Compressive Strength of High Strength Concrete Containing Cornice Adhesive as a Partial Subtitution of Cement

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Abstract. Concrete mixture containing is the result a number of water, cement, fine aggregate and coarse aggregate by certain comparisons appropriate to the function and purpose of making the concrete. The purpose of this study is to find out if Cornice Adhesive can increase the strength of concrete press if used as a partial replacement of cement in concrete mixture. This research is experimental in the laboratory. Concrete mixture without and with adhesive cornices as much as 5%, 10% and 15% were used to partially replace cement. The test specimen is made with a cylinder of size 15 × 30 cm with a slump plan of 6-10 cm. The quality of the planned concrete at 28 days is 40 MPa. The compressive strength test is used to evaluate the mechanical characteristics of the concrete produced at the ages of 3, 7, 14 and 28 days. The result of this research was the average compressive strength of normal concrete (without cornice adhesive) at ages 3, 7, 14 and 28 is 20.66 MPa, 26.41 MPa, 28.77 MPa, and 33.58 MPa. Meanwhile, the average compressive strength in concrete using Cornice Adhesive as a partial replacement for cement with 5% content at 3, 7, 14 and 28 days is 19.15 MPa, 24.15 MPa, 25.94 MPa and 30.1 MPa, respectively. Cornice Adhesive content 10% at 3, 7, 14 and 28 days were 17.55 MPa, 23.87 MPa, 26.13 MPa and 29.91 MPa, respectively. Then the Cornice Adhesive content 15% at 3, 7, 14 and 28 days were 17.73 MPa, 22.26 MPa, 25.47 MPa and 26.23 MPa, respectively. The results showed that the use of *Cornice Adhesive* as a partial replacement of cement at the age of 28 days could not exceed normal concrete. The higher the percentage of use of *Cornice Adhesive*, the lower the compressive strength produced compared to the normal concrete compressive strength, although it uses the same type of aggregate and aggregate composition.

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. 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 [1,2].

In line with the development of knowledge and technology, the quality of concrete is developed and improved to be even better so as to create high-quality and even very high-strength concrete. Factors that influence the success of making high-quality concrete are the state 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 [3].

In general, concrete can be obtained by mixing fine aggregate, coarse aggregate, cement and water. However, in this study, it will be tried to add other materials as a partial substitute for cement. The material is Cornice Adhesive [4,5].

Cornice Adhesive is a building material in the form of plaster powder and has a strong adhesive power that serves to repair cracked, uneven, rough, and smooth wall surfaces. In previous studies, Cornice Adhesive was used as a filler in the Asphalt Concrete Wearing Cours mixture and the results of the study revealed that Cornice Adhesive is a non-plastic material, does not contain organic matter, in terms of grain size fulfill the requirements as a filler material, and can improve the characteristics of Asphalt Concrete Wearing Course [6,7].

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. Where the results of the study stated that Cornice Adhesive can improve the characteristics of organic soil [8]. This study aims to find out the comparison of compressive strength between high-strength concrete and concrete using Cornice Adhesive as a partial cement substitution at 3, 7, 14 and 28 days.

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 (2-5 mm) and the characteristics of the coarse aggregate (10-20 mm), respectively. As shown in Table 1, the water content wass 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	Spesification (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	1.6 – 3.1
Saturated surface dry specific gravity	2.35	
Apparent specific gravity	2.43	
Water absorption (%)	2.14	0.1 – 5.0%

Table 2. Properties of coarse aggregate

Properties	Testing Result	Spesification (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	1.6 – 3.1
Saturated surface dry specific gravity	2.55	
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

In this research Portland composite cement (PCC) was used for high strength concrete mixture blended. This cement is produced by a national cement factory and complies with ASTM blended cement Type IP (Portland-pozzolan cement). Table 3 shows the physical properties of PCC. A study conducted by M. W. Tjaronge et al (2014), stated that the self compacting concrete containing PCC underwent the hydration process and created the tobermorite ($_3CaOSiO_2H_2O$) to develop the compressive strength of the hardened concrete with the elapse time.

