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Dimensional And Mechanical Deviation of Paving Block Type Rectangular from Several Manufacturers in Semarang City

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Abstract: The non-uniformity of paving block quality can result in uneven pavement, which in turn can increase the risk of traffic accidents. This study aims to determine the quality of compressive strength of paving block type Holland from several manufacturers in Semarang City area both manually and massively. As well as knowing why the physical dimensions of paving block type Holland from several producers in Semarang City are not uniform. This research was conducted by taking samples in the paving block manufacturing industry around the city of Semarang. The discussion in this study only covers the type of holland paving block in Semarang City from 4 producers namely CV Waringin Putih Banyumanik Semarang, PT Alam Daya Sakti, Anugerah Block, and Putra Alam Sari. All paving block products tested met or exceeded the minimum value of compressive strength specified in SNI 03- 0691-1998. This indicates that these products have an adequate ability to withstand the given compressive load. The compressive strength test results show that the lowest value was recorded for Anugrah Block at 17.21 MPa, while the highest value was achieved by PT Alam Daya Sakti with 20.112 MPa. The non-uniformity of the physical dimensions of Holland type paving from several producers in Semarang City can be influenced by several factors, including different production processes between producers, the use of different raw materials, and differences in the arrangement of machines or production equipment.

Keywords: *Holland; Masinal; Manual; Paving Block; Semarang*

1. Introduction

The development of the use of rigid pavement has now been widely used as a highway pavement material, including rigid pavement using reinforced concrete mixtures or using locked concrete blocks such as paving block Holland, Grass Block Holland, and others [1]. Rigid pavement, especially holland paving blocks, is widely used in special places that require more strength to withstand secondary loads (Secondary Force) such as in bend areas, bus stops, parking areas, inclines, ports, as well as for using pavement in certain areas such as road sections in residential areas, ports, paths / alleys, sidewalks, road sections in tourist areas, office yards, houses, and shopping complexes.

The non-uniformity of paving block quality can result in uneven pavement, which in turn can increase the risk of traffic accidents. By knowing the mechanical properties of paving blocks from different manufacturers, municipalities can select materials that can provide a safer road surface for users. Non-uniform pavement spacing, and flatness can lead to additional costs in road

maintenance. By resolving this issue, municipalities can reduce road infrastructure management costs and better allocate resources to other more pressing projects.

Uniformity in road infrastructure quality will increase public trust in local governments and paving manufacturers. Research that provides a solution to the problem of non-uniformity will demonstrate a commitment to improving the quality of life of residents and boost public confidence in urban development. By solving the problem of paving size non-uniformity, Semarang City can ensure that the road infrastructure complies with established quality standards. This is important to ensure that the road infrastructure can properly meet the needs of road users and provide optimal services [2].

The objective of this research is divided into three main stages. First, to determine the effect of the physical dimensions of Holland type paving blocks from several producers in Semarang City which are not uniform, thus affecting the spacing and flatness of the pavement after being arranged. Second, to determine the compressive strength quality of Holland type paving blocks from several producers in Semarang City both manually and massively produced. Third, to determine whether the quality of paving blocks in Semarang City can be uniform or almost the same, both physically and in terms of compressive strength.

Thus, research on paving size non-uniformity in Semarang City has a high urgency to improve the safety, quality and efficiency of road infrastructure and strengthen public trust.

2. Materials And Methods

The following are the materials and methods in the study "Dimensional And Mechanical Deviation Of Paving Block Type Rectangular From Several Manufacturers In Semarang City". This study involved the collection of rectangular type paving blocks from several manufacturers in Semarang City. The materials used included paving blocks obtained directly from these manufacturers. The research methods included dimensional measurement and mechanical testing on the collected paving blocks. Dimensional measurements were taken using precision measuring instruments to obtain accurate data on the length, width and height of the paving blocks [3]. Mechanical testing included compressive strength tests conducted in accordance with applicable standards [4]. The data obtained was then analyzed to determine the presence of dimensional and mechanical deviations among paving blocks from different manufacturers.

2.1. Paving Block Holland

Paving Block is a building material made from a mixture of portland cement or hydraulic adhesive, water and aggregate with or without other additives that do not reduce the quality of Paving Block [5]. For more than two decades, Paving Blocks have been used as material for sidewalks, parking lots, parks, bus stops, etc [6]. It is also used as a retaining wall. It is also used as a retaining wall, slope protection and erosion control. During this time, extensive research has been conducted on the characteristics and performance of paving blocks.

