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Physical and Mechanical Properties of Paving Blocks According To By the Addition of Mineral Mixture

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-ABSTRACT-
Paving blocks, which consist of concrete bricks blended with sand and cement, are frequently employed in ground surface hardening construction due to their favorable characteristics. These include being precast materials that possess a comparatively sizable form, the capability to absorb water, comparatively affordable prices, and ease of manipulation. Paving blocks consist of supplementary components, specifically mineral admixtures, in addition to the primary components of water, aggregate, and cement. The inclusion of these substances serves to enhance the overall quality of paving blocks. Included among the mineral admixtures utilized in this investigation are gypsum, quartz grit, and limestone.In addition, in testing mechanical properties, the compressive strength of paving blocks has met the established standards. The results show that the compressive strength of paving blocks becomes higher with age and the use of 3% limestone, 10% gypsum, and 6% quartz sand can increase the compressive strength value of paving blocks produced. Visual inspection test, compressive strength test, abrasion resistance test, and volume weight test. Ascertain whether the incorporation of mineral admixtures influences the physical and mechanical properties of paving blocks, following the analysis and graphing of the obtained research results, conclusions are reached. Furthermore, determine the ideal level of mineral admixture addition to paving blocks in order to achieve the highest possible compressive strength.

Keyword: *Limestone, Gypsum, Quartz Sand, Paving Blocks.*

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I. INTRODUCTION

Paving block or concrete brick, as defined by SNI 03-0691-1996, is a construction material composed of Portland cement, aggregate, and water, in which additional substances may or may not be added [1]. Paving block serves as a substitute infrastructure material for ground-level pavement. Paving blocks are typically installed in parks, roadways, parking lots, footpaths, and courtyards. Paving blocks are widely favored due to their low maintenance requirements, straightforward installation procedure, and attractive appearance.

When manufacturing paving pavers, variations in the gradation of the sand aggregates that are available frequently present a challenge. An optimal composition is necessary to ensure that the paving pavers produced satisfy the quality standards specified in the SNI-03-0691-1996 standard.

Adjunctive substances are frequently incorporated during the production of paving blocks, alongside the primary components of Portland cement, aggregate, and water. To alter the properties of the concrete mixture in accordance with SK SNI S-18-1990-03, admixtures are substances in the form of liquids or granules that are incorporated while the mixture is being stirred. Physically speaking, additives can be classified as either chemical or mineral admixtures [3].

The following are a few of the quality requirements for paving blocks as outlined in SNI 03-0691-1996 [1]:

Tabel 1.Quality Specifications for *Paving Blocks*

Quality	Compressive Strength (MPa)		Wear Resistance(mm/minute)		Absorption (%)
	Average	Minimum	Average	Minimum	Maximum
A	40,0	35,0	0,090	0,103	3
B	20,0	17,0	0,130	0,149	6
C	15,0	12,5	0,160	0,184	8
D	10,0	8,5	0,219	0,251	10

Mineral admixtures are usually added during the implementation of concrete making in the field which has the aim of increasing workability without changing the water content, reducing the water content without changing the workability, giving effect to the above combination, adjusting the setting time, reducing segregation and bleeding, increasing strength, durability, and reducing permeability. While chemical additives are additional constituents that are introduced during the cement manufacturing process at the factory. The purpose of using admixtures in this mixture has objectives such as increasing workability. In addition, to enhance the quality of paving blocks produced according to SNI-03-0691-1996, the finest aggregate size composition is required so that the paving blocks produced can have a quality that satisfies the standards.

In this investigation, a composition with a ratio of 1 cement: 0.2 pulverized stone: 1.8 sand where this ratio is derived from the experimental procedure in the Materials and Construction Laboratory, Faculty of Engineering, Tanjungpura University and produces class A paving block quality. In addition, in the composition of creating this paving block, mineral admixtures will be added, which in the end this research can contribute to the development of science regarding the addition of mineral admixtures to the physical and mechanical properties of paving blocks.

