COMPARATIVE ANALYSIS OF COMPRESSIVE STRENGTH BETWEEN NORMAL CONCRETE AND FAST TRACK CONCRETE AGAINST VARIATIONS IN COARSE AGGREGATE SIZE

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ABSTRAK

Objective: This research aims to compare the compressive strength performance of Normal Concrete (NC) and Fast Track Concrete (FTC) using PCC cement with variations in coarse aggregate size at 1, 3, and 28 days, and determine the optimal aggregate variation for both concrete types.

Research Method: A laboratory experimental method was used by preparing 18-cylinder specimens (150 cm diameter, 300 cm height) consisting of 6 mixture variations: 3 NC variations and 3 FTC variations.

Findings: The highest FTC compressive strength reached 27.88 MPa in 1 day (A3), representing a 93.07% increase compared to the highest NC (14.44 MPa).

Originality: This study provides specific empirical data on the influence of varied coarse aggregate combinations (A1, A2, A3) on the performance of High Early Strength concrete (FTC) based on PCC cement in Indonesia, contributing significantly to construction practices demanding accelerated curing times.

Keywords: Fast Track Concrete; High Early Strength; PCC Cement; Superplasticizer; Aggregate Variation.

1. INTRODUCTION

Modern infrastructure development demands significant acceleration of project schedules. The 28-day waiting period for concrete to achieve its full design strength often becomes a critical constraint. Responding to this challenge, Fast Track Concrete (FTC), or High Early Strength Concrete (HESC), emerges as a breakthrough solution designed to achieve strength equivalent to the 28-day compressive strength within 3 to 7 days (Rismono and Wibowo, 2022). This capability is typically achieved using high early strength cement and the addition of chemical accelerators, such as Polycarboxylate-based Superplasticizer.

Aside from the cement paste composition, concrete compressive strength is highly influenced by the quality and grading of coarse aggregates, which occupy up to 75% of the concrete volume (Kosasih, 2017). Good aggregate grading minimizes voids and increases packing density, which correlates directly and positively with compressive strength (SNI 03-2834-2000). Therefore, this research focuses on the comparative analysis of NC and FTC performance by examining three variations of coarse aggregate combinations against the development of compressive strength at 1, 3, and 28 days.

2. LITERATURE REVIEW

Fast Track Concrete fundamentally relies on the use of Superplasticizer admixture to reduce the water-cement ratio (w/c) while maintaining high workability. The reduction in w/c significantly enhances concrete strength (Al-Qadi et al., 2018). Furthermore, the accelerating admixture contained in the Superplasticizer helps increase the hydration rate of PCC cement at early ages, thus achieving early strength faster (Rizal et al., 2025).

Previous research by Basri (2023) also showed that the determination of cement type and admixture has a significant correlation with the acceleration of concrete's

early strength. In addition, Basri et al. (2021) emphasized the importance of concrete curing to ensure a perfect hydration process, which greatly influences the achievement of ultimate 28-day compressive strength. According to research by Hermawati (2023), the better the grading and the larger the maximum aggregate size, the potential compressive strength of the concrete tends to increase due to the mechanical interlocking effect and the increased contact area between particles. SNI 03-2834-2000 itself stresses the importance of coarse and fine aggregate proportions to achieve optimal mixture density.

3. METHODOLOGY

3.1. Materials and Mixture

The research used Portland Composite Cement (PCC) as the main binder, natural sand as fine aggregate, and three variations of Crushed Stone coarse aggregates:

1. A1 (Crushed Stone 1-2 cm): Single-size aggregate.
2. A2 (Combination 1-2 cm and 0.5-1 cm): Combination of medium and small sizes.
3. A3 (Combination 1-2 cm and 2-3 cm): Combination of medium and large sizes.

Fast Track Concrete (FTC) was made by adding a Polycarboxylate-based Superplasticizer (SP) admixture at a certain dose by cement weight, while Normal Concrete (NC) did not use any admixture.

