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Technical Properties of Normal Concrete with Alum Additive

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Abstract: Concrete is a widely used construction material due to its numerous advantages in terms of structural performance, cost-effectiveness, implementation, and maintenance. Compressive strength is a critical property that must be considered for concrete used as a structural component. This property can be influenced by various factors, including the addition of chemical substances to the concrete mix. Alum is commonly employed as a water clarifying agent. In concrete mixtures, alum decomposes into aluminium and trioxide sulfate compounds found in cement. Incorporating alum into concrete is expected to enhance the aluminium and cement content. This research aims to investigate the technical properties of normal concrete when supplemented with alum. The technical properties under consideration include slump value and compressive strength, with a fixed mix proportion of cement: sand: gravel = 1:2:3. Alum is added in proportions of 2%, 4%, 6%, and 8% by weight of cement in the concrete mix. The findings of this present study indicate that the highest compressive strength is achieved in concrete specimens with 2% alum addition by weight of cement, reaching 35.629 MPa, while the corresponding slump value is 7.75 cm.

Keywords: concrete; alum; technical properties; compressive strength; mix-proportion

1. Introduction

Concrete is a construction material composed of a mixture of cement, aggregates, and water, and it can be supplemented with an additive if desired to impart specific properties to the concrete. Currently, concrete is more extensively utilized in construction compared to steel and wood due to its advantages, such as easy availability of constituent materials, simple manufacturing process, and flexibility in shaping according to requirements. The strength of concrete is influenced by several factors, including the water-cement ratio, degree of compaction, proportion of constituent materials, compaction method, type and quality of cement, type and texture of aggregate surface, curing efficiency, temperature, and age. Additionally, the strength of concrete can be enhanced by incorporating supplementary materials into the fresh concrete mix. Alum, a chemical substance, is extensively employed as a material for water clarification. In water, alum binds suspended colloidal particles, causing them to aggregate into larger masses, thereby facilitating easy sedimentation. The aluminium compounds present in alum represent a specific type of compound that acts as a binding accelerator. Within the concrete mixture, alum will decompose into aluminium and trioxide sulfate compounds, which are constituents found in cement. With specific proportions, the addition of alum will not induce adverse effects on the concrete; rather, it can increase the content of aluminium and cement. To understand the influence of alum addition on the properties of normal concrete, this research needs to be conducted.

2. Literature Review

Nawy (1998) argues that the mechanical properties of concrete can be examined under two conditions, pre-hardened concrete and post-hardened concrete. The characteristics of the pre-hardened concrete are typically assessed based on its workability, whereas the properties of the post-hardened concrete are observed once the concrete has reached a solid and dense state. Workability can be evaluated through the four distinct attributes, such as first*, compactibility*, it is the initial attribute that pertains to the ease with which the concrete mixture can be compacted, eliminating or reducing air voids within the material. Second, *Stability*, it is the second attribute, signifies the concrete's capacity to maintain its integrity as a stable mass during handling and vibration without experiencing detrimental effects like segregation or bleeding. third, *Mobility*, it is the third attribute, addresses the concrete's ability to flow around reinforcement structures, enabling effortless pouring into molds and desired placements. Lastly, *Finishability*, it is the fourth attribute, emphasizes the concrete's ease of achieving a smooth and impeccable final finish, ensuring that the concrete surface remains undamaged when the mold is released from the concrete. These individual attributes collectively contribute to the overall workability of fresh concrete, facilitating successful construction practices and achieving desired outcomes.

The properties of concrete after it has hardened are examined when the concrete has achieved a solid and compact state. These properties are divided into two categories. The first category is short-term properties, which encompass attributes such as compressive strength, tensile strength, splitting tensile strength, and elastic modulus. These properties provide insights into the immediate performance of the concrete, including its load-bearing capacity and structural integrity. The second category is long-term properties, which are further divided into two aspects: shrinkage and curling. Shrinkage relates to the reduction in concrete volume during the curing process, which can impact long-term durability. Curling, on the other hand, refers to the upward or downward deformation of concrete slabs at their edges, often caused by differential drying or temperature effects. Understanding these long-term properties is essential for ensuring the concrete's durability, stability, and performance over extended periods.

Alum, chemically represented as $[Al_2(SO_4)_3 18H_2O]$, is a chemical compound well-known for its application in water clarification. When introduced into water, alum exhibits the property of binding suspended colloidal particles, causing them to aggregate into larger masses, thereby facilitating easy sedimentation. The presence of aluminium compounds in alum acts as accelerators for this binding process.