II. METHOD

This research employs the literature study and experimental methods as the commonly applied approaches. This method was chosen because prior to the experimental stage, information gathering through literature and standard references is an essential prerequisite, while experiments are conducted to attain objective truth supported by reliable data and facts. The objective of this study was to investigate the physical and mechanical properties of paving blocks as a consequence of variations in fine aggregate gradation, in accordance with the applicable regulations.

At the outset of the research phase, an in-depth analysis of the component materials used in the mix design of paving blocks was conducted. The materials involved in this investigation included Portland Composite Cement (PCC), sand of various gradations (coarse, medium, barely fine, fine), and pulverized stone. The analysis of these materials included various parameters such as organic content, particulate content, moisture content, specific gravity, water absorption, gradation, volume weight, as well as wear-related analysis of the coarse aggregate. In addition, the specific gravity of cement and volume weight of cement were also analyzed. All these analytical results formed the premise for designing the appropriate combination design for the paving blocks.

The Materials and Construction Laboratory, Faculty of Engineering, Tanjungpura University Pontianak, was the location of this study, which spanned a duration of two months. "The Effect of Fine Aggregate Gradation on the Physical and Mechanical Properties of Paving Blocks" research utilizes a literature review methodology that incorporates citations from scholarly publications and a variety of SNI standards that are pertinent to the paving block manufacturing process. A component of the population, denoting all subjects integrated into this investigation, constitutes the subject of this study. Specifically, a paving block measuring 210 x 105 x 80 mm was utilized as the specimen in this study.

Paving slabs measuring 210 x 105 x 80 mm will be manufactured utilizing the following machinery:

1. The apparatus for material analysis, including:
   - *Organik plate.*
   - Container.
   - Measuring cup.
   - *Sieve shaker machine.*
   - Aggregate sieve.
   - Drying oven.
   - Piknometer
2. Digital scales.
3. Compression testing machine
4. Cement scoop.
5. Mixer *paving block*.
6. *Paving block pressmachine*.

1.1. Material Analysis

Recognizing the physical characteristics of the materials utilized in scientific investigations, particularly in the context of mix design, is the primary objective of materials analysis. The quantity of material needed for the mix design procedure can be ascertained via material analysis. Presented below is the completed material analysis:

2.2.1 Fine Aggregate

In this investigation, river sand is utilized as the fine aggregate; this substance is subject to a battery of tests pertaining to its properties and characteristics. The subsequent series of experiments were conducted within this particular context:

1. 1. Solid Aggregate Organic Composition
2. 2. Analysis of Fine Aggregate Sludge Content
3. 3. Analysis of Absorption of Fine Aggregates

4. 4. Analysis of specific gravity and water absorption
5. 5. Analysis of Fine Aggregate Gradation
6. 6. Analysis of the Volume Weight of Fine Aggregate

2.2.2 Coarse Aggregate

1. The coarse aggregate utilized in this investigation was 0.5 pulverized stone, which underwent a battery of experiments to determine its properties and attributes. The following series of experiments were performed within this context:
2. Analysis of Coarse Aggregate Moisture Content
3. Analysis of specific gravity and water absorption
4. Analysis of Coarse Aggregate Gradation
5. Analysis of the Volume Weight of Coarse Aggregate
6. Check for Coarse Aggregate Wear

2.2.3 Cement

Available at building material retailers in the Pontianak City region, the Conch brand of composite Portland cement was utilized in this investigation. Conch cement satisfies the specifications outlined in SNI 7064-2014 [8], thus no analysis of its chemical and physical properties was conducted. A sequence of experiments pertaining to cement is as follows:

1. Analysis of cement specific gravity
2. Weights of Volumes of Cement

2.2.4 Water

The water utilized in this investigation must satisfy the visual and chemical standards outlined in SNI 03-6861.1-2002 [9]. The water utilised in this investigation originates from PDAM Pontianak and complies with the specifications outlined in the Indonesian Concrete Code (PBI-71) [10]. Consequently, chemical monitoring of water was omitted from this investigation.