3.2. Weight of Concrete Components with Three Variants

The weight of the materials used in each variant can be seen in the table below.

Table 1. Weight of Component Materials for 1 m3 of Normal Concrete and Fast Track Concrete

Material	Unit	Normal Concrete			Fast Track Concrete		
		A1	A2	A3	A1	A2	A3
Cement	Kg	520.00	520.00	520.00	520.00	520.00	520.00
Water	Kg	210.00	234.00	182.00	210.00	234.00	182.00
Crushed Stone 1-2 cm	Kg	986.89	718.54	780.93	986.89	718.54	780.93
Crushed Stone 0.5-1 cm	Kg		239.51			239.51	
Crushed Stone 2-3 cm	Kg			260.31			260.31
Concrete Sand	Kg	657.93	638.70	694.16	657.93	638.70	694.16
Superplasticizer (SP)	Kg				3.12	3.12	3.12

In the table above, the amount of cement and superplasticizer (SP) used is equal, 520 kg and 3.12 kg, respectively.

3.3. Test Specimens and Testing

A total of 18-cylinder specimens (3 variations x 2 concrete types x 3 testing ages) with dimensions of 150 cm x 300 cm were cast and cured in water. Compressive strength testing was conducted using a Compression Testing Machine (CTM) at ages 1 day, 3 days, and 28 days, in accordance with the concrete compressive strength testing standard (SNI 1974:2011).

4. RESULTS AND DISCUSSION

4.1. Compressive Strength Results Summary (MPa)

The compressive strength results at 1, 3, and 28 days are presented in the table below.

Table 2: Presents the summary of average compressive strength results for each variation.

No	Concrete Type	Coarse Aggregate Variation	Compressive Strength at 1 Day (MPa)	Compressive Strength at 3 Days (MPa)	Compressive Strength at 28 Days (MPa)
A1	Normal Concrete (NC) PCC	A1 (1-2)	13.73	12.88	26.89
A2		A2 (1-2 and 0,5-1)	13.59	12.60	24.91
A3		A3 (1-2 and 2-3)	14.44	24.20	31.14
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A1	Fast Track Concrete (FTC) PCC + SP	A1 (1-2)	18.68	20.95	26.47
A2		A2 (1-2 and 0,5-1)	19.96	36.30	28.53
A3		A3 (1-2 and 2-3)	27.88	35.67	47.42

