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Alternative Coarse Agregate Using Locally Available Materials in Bangkalan

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ABSTRACT

Madura Island possesses significant natural resources, particularly aggregates from class C excavations in Bangkalan Regency. These aggregates, including fine aggregate (sand) and coarse aggregate (gravel), are potential materials for concrete mixtures. However, concrete produced solely with Bangkalan aggregates typically achieves a compressive strength of 14 MPa. Combining these aggregates with those from Java Island can enhance compressive strength to 20 MPa. This study aims to determine the optimal composition of Bangkalan and Pandaan coarse aggregates, using admixtures type D (0.3%) and type F (0.6%), to achieve a target compressive strength of 35 MPa. Various combinations of coarse aggregates (100% Bangkalan, 90% Bangkalan and 10% Pandaan, 80% Bangkalan and 20% Pandaan, and 70% Bangkalan and 30% Pandaan) were tested using cylindrical specimens (15 x 30 cm). The results indicate that the combination of 90% Bangkalan and 10% Pandaan aggregates, with the specified admixtures, produced the highest compressive strength of 31.06 MPa at 28 days, which did not meet the target of 35 MPa. This suggests further research is needed to explore additional aggregate combinations and admixture variations to achieve the desired compressive strength.

Keywords: *Bangkalan; Coarse Aggregates; combination; compressive strength; admixtures*

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ABSTRACT

Pulau Madura khususnya mempunyai sumber daya alam yang sangat besar agregat hasil galian kelas C di Kabupaten Bangkalan. Agregat ini, termasuk agregat halus (pasir) dan agregat kasar (kerikil), merupakan potensi bahan untuk campuran beton. Namun, beton diproduksi secara eksklusif dengan Agregat Bangkalan biasanya mencapai kuat tekan 14 MPa. Menggabungkan agregat ini dengan agregat dari Pulau Jawa dapat meningkatkan kuat tekan hingga 20 MPa. Penelitian ini bertujuan untuk mengetahui optimalnya komposisi agregat kasar Bangkalan dan Pandaan, menggunakan bahan tambahan tipe D (0,3%) dan tipe F (0,6%), untuk mencapai target kuat tekan sebesar 35 MPa. Berbagai kombinasi agregat kasar (100% Bangkalan, 90% Bangkalan dan 10% Pandaan, 80% Bangkalan dan 20% Pandaan, dan 70% Bangkalan dan 30% Pandaan) diuji dengan menggunakan benda uji berbentuk silinder (15 x 30 cm). Itu hasil menunjukkan bahwa kombinasi 90% Bangkalan dan 10% Pandaan agregat, dengan bahan tambahan tertentu, menghasilkan tekan tertinggi kekuatan sebesar 31,06 MPa pada umur 28 hari, belum memenuhi target sebesar 35 MPa. Hal ini menunjukkan penelitian lebih lanjut diperlukan untuk mengeksplorasi agregat tambahan kombinasi dan variasi campuran untuk mencapai tekan yang diinginkan kekuatan.

Keywords: Agregat Kasar; kombinasi; kuat tekan; zat aditif.

INTRODUCTION

Madura Island has the potential for natural resources, one of which is mining products of type C, especially in Bangkalan regency. The potential mining products include fine and coarse aggregates that can be used for concrete mixtures [1](Julistiono Handojo, Handoko Sugiharto, 2001). The development on Madura Island has traditionally utilized high-quality concrete, often importing materials from regions in East Java with good quality. However, due to the need to preserve the environment, the extraction of natural materials is heavily restricted. Therefore, there is a need for alternative materials for concrete mixtures sourced locally on Madura Island.

study titled "Potential Use of Paterongan, Torjun, and Omben Gravel on Madura Island for Structural Concrete," compared concrete made using gravel from Paterongan, Torjun, and Omben on Madura Island. The results of physical property tests for these three types of gravel showed that they are almost equivalent to gravel from Mojokerto or Pasuruan. Using Paterongan, Torjun, and Omben gravel in mix designs with a planned concrete strength of 22.5 MPa, the compressive strength of concrete using Paterongan and Omben gravel was found to be lower than the planned strength, and thus it is recommended only for non-structural concrete. On the other hand, Torjun gravel performed better, with an average compressive strength of 25.9 MPa, making it suitable for structural concrete.[1]