2.7 Testing of Test Objects

2.7.1 Visual Check

Paving blocks that satisfy specific criteria—including a smooth surface devoid of any imperfections and cracks—are subjected to visual inspection. Additionally, the ridges and corners of the paving slabs must be resistant to finger pressure when smoothing. The dimensions of the paving blocks must include a thickness tolerance of +8% and a minimum thickness of 60 mm.

2.7.2 Volume Weight Test

The process of determining the weight of an object per unit volume is known as volume weight testing. In contrast to its porosity, the weight of an object is inversely proportional to its weight per unit volume. The volume weight is determined by employing the subsequent equation:

$$BV = \frac{w}{v} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

Where :

BV = Volume weight(kg /m^3)
W = Weight of Test object(g)
V = Volume of test specimen(m^3)

2.7.3 *Paving Block* Compressive Strength Test

Compressive strength of concrete is defined as the quantity of burden per unit area that a concrete specimen experiences when subjected to a specific compressive load by a press machine [11], in accordance with Indonesian National Standard S-14-1989-F on testing the compressive strength of concrete. Debris quantity, cement type, age of concrete, water-cement ratio, aggregate properties, and cement type are all variables that influence the strength of concrete. Utilizing the equation [1] outlined in SNI 03-0691-1996, the compressive strength of paving blocks can be determined.

$$KT = \frac{P}{L} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

Where :

KT = Compressive strength(N /mm^2)
P = Compressive load(N)
L = Area of the compressive field (mm^2)

Using the subsequent equation, the mean compressive strength of the paving block samples was determined:

$$KT_R = \frac{\Sigma KT}{\Sigma Sampel} \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \quad (3)$$

2.7.4 Absorption Test

Absorption or water absorption quantifies, as a percentage, the weight of water assimilated by the pores of the specimen. The rate at which water is absorbed is determined by the specimen's porosity; a high porosity will cause the specimen to absorb a great deal of water, which can diminish its durability. An inadequate composition and quality of the aggregate comprising the paving block frequently results in elevated water absorption. The equation utilized to determine water absorption is as follows:

$$Wa = \frac{Mj - Mk}{Mk} \times 100\% \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \quad (4)$$

Where :
Wa = *Water absorption* (%)
Mj = Mass of object in saturated condition(g)
Mk = Mass of dry object(g)

2.7.5 Wear Resistance Test

The wear resistance of paving pavers serves as an indicator of the surface layer's ability to withstand persistent friction. During the wear resistance test, the paving blocks underwent a series of 100 rubs at a rate of 20 rubs per minute for 5 minutes, after which they were massaged with portions of tubeless motorcycle tires. The blocks were weighed both prior to and subsequent to the test. Following this, a brush was used to remove grit and detritus from the paving block's surface, and a pushbar was used to measure the rubbed surface area of each block. The computation for determining the wear resistance value of paving blocks is as detailed in SNI 03-0028-1987 [12]:

$$\text{Wear resistance} = \frac{A \times 10}{BJ \times L \times W} \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \quad (5)$$

Where :
A = Weight disparity between *paving blocks* prior to and subsequent to deterioration
BJ = The specific gravity of *paving blocks*
L = Surface area of the wear plane(cm^2)
W = Duration of wear (5 minutes)
Results & Discussion

III. RESULTS AND DISCUSSION

The subsequent findings elucidate the outcomes derived from the conducted experiments:

Tabel 2.*Paving Block* Thickness Check Result

Variation	Average Thickness	Plan Thickness
Normal	60,53	60
Gypsum 6%	60,61	60
Gypsum 8%	59,58	60
Gypsum 10%	60,40	60
Quartz Sand 6%	60,75	60
Quartz Sand 8%	60,34	60
Quartz Sand 10%	59,28	60
Limestone 3%	59,43	60
Limestone 5%	60,70	60
Limestone 7%	59,35	60

Based on the information provided, it can be deduced that the paving blocks demonstrate the qualities of an even plane, cracked-free construction, and a coarse texture across all sand gradation variations. The side ribs are similarly robust and lack sharpness. Moreover, the paving blocks' thickness adhered to the predetermined blueprint and satisfied the established benchmarks for quality.