Although sidewalks made of paving blocks are passed by buses and trucks, the performance of paving blocks is very satisfactory. The Paving Block pavement layer consists of 5 layers, namely: subgrade, subbase, course, basecourse, bedding sand and concrete block[7]. Where jointing sand as a connector of paving blocks with each other. The working principle of Paving Block is the same as flexible pavement whose load is distributed to other layers so that the load will be transferred perpendicularly from Paver to Bedding Sand, Basecourse and Subgrade .[8]

Subgrade can be compacted native soil or soil imported from elsewhere and compacted and stabilized with lime or other materials[9]. It is the responsibility of the designer to evaluate the behavior and performance requirements of the structure to ensure the requirements are compatible with the soil and site conditions [10]. Subgrade preparation should extend to the back of all edge restraints. Bedding Sand has a very thin thickness of about 25 mm or 10 mm after compaction. This layer is usually river sand. The function of this layer is a layer that is leveled as a base or

bearing paving block[11]. In addition, the benefits, among others, are as fillers between paving from below and forwarding the load to the previous surface.[12]

Paver or Paving Block is the top component in Concrete Block Pavement. Paver is made from a mixture of portland cement and water and aggregate as a filler[13]. The Paving Block layer is filled with sand filling the joints in the gaps between the pavers. In addition, at the end of the edge restraint is placed to hold the paving block so that it does not come off. The use of filler sand aims to produce a bond between Paving Blocks and prevent water absorption into the bottom layer[12]. The pavers have classifications including thickness, arrangement pattern, size, shape and strength.

2.2. Methods And Data Collection

In this study using two types of data, namely for qualitative data in the form of interview results, general description, data from holland paving block producers in the Semarang City area, while for quantitative data in the form of survey results and author's research. In the research conducted, researchers used primary data. For primary data itself is obtained directly on the object under study through records, hollow paving block production in Semarang City.

This research was conducted by taking samples from the paving block manufacturing industry around the city of Semarang. Sample testing was carried out at the Materials and Construction Laboratory of Sultan Agung University Semarang. The research method used consisted of five main stages. First, a field survey was conducted to collect preliminary data and understand the conditions at the research site. Second, field sampling was conducted to obtain materials for further testing. Third, testing of the specimens was carried out in the laboratory to measure the various parameters required. Fourth, the test results were analyzed and discussed in the context of the laboratory to gain a deeper understanding. Finally, an overall analysis and discussion of the data obtained was conducted to draw conclusions and recommendations relevant to the research objectives.

The sampling to be studied is brick type, with the paving sizes as follows: 20 cm long, 10 cm wide and 6 cm thick paving. The choice of paving size is because this type of paving is widely used in development. The location where the pacing is taken is in the Semarang area, namely from the industry:

a. CV Waringin Putih Banyumanik Semarang
b. PT Alam Daya Sakti
c. Anugerah Block
d. Putra Alam Sari

2.3. Test Specimens

The sample size used in this study is selected from various segments of the paving block industry, encompassing different manufacturers and production methods, as follows:

1. The sample used is a rectangular type with a size of 20 x 10 x 6 cm.
2. Samples were taken from 4 manufacturers with information, 3 masinal products and 1 manual product.
3. Samples to be tested are taken randomly from each industry and the sample age is 28 days (about 4 weeks).
4. The samples to be tested amounted to 12 pieces of paving block, where each industry took 3 samples.

This research was conducted by taking samples from the paving block manufacturing industry around the city of Semarang. Sample testing was carried out at the Materials and Construction Laboratory of Sultan Agung University Semarang. The equipment used in this study included a soaking tub for the treatment of paving blocks, a Compression Testing Machine (CTM), and complementary equipment such as gloves, mats and water buckets, as well as markers, and others.

2.4. Compressive Strength Test

Testing of Paving Blocks Compressive Strength Test Before testing the compressive strength of paving blocks, in accordance with the existing provisions in the compressive testing of cube test objects, the objects tested must have the same sides so that the paving blocks to be tested must be cut to have the same side [14]. Cutting is done with the size of all sides 6 cm. After cutting, the compressive strength test can then be carried out. The steps in testing compressive strength are carried out as follows:

1. Prepare the tools needed in testing such as tools for recording, scales and carts as a place for test objects after testing.
2. Checking the CCM (concrete compression machine) compressive strength testing tool, make sure everything works properly.
3. Prepare Paving Block test objects that have been cut into 6 x 6 cm cubes;
4. Weigh and record the weight of the paving block test object for each sample to be tested for compressive strength and place the Paving Block test object on the compressive strength test tool.
5. Set the needle of the CCM (concrete compression machine) right at the zero position and pump the compressor by pressing the lever up and down continuously until the test object breaks or is destroyed.
6. Record the maximum compressive load value read on the needle of the CCM (concrete compression machine), then remove the specimen.
7. Repeat activities 2 through 4 using paving block material in the same composition sample code.
8. Repeat activities 2 through 6 using paving block materials in different composition sample codes.