Study titled “Utilization of Local Material (Langkap Sand) as a Fine Aggregate Mixture for Composite Beams in Terms of Deflection,” aimed for a planned concrete compressive strength of 20 MPa. The results showed that concrete using Langkap sand from Bangkalan District achieved a compressive strength of 15.73 MPa.[2] Study titled “Alternative Use of Aggregates from Bangkalan for Concrete Mixes in Terms of Concrete Compressive Strength.” This research used fine and coarse aggregates from Bangkalan for concrete mixes with water-cement ratios of 0.4, 0.45, and 0.5. The highest compressive strength of concrete at 28 days was achieved with a water-cement ratio of 0.4, reaching 14.41 MPa. However, this did not meet the specified planned compressive strength of 25 MPa.[3]

Study titled “Study on the Combination of Lumajang Sand and Bangkalan Sand in Terms of Concrete Compressive Strength.” This research used coarse aggregates from Bangkalan and a combination of fine aggregates from Lumajang and Bangkalan with varying proportions: 100% - 50% Bangkalan and 50% - 0% Lumajang. The aim was to enhance the compressive strength of the concrete. The results showed that the highest compressive strength at 28 days was achieved with a mix of 50% Lumajang sand and 50% Bangkalan sand, reaching 28.023 MPa..[4] Study titled “Advantages of Crushed Stone from Java over Crushed Stone from Madura as Coarse Aggregates in Terms of Concrete Compressive Strength,” compared the compressive strength of concrete using coarse aggregates from Madura and Java. The planned concrete compressive strength ranged from 15 to 25 MPa. The study found that the maximum compressive strength of concrete using Java crushed stone reached 32 MPa, while concrete using Madura crushed stone reached 28 MPa.[5]

Study titled "Analysis of the Use of Type D and F Additives for Concrete with fc' 40 MPa Using Coarse Aggregates from Bangkalan and Fine Aggregates from Lumajang," investigated the use of three variations of additives. Variation 1 used 0.3% Type D additive by weight of cement, Variation 2 used 0.6% Type F additive by weight of cement, and Variation 3 used a combination of 0.3% Type D and 0.6% Type F additives by weight of cement. The highest compressive strength of concrete at 28 days was 29.40 MPa, achieved with 0.3% Type D additive. However, the study did not achieve the target strength of 40 MPa.[6] The aim of this study is to examine the impact of the combination of Bangkalan and Pandaan aggregates in concrete mixtures with variations of 100%:0%, 90%:10%, 80%:20%, and 70%:30%. Additionally, additives of type D at 0.3% and type F at 0.6% were included, with a planned concrete strength of 35 MPa.

LITERATURE REVIEW

Additive

Additive is a production that, alongside the primary ingredients such as cement, aggregate mixture, and water, is also mixed into the concrete mixture. The purpose of this material is to enhance specific properties of both hardened and fresh concrete. The dosage or proportion of this supplementary material is very small compared to the main components, to the extent that its proportion can be disregarded. Supplementary materials cannot compensate for poor concrete mix composition; therefore, every effort is made to optimize the concrete composition with suitable primary materials.

Types of additive materials are as follows:

a. Air Entraining Agent (ASTM C260): This is an additional substance used to increase the air content in concrete, making it resistant to freezing and washing, especially in snow-affected areas.[7]

b. Chemical Admixture (ASTM C494 and BS 5075): This is a liquid-form supplementary material added to the concrete mixture. This admixture serves various functions, such as controlling the setting time of concrete (both accelerating and retarding), reducing the water requirement in the concrete mix, improving the workability of concrete (increasing the slump value), and so on. Chemical admixtures can have various positive effects depending on the specific needs of the concrete.[8]

Chemical Admixture

Terms and conditions for the quality of chemical additives in accordance with ASTM C494-81"Standart Specification for Chemical Admixture for Concrete". "The various types and kinds of chemical additives can be explained as follows:"

Type A : Water-reducing Admixtures, is a admixture material that serves to reduce the amount of mixing water in concrete to produce concrete with a specific consistency.