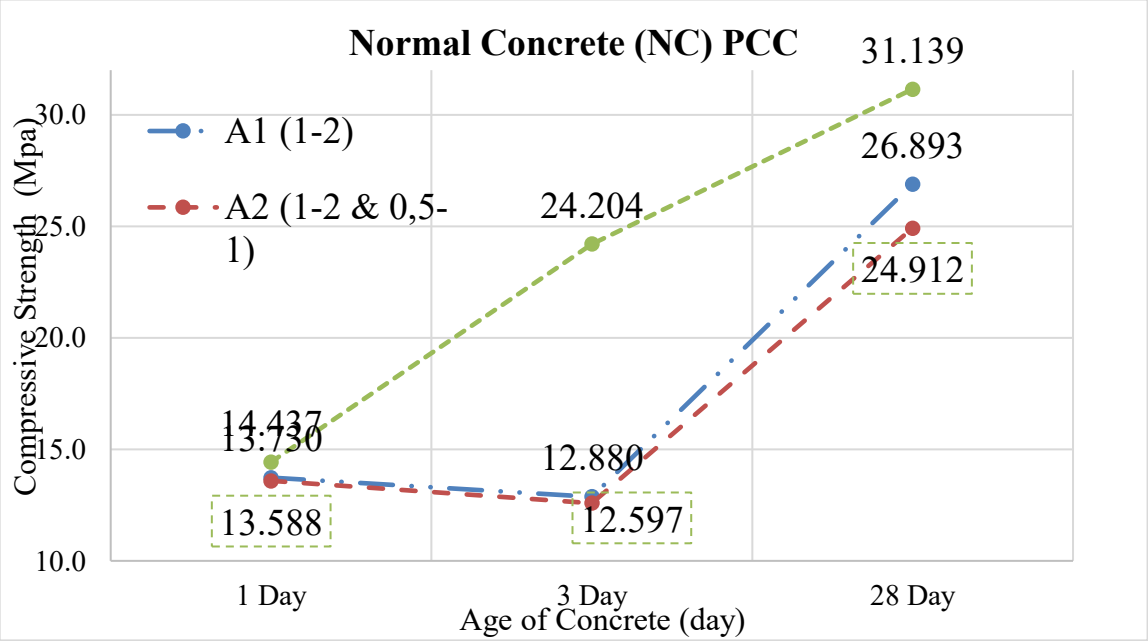

Figure 1. Compressive Strength of Normal Concrete (NC) PCC.

As shown in Figure 1, the Normal Concrete (NC) variant A3 (1–2 and 2–3) exhibited the highest compressive strength among all mixes, reaching 14.437 MPa at 1 day and 31.139 MPa at 28 days.

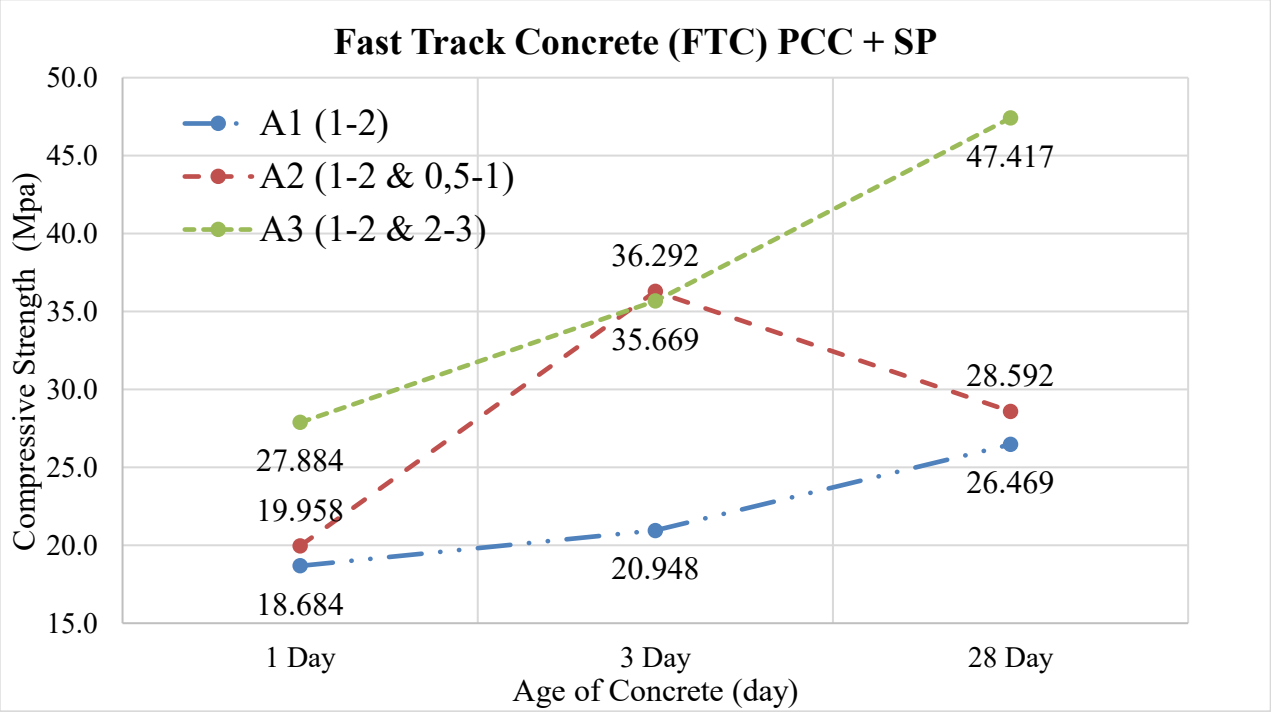

Figure 2. Compressive Strength of Fast Track Concrete (PCC + SP).