3. Results And Discussions

The following is a detailed description of each of the paving block industry profiles involved in this study.

3.1. Paving Block Industries

3.1.1. CV Waringin Putih Banyumanik Semarang

CV Waringin Putih Semarang is a company that produces paving and similar products with an address at Jl. Bendo, Banyumanik Semarang, Central Java. zip code 50264. The materials used for making paving blocks are sand, cement, and water. The equipment used is a paving block printing machine and is classified as complete, fast and technological in its operation because this business is classified as a masinal paving block printing industry.

3.1.2. PT Alam Daya Sakti

PT Alam Daya Sakti, known as ALDAS, is a company engaged in the concrete industry and building materials known for the best quality and quality. Aldas acts as a manufacturer of various products such as paving blocks, terrazzo tiles, bataco, kanstein, and grassblock which are in accordance with ISO 9001: 2008 standards. Through the development of the times Aldas is also engaged in natural stones such as marble and granite. In 1984 PT Alam Daya Sakti has developed into a paving block manufacturer, with the ownership of automatic paving production machines from Germany.

Head Office & Factory: Jl. Simongan No.39 Ringintelu, Semarang. Area: 12,500 m2 of land and building. The equipment used is a paving block printing machine and is considered complete, fast and technological in its operation because this business is classified as a mass paving block printing industry.

3.1.3. Anugrah Block

Anugrah Block, Jl. Medoho Raya I No.87, Kalicari, Kec. Pedurungan, Semarang City, Central Java 50198. The equipment used is still simple because this business is still classified as a manual paving block printing industry. The tools used are manual paving block molds, sand carts, cement & sand scoops, sand sieves, buckets, cement scoops and hoes. Materials used in this manufacturing site include sand, cement, screening and water.

3.1.4. Putra Alam Sari

Putra Alam Sari, Jl. Kp. Pekayon No.5, Pekayon Jaya, Kec. Bekasi Sel., Bks City, West Java 17148 is a manufacturer of paving blocks, building materials and a provider of natural materials for building and housing construction including Paving blocks/Conblock, kanstin, Roster/Jalusi, U-Ditch, Buis Beton, Tile and sand. The equipment used is a paving block printing machine and is classified as complete, fast and technological in its operation because this business is classified as a masinal paving block printing industry.

3.2. Sample Shape and Size

The following table shows the observations and measurements of the samples obtained from various paving block industries, indicating the shape and size of the samples used in the study:

Table 1. Sample Shape And Size

CV Name	Sample	Dimension			Weight (gram)	Description
		P (cm)	L (cm)	T (cm)		
CV Waringin Putih Banyumanik Semarang	I	20.8	10.4	6	2888.00	Masinal
	II	20.8	10.4	6	2838.00	
	III	20.7	10.4	6.1	2805.00	
Average:		20.76	10.4	6.03	2510.33	
PT. Alam Daya Sakti	I	19.9	9.9	6	2688.00	Masinal
	II	19.9	9.8	6	2538.00	
	III	20	9.9	6	2605.00	
Average:		19.93	9.86	6	2510.33	
Anugerah Block	I	20.1	9.6	5.6	2223.00	Manual
	II	20.3	9.6	5.5	2049.00	
	III	20.1	9.7	5.5	2169.00	
Average:		20.16	9.63	5.53	2147	
Putra Alam Sari	I	21.5	10.5	6	2973.50	Masinal
	II	21.5	10.3	6	2972.00	
	III	21.6	10.5	6.1	2994.00	
Average:		21.53	10.43	6.03	2979.83	

Based on the laboratory measurements, extreme size differences occurred in the thickness of the test specimens from the Anugrah Blok paving block molding site. The average thickness produced is 5.53 cm. This was caused by several factors, including:

1. Manual Printing: The molding process is still done manually, which can cause variations in the thickness of the specimens. The skill and consistency of the operator in the molding process can affect the result.