Type B : Retarding Admixture, is a admixture material that functions to inhibit the setting of concrete binders.

Type C : Accelerating Admixture is an additional material that functions to accelerate the setting or drying and develop the initial strength of concrete.-

Type D : Water Reducing dan Retarding Admixture, is a dual-function additive that reduces the amount of mixing water required to achieve a specific consistency of concrete and inhibits the setting of the concrete. -

Type E : Water Reducing dan Accelerating Admixture, is a dual-function additive that serves to both reduce the amount of mixing water needed to produce concrete with a specific consistency and accelerate the setting of the concrete.

Type F : Water Reducing, High Range Admixture, is an additive that functions to reduce the amount of mixing water required to produce concrete with a specific consistency by 12

Type G : Water Reducing High Range and Retarding Admixture, is an additive that serves to reduce the required amount of mixing water to produce concrete with a specific consistency, by 12% or more, while also inhibiting the setting of the concrete.[9][10]

Compressive strength concrete

The compressive strength concrete is the ratio between the applied load and the cross-sectional area. Factors influencing the results of concrete compressive strength include materials, methods used, concrete production procedures, and maintenance. The compressive strength value of concrete is obtained through standard testing, which involves applying incremental compressive loads at a specific rate to the test specimen. The compressive strength of concrete is expressed in MPa (Megapascals) or kg/cm2 (kilograms per square centimeter). Testing procedures generally follow ASTM C.39 standards or other standards as required by PBI 1989.[11]

The formula used for calculating compressive strength concrete is:

$$f'c = P/A \qquad \text{….. (1)}$$

Where : f'c = Compressive Strength Concrete (N/mm2)
P = Maximum Load (N)
A = Cross-sectional area of the test specimen.(mm^2)