Table 3. Physical properties of Portland composite cement

Material characteristics	SNI 15-7064-2004 Standard	Value
Water content (%)	12 max.	11.5
Smoothness	280 min.	382
Expansion, % (max.)	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, an inspection and testing of the material will be made for the test sample. If the inspection has been carried out and does not meet the requirements, a more accurate re-examination will be carried out, but if the material inspection meets the ASTM requirements, a mix design will be carried out. After the design of the mix design is complete, then proceed to the manufacture of fresh concrete for testing the slump value in order to determine the thickness of the mixture as well as the manufacture of test

objects. Furthermore, after the test object has started to dry (can be removed from the mold) cylindrical mold 15 × 30 cm, then the next process is the treatment of the test object by immersing the test object into an immersion bath for 3, 7, 14, 28 days. The used of cornice adhesive were 0, 5, 10 and 15% to partially replace composite portland cement. Then the test object is removed from the bath to dry the day before testing the compressive strength of the concrete. After the test is complete, the data is processed to find out how much the concrete compressive strength of the test object is.

2.4. Compressive Strength Test

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 Aggregates 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 percentation		∑ 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 percentation		∑ 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
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 in units of 1 m^3, 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 using 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 the concrete decreases as the age of the concrete increases. In addition, the weight of the concrete also decreases with the addition of cornice adhesive at each age of the concrete. It can be said that the cornice adhesive contributes positively to the weight loss of concrete and can be used to reduce the weight of the structure.

3.5. Compressive Strength of Concrete

Table 9 shows the results of testing the compressive strength of concrete without and using cornice adhesive at 5, 10 and 15% of the weight of composite portland cement. The results of the compressive strength test shown are the average of 3 test objects at the age of 3, 7, 14 and 28 days.

Table 9. Compressive Strength of concrete without and with cornice adhesive

Variation of Specimens	Age of Concrete (Days)			
	3	7	14	28
0%	20.66 MPa	26.41 MPa	28.77 MPa	33.58 MPa
5%	19.15 MPa	24.16 MPa	26.14 MPa	30.10 MPa
10%	17.73 MPa	23.87 MPa	25.95 MPa	29.91 MPa
15%	17.55 MPa	22.27 MPa	25.48 MPa	26.23 MPa

On the 3 days the lowest compressive strength of normal concrete specimens was 15.57 MPa, while the lowest compressive strength of specimens using cornice adhesive as a partial replacement for cement with 5%, 10% and 15% contents were 17.83 MPa, 14.44 MPa and 14.15 MPa. While on 7 days the lowest compressive strength of normal test specimens was 25.48 MPa, while the lowest compressive strength of specimens using cornice adhesive as a partial replacement for cement with 5%, 10% and 15% contents were 22.08 MPa, 19.25 MPa and 21.23 MPa. On the 14 days the lowest compressive strength of normal specimens was 26.89 MPa while the lowest compressive strength of specimens using cornice adhesive as a partial replacement for cement with 5%, 10% and 15% contents was 23.213 MPa, 24.91 MPa and 22.08 MPa. On the 28 days, the lowest compressive strength of normal specimens was

32.55 MPa while the lowest compressive strength of specimens using cornice adhesive as a partial replacement for cement with 5%, 10% and 15% contents was 27.46 MPa, 28.87 MPa and 22.65 MPa.

4. Concluding Remarks

Based on the analysis and discussion, it is concluded that the use of cornice adhesive as a partial replacement for cement can't increase the compressive strength of concrete. The average compressive strength of normal concrete at the ages of 3, 7, 14 and 28 is 20.66 MPa, 26.41 MPa, 28.77 MPa, and 33.58 MPa. While the average compressive strength of concrete using cornice adhesive as a partial replacement for 5% cement at 3, 7, 14 and 28 days were 19.15 MPa, 24.15 MPa, 25.94 MPa and 30.10 MPa. The content of 10% at 3, 7, 14 and 28 days were 17.55 MPa, 23.87 MPa, 26.13 MPa and 29.91 MPa. Then the content of 15% at 3, 7, 14 and 28 days were 17.73 MPa, 22.26 MPa, 25.47 MPa and 26.23 MPa.

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