As shown in Figure 2, after the addition of the Superplasticizer (SP), the Fast Track concrete variant A3 exhibited the highest compressive strength, achieving 27.884 MPa at 1 day, 36.292 MPa at 3 days, and 47.417 MPa at 28 days.

4.2. Discussion on Early Compressive Strength (1 and 3 Days)

The effect of the Superplasticizer admixture is highly dominant at early ages.

i. 1 Day Age: A significant increase occurred in all FTC variations. Variation FTC-A3 reached 27.88 MPa, showing an increase of 93.07% from NC-A3 (14.44 MPa). This drastic increase proves the effectiveness of the admixture in accelerating the hydration rate of PCC cement during the early curing period, resulting in the very high early strength crucial for Fast Track projects (Sani et al., 2024).

ii. 3 Days Age: FTC performance continued to excel. FTC-A2 achieved the highest value of 36.29 MPa, surpassing FTC-A3 (35.67 MPa). Both values significantly exceeded the standard target design strength (f'c 25 MPa), which is typically targeted at 28 days, confirming FTC's potential to accelerate formwork removal time and load mobilization.

4.3. Discussion on Ultimate Compressive Strength (28 Days) and Aggregate Influence

At 28 days, the compressive strength of FTC and NC tended to converge, where FTC-A3 (47.42 MPa) was only slightly higher than NC-A3 (31.14 MPa). This is consistent with other research that the main function of the accelerating admixture is early strength acceleration, while the ultimate 28-day strength is determined by the water-cement ratio and aggregate density (Rismono and Wibowo, 2022). Furthermore, the importance of concrete curing, as highlighted by Basri et al. (2021), ensures that the maximum final strength potential is achieved.

The influence of coarse aggregate variation is as follows:

i. Variation A3 (1-2 cm and 2-3 cm) consistently yielded the highest compressive strength at 28 days for both NC (31.14 MPa) and FTC (47.42 MPa). This aggregate combination has a more balanced grading (well-graded), allowing the larger particles (2-3 cm) to form the main framework

and the medium particles (1-2 cm) to fill the voids, thereby increasing the packing density and the bond with the cement paste (Hermawati, 2023; Siregar et al., 2020).

ii. Variation A2 (1-2 cm and 0.5-1 cm) resulted in relatively low 28-day compressive strength for both NC (24.91 MPa) and FTC (28.59 MPa). Although this variation excelled at 3 days, its ultimate compressive strength was relatively low, possibly due to the high specific surface area of the smaller aggregates (0.5-1 cm), which could lead to higher porosity if hydration is incomplete.

5. CONCLUSION

Based on the analysis of compressive strength test results between Normal Concrete (NC) and Fast Track Concrete (FTC) with variations in coarse aggregate size, the following can be concluded:

i. Fast Track Effectiveness (Early Strength): The use of Superplasticizer admixture in PCC-based FTC mixture is highly effective for strength acceleration. The highest FTC compressive strength (A3) reached 27.88 MPa in 1 day, an increase of 93.07% from NC. FTC-A2 achieved 36.29 MPa in 3 days, confirming FTC's potential to accelerate construction schedules.

ii. Ultimate Compressive Strength (Final Strength): At 28 days, Fast Track Concrete with optimal aggregate (A3) achieved the highest compressive strength of 47.42 MPa, which shows that the admixture and optimal aggregate grading can significantly increase the final strength, far surpassing NC.

iii. Optimal Aggregate Variation: The coarse aggregate combination A3 (Crushed Stone 1-2 cm and 2-3 cm) is the most optimal, consistently producing the highest compressive strength at all testing ages for FTC ultimate strength.

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