METHOD

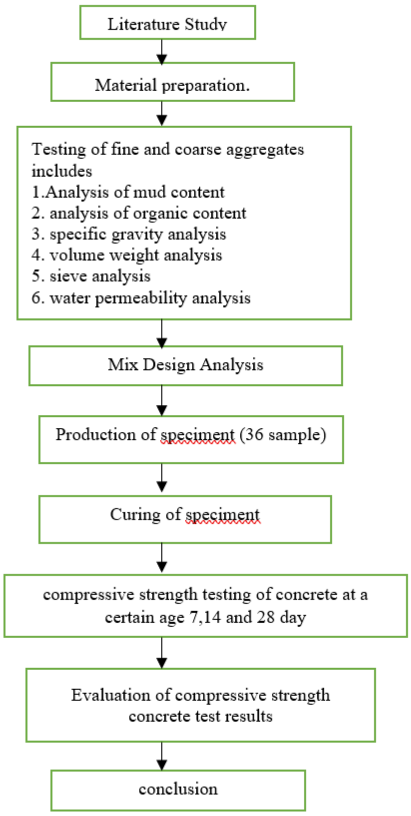

Figure 1 . Flowchart of the research

The research steps follow the flow chart in Figure 1

1. The literature study in this research examines the literature and journals that support the research.
2. The material preparation consists of Lumajang fine aggregate, Bangkalan coarse aggregate, Pandaan coarse aggregate, water, Portland cement, type D and F additives.
3. The equipment used for this research includes:
   a. 1000 ml pycnometer for testing the specific gravity of fine aggregates
   b. A set of equipment for testing the specific gravity of coarse aggregates
   c. A set of sieves and a vibrating machine for sieve analysis of coarse and fine aggregates
   d. Cylinder molds for making concrete test specimens
   e. A set of slump test tools for testing the slump height of fresh concrete
   f. A concrete mixer for mixing concrete
   g. A concrete compression testing machine for testing the compressive strength of concrete
4. Testing of fine aggregate and coarse aggregate includes specific gravity analysis, mud content analysis, organic content analysis, volumetric weight analysis, sieve analysis, infiltration analysis. Data from the aggregate testing results will be used to calculate the composition of the concrete mixture.
5. Mix design analysis, used to calculate the composition of the concrete mix according to the planned quality of 35 Mpa
6. After obtaining the composition of the concrete mixture, then proceed with making test specimens with a size of 15x 30 cm, the ratio of the use of Bangkalan and Pandaan coarse aggregates is 100%; 0%, 90%; 10%, 80%: 20%, 70%; 30% by adding 0.6% type D additive and 30% type F, each variation of 9 test objects
7. Concrete cylinders are treated by soaking in water until they are 28 days old.
8. Compressive strength Concrete tests were carried out at 7, 14 and 28

9. After obtaining laboratory data, the compressive strength concrete is calculated and evaluated whether the concrete compressive strength results are in accordance with the plan

(a)	(b)	(c)

Figure 2 (a) Casting concrete (b) Compressive strength concrete (c) Test object concrete

RESULTS AND DISCUSSION

Testing of fine aggregates

Table 1 Testing of fine aggregates

No	Experiment	Lumajang fine	Standard	Description	Code
a	Moisture	1,50 %	1 - 5%	According to	ASTM C 556 – 89
b	Density	2,70 gr/cm^3	1,60 – 3,30 gr/cm^3	According to	ASTM C127 – 93
c	Infiltration	2,36 %	Maks 5%	According to	ASTM C 127 – 93
d	Mass Volume (Detached)	1,45 kg/dm^3	0,4 - 1,9 kg/dm^3	According to	ASTM C 29 / C 29 M – 91
	Mass Volume (Solid)	1,56 kg/dm^3	0,4 - 1,9 kg/dm^3	According to	ASTM C 29 / C 29 M – 91
e	Mud Content	2,5 %	Maks 5%	According to	ASTM C 117 – 95
f	Organic Content	No.3	No.6	According to	ASTM C 40 – 92
g	Sieve Analysis	Zona 2 (Fm = 2,37)	2,0 < Fm <3,1	According to	ASTM C 136 – 95A (ASTM C 33)

Testing of Coarse Agregates

Table 2 Testing of Coarse Agregates size 5-10 Pandaan

No	**Experiment**	**Agregates 10-20 Pandaan**	Standard **ASTM**	**Description**
a	Mud Content	1,05 %	Maks 1%	According to
b	Moisture	1,32 %	1% - 5%	According to
c	Density	2,64 gr/dm^3	1,66 - 3,30 gr/dm^3	According to
d	Infiltration	2,67 %	Maks 4%	According to
e	Mass Volume (Detached)	1,45 gr/dm^3	Maks 4,00 gr/dm^3	According to

No	Experiment	Agregates 10-20 Pandaan	Standard ASTM	Description
	Mass Volume (Solid)	1,62 gr/dm³	Maks 4,00 gr/dm³	According to

Form table 2 Coarse Aggregate Test Results size 5-10 Pandaan mud content coarse aggregates 1,05 % > 1% Therefore, before being used in concrete mixtures, the gravel is washed first.

Table 3. Testing of Coarse Agregates size 10-20 Bangkalan

No	Experiment	Agregates 10-20 Bangkalan	Standard ASTM	Description
a	Mud Content	1,50 %	Maks 1%	Not according to
b	Moisture	1,94 %	1% - 5%	According to
c	Density	2,65 gr/dm³	1,66 - 3,30 gr/dm³	According to
d	Infiltration	0,67 %	Maks 4%	According to
e	Mass Volume (Detached)	1,33 gr/dm³	Maks 4,00 gr/dm³	According to
	Mass Volume (Solid)	1,50 gr/dm³	Maks 4,00 gr/dm³	According to

Form table 3 Coarse Aggregate Test Results size 10-20 Bangkalan mud content coarse aggregates 1,50 % > 1% Therefore, before being used in concrete mixtures, the gravel is washed first.