2. Tool Wear: The tools used by the artisans have experienced wear and tear. Wear and tear on the molding tools can result in the molding yield being less than it should be. This can result in an imbalance in the thickness of the test piece produced.
3. Quality Control: The absence or lack of quality control in the molding process can also lead to variations in the thickness of the specimens. An ineffective control system can lead to significant differences in production results.

Test results that show low values for the production output at this site may indicate problems in the production process, especially related to imbalances in the thickness of the specimens. To improve product quality, measures such as replacement or repair of worn tools, training of operators to improve skills in the molding process, and implementation of stricter quality control during the production process are necessary. Thus, it is expected that the production results can meet the desired standards.

3.3. Characterization of Physical Properties

The physical properties of different compositions of different blends with molecular density and water absorption based on each sample obtained from each industry are as follows [15].

3.3.1. Density

Based on samples from four paving block industries taken randomly from production, the density values were analyzed. This measurement process is carried out to gain a deeper understanding of the physical characteristics of the product [15]. By taking this measurement, it is expected to provide a more accurate picture of the quality and suitability of the product against the set standards. The results of the analysis will be an important guideline for related parties, both in efforts to improve product quality and in the evaluation process for further improvement in the production process.

Table 2. Density Value

CV Name	Sample	Weight (gram)	Density (g/cm^3)	SNI 03-2847-2002
CV Waringin Putih Banyumanik Semarang	I	2888.00	2.23	2.20 -2.50
	II	2838.00	2.19	
	III	2805.00	2.14	
Average:		2843.67	2.18	
PT. Alam Daya Sakti	I	2688.00	2.27	2.20 -2.50
	II	2538.00	2.17	
	III	2605.00	2.19	
Average:		2610.33	2.21	
Anugerah Block	I	2223.00	2.06	
	II	2049.00	1.91	
	III	2169.00	2.02	
Average:		2147.00	2.00	
Putra Alam Sari	I	2973.50	2.20	2.20 -2.50
	II	2972.00	2.24	
	III	2994.00	2.16	
Average:		2979.83	2.20	

Based on the test results, the density value of Anugrah Bloock's product did not meet the requirements as it was below the desired range of 2.20 - 2.50 g/cm3. Meanwhile, products from the other three industries met the specifications. In particular, the PT Alam Daya Sakti industry

recorded the highest density value compared to other industries with a value of 2.21 g/cm3.

3.3.2 Water Absorbency

Based on samples from four paving block industries taken randomly from production, the value of water absorption has been analyzed. This measurement process is carried out to gain a deeper understanding of the physical characteristics of the product. By taking these measurements, it is expected to provide a more accurate picture of the quality and suitability of the product to the set standards. The results of the analysis will be an important guideline for related parties, both in efforts to improve product quality and in the evaluation process for further improvement in the production process.

Table 3. Water Absorbency

CV Name	Sample	Water Absorbency (%)	SNI 03-0691-1996
CV Waringin Putih Banyumanik Semarang	I	9.7	Max 10
	II	7.8	
	III	8.9	
Average:		8.8	
PT. Alam Daya Sakti	I	8.5	Max 10
	II	9.2	
	III	8.8	
Average:		8.8	
Anugerah Block	I	8.9	Max 10
	II	9.1	
	III	9.0	
Average:		9.0	
Putra Alam Sari	I	8.6	Max 10
	II	9.3	
	III	9.0	
Average:		9.0	

Based on Indonesian National Standard (SNI) 03-0691-1996, the specification for water absorption value is a maximum of 10%. The test results showed that the highest water absorption value, 9.0%, was recorded in the products from Putra Alam Sari and Anugrah Block. Meanwhile, the lowest value, 8.8%, was observed in products from CV Waringin Putih and PT Alam Daya Sakti. Although all products were below the maximum limit allowed by the standard, small differences in water absorption values can affect the quality and performance of the products under various environmental conditions. Therefore, it is important for manufacturers to continuously monitor and ensure that the water absorption values remain within the set limits to meet the desired quality standards.

3.4. Mechanical Properties Characteristics

Compressive strength and flexural strength tests are commonly used methods to test the mechanical properties of various materials or mixtures, including paving blocks. In the context of paving blocks, compressive strength and flexural strength tests provide valuable information about the material's ability to withstand pressure and flexural loads[16].