Within the concrete mixture, alum will decompose into aluminium and trioxide sulfate compounds, which are constituents found in cement. With specific proportions, the addition of alum to the cement will increase the aluminium content within the cement, consequently enhancing its strength.

According to Murdock and Brook (1999), when cement contains a high concentration of aluminium compounds and a low concentration of silica, the cement binds rapidly and attains high strength. Additionally, cement with a high aluminium content is as strong as, or even stronger than, conventional Portland cement.

3. Research Method

3.1. Materials and Specimens

The materials utilized in this study consist of the following:

1. Type I Portland cement (Gresik brand)
2. Coarse aggregates with a size range of 10-20mm sourced from Muntilan
3. Fine aggregates (sand) obtained from Muntilan
4. Water sourced from the clean water supply of the Faculty of Engineering, UNISSULA.

Test specimens employed were concrete cubes of 15x15x15 cm with the amount of each percentage of alum of 9 specimens. See Table 1 for detail.

Table 1. Number of Test Specimens for Compressive Strength Testing

Percentage of Alum	Number of Test Specimens and Testing Time			Quantity
	3 days	7 days	28 days	
0 %	3	3	3	9
2 %	3	3	3	9
4 %	3	3	3	9
6 %	3	3	3	9
8 %	3	3	3	9

3.2. Testing Equipment

The equipment employed in this study comprised the following tools for material inspection, specimen preparation, and specimen testing:

1. Molds
2. Large steel rod with a diameter of 16 mm and a length of 610 mm
3. Mallet or tamper
4. Slump test apparatus
5. Mixing support tools
6. Sieves
7. Weighing scale
8. Concrete mixer
9. Compressive strength testing machine

3.4. Testing Procedure

This research commenced with aggregate examination, mixture design, batch preparation, slump testing, specimen creation, and specimen curing following the stipulations outlined in the relevant Indonesian National Standards (SNI).

4. Results and Discussion

4.1. Slump Value

The test results of slump values for concrete mixtures with varying percentages of alum are presented in Table 2.

Table 2. Average Slump Values with Alum Percentage Variation.

Percentage of alum	*Slump* value (cm)	Average *slump* value(cm)
0 %	12,0 12,5	12,25
2 %	7,5 8,0	7,75
4 %	5,8 5,2	5,50
6 %	4,3 3,7	4,00
8 %	1,6 1,2	1,40

From Table 2, it is evident that an increase in the percentage of added alum in the concrete mix leads to a reduction in the slump value of the mixture. This outcome indicates that the workability of the concrete mix becomes more manageable. Consequently, it becomes essential to carefully consider the optimal alum percentage to be added to the concrete mix.

4.2. Compressive Strength

Compressive strength testing of the concrete was conducted at the age of 28 days, with three specimens for each alum percentage. The test results are presented in Table 3.

Table 3. Compressive Strength of Concrete at 28 days

Specimen code	Percentage of alum	Maximum load (kg)	Compressive strength (kg/cm^2)	Average of compressive strength (kg/cm^2)
T.0.1	0%	75500	335.56	335.56
T.0.2	0%	76000	337.78	
T.0.3	0%	75000	333.33	
T.2.1	2%	80000	355.55	356.29
T.2.2	2%	81500	362.22	
T.2.3	2%	79000	351.11	
T.4.1	4%	64500	286.67	273.33
T.4.2	4%	55000	244.44	
T.4.3	4%	65000	288.84	
T.6.1	6%	56000	248.89	248.89
T.6.2	6%	55500	244.45	
T.6.3	6%	57000	253.34	
T.8.1	8%	47500	211.11	208.14
T.8.2	8%	47000	208.88	
T.8.3	8%	46000	204.44	

From the Table 3, it is evident that the maximum compressive strength is achieved in the specimen with a 2% alum percentage, reaching 356.29 kg/cm^2. Therefore, it can be concluded that the optimal alum percentage to be added to the concrete mix to attain maximum compressive strength is 2% of the cement weight in the mixture, accompanied by an average slump value of 7.75 cm.

5. Conclusion

Based on the findings, the following conclusions are obtained:

1. The addition of alum to the concrete mix can influence the technical properties of the concrete, particularly in terms of workability (slump) and its compressive strength.
2. The highest compressive strength of concrete was achieved in the test specimens with a 2% alum addition from the weight of cement of 356.29 kg/cm^2 with a slump value of 7.75 cm.

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