Tabel 3.Result of *Paving Block* Volume Weight Check

Variation	Average Volume Weight (kg/m^3)
Normal	2015,21
Gypsum 6%	1964,78
Gypsum 8%	2071,06
Gypsum 10%	1996,26
Quartz Sand 6%	2001,54
Quartz Sand 8%	2020,69
Quartz Sand 10%	2067,61

Limestone 3%	2051,58
Limestone 5%	1990,62
Limestone 7%	2045,09

The utilization of mineral admixtures has no discernible effect on the volumetric weight of paving blocks, as shown in the table.

Tabel 4.Results Of An Analysis Of The Fine Aggregate Fineness Modulus And Compressive Strength Of *Paving Blocks*

Variation	Average Volume Weight (kg/m^3)
Normal	42,40
Gypsum 6%	25,64
Gypsum 8%	38,73
Gypsum 10%	45,39
Quartz Sand 6%	45,84
Quartz Sand 8%	37,30
Quartz Sand 10%	31,74
Limestone 3%	45,75
Limestone 5%	33,73
Limestone 7%	30,35

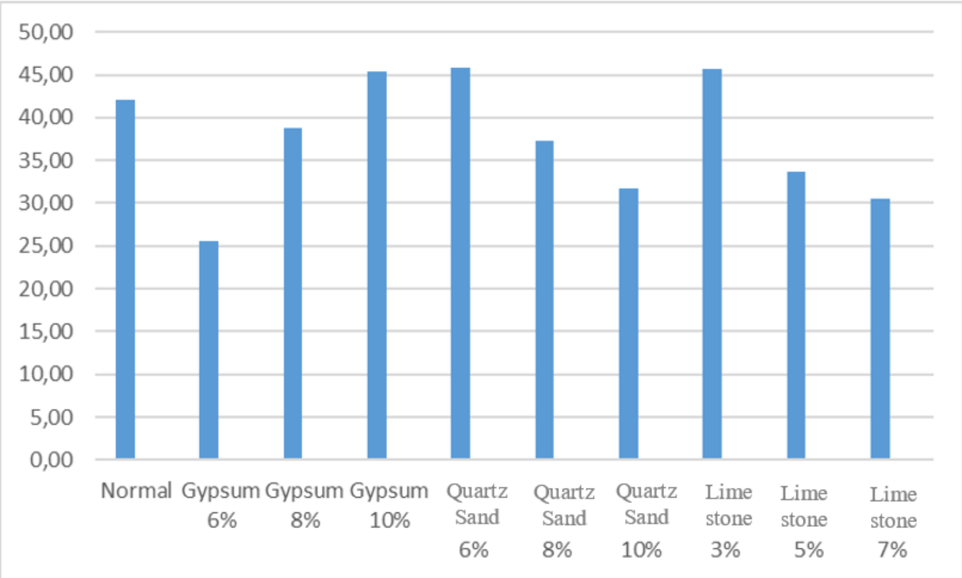

Figure2. Graph of Combined Average Compressive Strength of *Paving Blocks*

In line with the findings presented in the table and graph, it can be concluded that paving blocks containing 10% gypsum, 3% limestone, and 6% silica sand can enhance their compressive strength.

Tabel 5.Results of *Paving Block* Absorption and Fine Aggregate Fineness Modulus Inspection

Variation	Absorption(%)
Normal	7,14
Gypsum 6%	7,18
Gypsum 8%	6,67
Gypsum 10%	7,16
Quartz Sand 6%	7,67
Quartz Sand 8%	7,75
Quartz Sand 10%	8,05
Limestone 3%	6,89
Limestone 5%	6,70
Limestone 7%	6,99

The research findings indicate that the majority of the paving blocks, with the exception of the 10% quartz sand variation, which yields quality D, perform in category C during the absorption test..

