8 shows the average concrete weight of 3 specimens without and using cornice adhesive of 5%, 10% and 15% as a cement substitute at 3, 7, 14 and 28 days.

Table 8 Weight of concrete without and with cornice adhesive

Age of concrete (Days)	Variation of Specimens			
	0%	5%	10%	15%
3	11.78 kg	11.40 kg	11.25 kg	10.91 kg
7	11.79 kg	11.49 kg	11.47 kg	11.23 kg
14	11.91 kg	11.59 kg	11.29 kg	11.12 kg
28	11.96 kg	11.65 kg	11.39 kg	11.05 kg

It can be seen that the weight of normal concrete (0% cornice adhesive) increased with increasing age of concrete from 3 days, 7 days, 14 days, and 28 days. but decreases with increasing cornice adhesive content in all tested concrete ages. It can be said that cornice adhesive makes a positive contribution to the weight loss of concrete and can be used to reduce the weight of the structure.

3.5. Compressive Strength of Concrete

Figure 2 shows the comparison of the results of the compressive strength test of normal concrete and concrete with variations in the use of cornice adhesives of 5%, 10%, and 15% as a replacement for the weight of the Portland cement composite. The results of the compressive strength test shown in the figure are the average of 3 specimens at the age of 3, 7, 14 and 28 days.

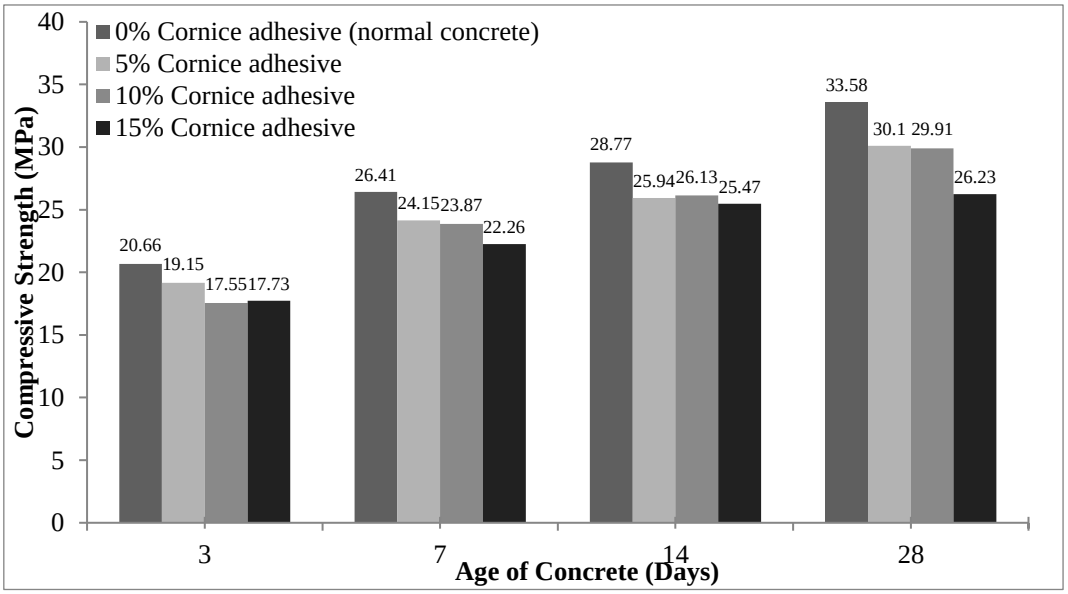

Figure 2 Compressive Strength of concrete without and with cornice adhesive

The increase in the value of the compressive strength of concrete against the age of concrete occurs for all variations of the use of cornice adhesive as a replacement for cement. The compressive strength values of concrete without cornice adhesive on 3 days, 7 days, 14 days, and 28 days were 20.66 MPa, 26.41 MPa, 28.77 MPa, and 33.58 MPa, respectively. The increase in the compressive strength of concrete with 5% cornice adhesive from 3 days to 28 days was 62.5%. The compressive strength values of concrete with 5% cornice adhesive on 3 days, 7 days, 14 days, and 28 days were 19.15 MPa, 24.15 MPa, 25.94 MPa, and 30.1 MPa, respectively. The increase in the compressive strength of concrete with

5% cornice adhesive from 3 days to 28 days was 57.2%. The compressive strength values of concrete with 10% cornice adhesive on 3 days, 7 days, 14 days, and 28 days were 17.55 MPa, 23.87 MPa, 26.13 MPa, and 29.91 MPa, respectively. The increase in compressive strength of concrete with 10% cornice adhesive from 3 days to 28 days was 70.4%. The compressive strength values of concrete with 15% cornice adhesive on 3 days, 7 days, 14 days, and 28 days were 17.73 MPa, 22.26 MPa, 25.47 MPa, and 26.23 MPa, respectively. The increase in compressive strength of concrete with 15% cornice adhesive from 3 days to 28 days was 47.9%. The biggest increase in strength value from 3 days to 28 days is using a concrete mixture with a variation of 10% cornice adhesive as a replacement for cement. But overall, the compressive strength value at all ages and in all variations, the compressive strength value of normal concrete (0% cornice adhesive) is the highest compressive strength value. It can be said that to increase the compressive strength of normal concrete, the use of cornice adhesive as a replacement for cement does not give better results.

4. Concluding Remarks

Based on the analysis and discussion, it is concluded that the use of cornice adhesive as a partial replacement of cement can make a positive contribution to the weight loss of concrete and can be used to reduce the weight of the structure. However, it has not been able to provide a better compressive strength value than the normal concrete compressive strength value.

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