1. Compressive Strength Test: This test is conducted to determine the resistance of paving blocks to pressure. In this process, the paving block is placed under a gradually applied

pressure load, and then the maximum force that the material can withstand is measured[17]. The results of this compressive strength test give an idea of the paving block's ability to withstand vertical loads, such as vehicular traffic loads or other structural loads.

2. Flexural Strength Test: This test is used to measure the ability of paving blocks to withstand stress on surfaces that tend to flex. In this process, the paving block is placed on top of two support points and loaded in the center. Then, the maximum force that the material can withstand before undergoing permanent deformation is measured. The results of the flexural strength test give an idea of the strength of the paving blocks in resisting horizontally acting loads, such as pressure from vehicle movement [18].

3.4.1. Compressive Strength

Based on samples from four paving block industries taken randomly from production, compressive strength values were analyzed. This measurement process was carried out to gain a deeper understanding of the mechanical characteristics of the product. By taking these measurements, it is expected to provide a more accurate picture of the quality and suitability of the product to the set standards. The results of the analysis will be an important guideline for related parties, both in efforts to improve product quality and in the evaluation process for further improvement in the production process.

Table 4. Compressive Strength

CV Name	Sample	Compressive Strength (MPa)	SNI 03-0691-1998
CV Waringin Putih Banyumanik Semarang	I	20.312	Min 17
	II	19.871	
	III	17.715	
Average:		19.2993	
PT. Alam Daya Sakti	I	18.9618	Min 17
	II	18.937	
	III	20.112	
Average:		19.3369	
Anugerah Block	I	17.812	Min 17
	II	16.832	
	III	16.989	
Average:		17.211	
Putra Alam Sari	I	20.187	Min 17
	II	17.907	
	III	19.435	
Average:		19.1763	

Based on Indonesian National Standard (SNI) 03-0691-1998, the minimum expected compressive strength is 17 MPa. The compressive strength test results show that the lowest value was recorded for Anugrah Block at 17.21 MPa, while the highest value was achieved by PT Alam Daya Sakti with 20.112 MPa. Thus, it can be concluded that all compressive strength test results meet or exceed the minimum standards set by SNI 03-0691-1998. This indicates that all these products can withstand compressive loads in accordance with the requirements of the applicable standards.

3.4.2. Flexural Strength

Based on samples of four industrial paving blocks taken randomly from production, the flexural strength values were analyzed. This measurement process was carried out to gain a deeper understanding of the mechanical characteristics of the product. By taking these measurements, it is expected to provide a more accurate picture of the quality and suitability of the product to the set standards. The results of the analysis will be an important guideline for related parties, both in

efforts to improve product quality and in the evaluation process for further improvement in the production process.

Table 5. Compressive Strength

CV Name	Sample	Flexural Strength (MPa)
CV Waringin Putih Banyumanik Semarang	I	3.234
	II	3.879
	III	4.156
Average:		3.756
PT. Alam Daya Sakti	I	4.012
	II	3.440
	III	3.798
Average:		3.750
Anugerah Block	I	1.570
	II	2.345
	III	4.150
Average:		2.688
Putra Alam Sari	I	4.765
	II	3.988
	III	3.345
Average:		4.033

Although there is no official specification for flexural strength in SNI 03-0691-1998, the flexural strength test results provide additional insight into product quality and strength. Based on the test results, the lowest value for flexural strength was recorded for Anugrah Block at 2,688 MPa, while the highest value was achieved by CV Waringin Putih at 3,756 MPa. Although no standard is used as a reference, a comparison between these values can provide insight into the relative strength of various products and be used as a reference in the selection of products that are suitable for construction needs.

4. Conclusions

Based on the results of the research conducted, several conclusions can be drawn:

a. The non-uniformity of the physical dimensions of Holland paving blocks from several producers in Semarang City can be influenced by several factors, including different production processes between producers, the use of different raw materials, and differences in the arrangement of machines or production equipment. These variations cause the resulting paving blocks to have inconsistent dimensions, which in turn can affect the fit and flatness of the paving pavement once it is assembled.

b. All paving block products tested met or exceeded the minimum compressive strength values set out in SNI 03-0691-1998. This indicates that the products have adequate ability to withstand the applied compressive load. The compressive strength test results showed that the lowest value was recorded for Anugrah Block at 17.21 MPa, while the highest value was achieved by PT Alam Daya Sakti at 20.112 MPa.

c. To ensure uniform paving quality in Semarang City, measures such as consistent production standards, strict quality control, labor training, collaboration among producers, and supervision from the government or relevant authorities need to be implemented in a consistent and coordinated manner.

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