Tabel 6.*Paving Block* Wear Resistance Results

Variation	Average *Paving Block* Wear
Gypsum 6%	25,64
Gypsum 8%	38,73
Gypsum 10%	45,39
Quartz Sand 6%	45,84
Quartz Sand 8%	37,30
Quartz Sand 10%	31,74
Limestone 3%	45,75
Limestone 5%	33,73
Limestone 7%	30,35
Normal	0,059

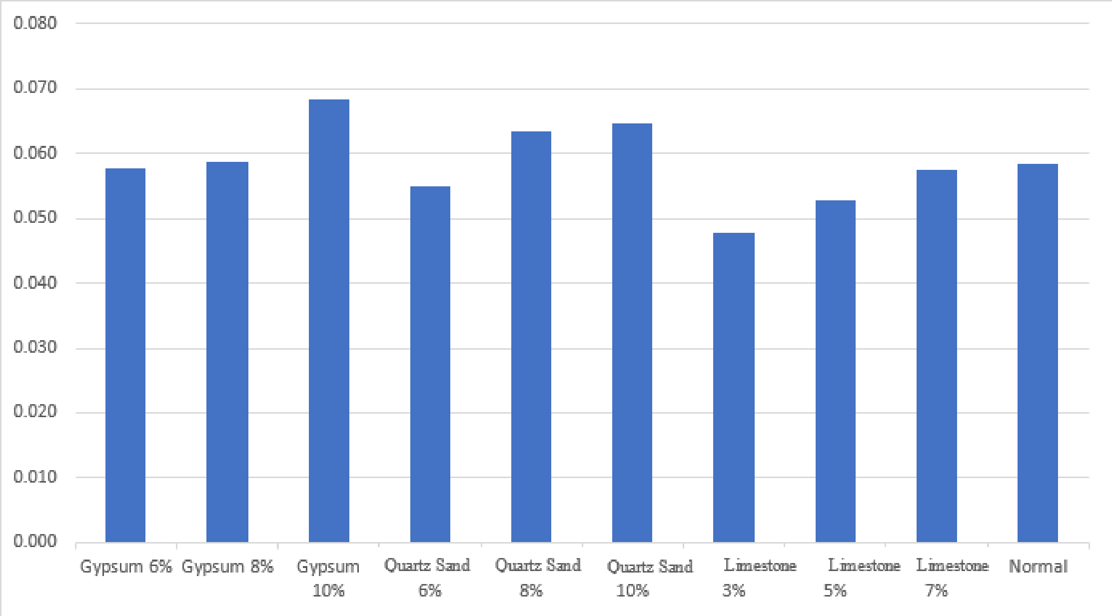

Figure2. Combined Graph of Wear Resistance Test

It can be concluded that all paving blocks exhibit a wear resistance quality of A as a result of the analysis, which demonstrates that the incorporation of mineral admixtures improves the wear resistance of paving blocks.It can be concluded that all paving blocks exhibit a wear resistance quality of A as a result of the analysis, which demonstrates that the incorporation of mineral admixtures improves the wear resistance of paving blocks.

IV. CONCLUTION

Based on the initial hypothesis, it is expected that the various quality tests carried out on paving blocks with additional mineral admixtures will produce higher quality than ordinary paving blocks. Therefore, it can be concluded that at certain levels the addition of mineral admixtures can improve the quality of paving blocks.

However, the results of the physical properties test on the paving block have met the visual requirements, but in the volume weight section there is no significant change in the paving block.

In addition, in testing mechanical properties, the compressive strength of paving blocks has met the established standards. The results show that the compressive strength of paving blocks becomes higher with age and the use of 3% limestone, 10% gypsum, and 6% quartz sand can increase the compressive strength value of paving blocks produced.

Thus, the results of this study provide an important insight that the effect of mineral admixtures on the quality of paving blocks can vary, and not always in accordance with the initial hypothesis.

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