Compression Test

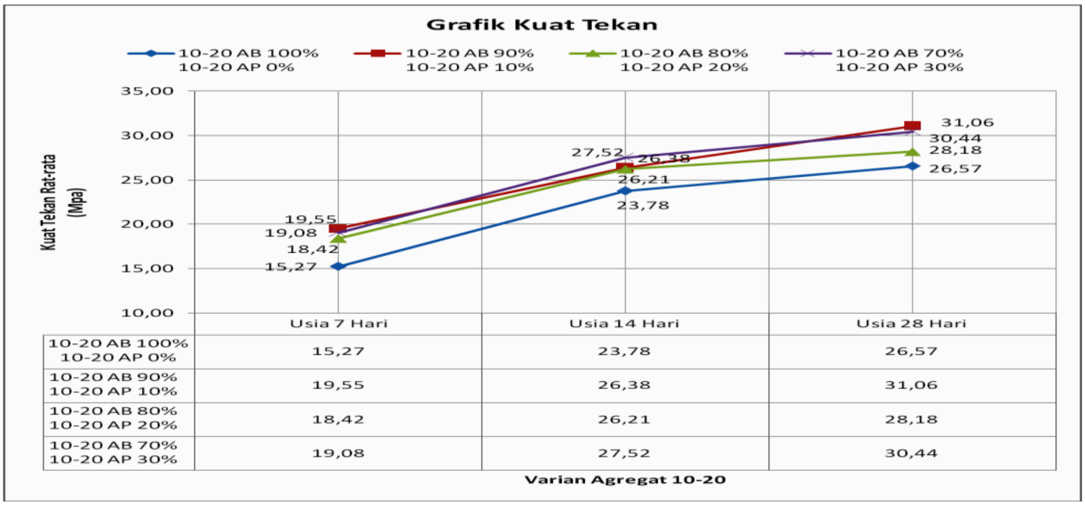

Figure 3 Comparison Chart of Concrete Compression Strength

Based on Figure 3, the results appear as follows.

- The 10-20 variant in Bangkalan shows 100%, while the 10-20 variant in Pandaan shows 0% at the age of 7 days, resulting in a compressive strength of 15.27 MPa. At the age of 14 days, the compressive strength increases to 23.78 MPa, and at the age of 28 days, it further increases to 26.57 MPa.
- The 10-20 variant in Bangkalan is at 90%, while the 10-20 variant in Pandaan is at 10%. At the age of 7 days, it yields a compressive strength of 19.55 MPa. At the age of 14 days, the compressive strength increases to 26.38 MPa, and at the age of 28 days, it further increases to 31.06 MPa.

- The 10-20 variant in Bangkalan is at 80%, while the 10-20 variant in Pandaan is at 20%. At the age of 7 days, it yields a compressive strength of 18.42 MPa. At the age of 14 days, the compressive strength increases to 26.21 MPa, and at the age of 28 days, it further increases to 28.18 MPa.
- The 10-20 variant in Bangkalan is at 70%, while the 10-20 variant in Pandaan is at 30%. At the age of 7 days, it yields a compressive strength of 19.08 MPa. At the age of 14 days, the compressive strength increases to 27.52 MPa, and at the age of 28 days, it further increases to 30.44 MPa.

CONCLUSION

Based on the research findings, several conclusions

1. The combination of coarse aggregates 10-20 from Bangkalan and 10-20 from Pandaan in the concrete mix with additives at the age of 28 days results in a compressive strength of 31.06 MPa, which is higher than the concrete mix with 100% coarse aggregates from Bangkalan with additives, yielding a compressive strength of only 26.57 MPa.
2. There is no optimum composition for the use of coarse aggregates from Bangkalan and Pandaan because all variations of concrete mixes with compressive strengths at both 7 and 28 days still do not meet the targeted compressive strength of Fc'35 MPa.

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