

Concrete Quality Control on Rigid Pavement in The Petamanan - Sidomulyo Road Rehabilitation Project Limpung Sub-District Batang District

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Abstract — The implementation of rigid pavement construction, in fact, has concrete quality results that do not meet the applicable criteria or specifications so that concrete work on rigid pavement can experience cracks or concrete fractures. The research was conducted by direct observation in the field and collecting laboratory testing data, then analyzing by comparing the results of concrete work against the Indonesian National Standard (SNI) and the acceptance of concrete quality based on the 2018 Bina Marga General Specifications (Revision 2) on the Petamanan - Sidomulyo Road Rehabilitation project, Limpung District, Batang Regency. The results showed that the Job Mix Formula (JMF) used in the field produced slump values that met the criteria. The level of uniformity of the quality of concrete implementation on the results of the bending strength of the beam shows the value of the standard deviation with the classification of "excellent" and the level of variation is included in the classification of "very good". The conclusion from the calculation shows that the flexural strength of the beam samples during implementation at each station meets the specification $>f_s' 45 \text{ kg/cm}^2$ (4.41Mpa) at the age of >28 days.

Keywords: quality control; rigid pavement; concrete; flexural strength.

I. INTRODUCTION

Roads are transportation infrastructure that includes all parts of the road, ancillary buildings and equipment for transportation, on the ground, above the ground, below the ground and water surface, and above the water surface. Roads are a means of transportation that has an important role in various community activities in an area. The state and condition of the road greatly affects the smoothness of transportation. For example, the Petamanan - Sidomulyo road in Limpung Subdistrict has been damaged, thus hampering the smooth running of community activities. Therefore, the Department of Public Works and Spatial Planning (DPU) repaired the road. Roads have 3 types of structures, namely flexible pavement, rigid pavement, and composite pavement. In the road improvement project, using rigid pavement (concrete), this pavement is located above the LPA or (aggregate foundation layer A). The advantages of using rigid pavement include a high modulus of elasticity or a fairly high level of strength, durability, and maintenance-free. The ingredients of concrete itself are cement (Portland cement), coarse aggregate, fine aggregate, water, and admixture or additive. The General Specifications of Bina Marga 2018 (revision 2), suggests that the measurement of acceptability of concrete quality for rigid pavements is expressed in flexural strength or flexural strength by requiring a

minimum flexural strength of 45 kg/cm² for 28 days of concrete age. If the minimum flexural strength is not achieved, the work can be accepted with a minimum tolerance of 90% of $f_s' 45 \text{ kg/cm}^2$ (4.41 MPa) but any decrease in concrete quality will be deducted from the unit price.

Based on this description, this research aims to conduct a study of the results of concrete quality control in the implementation of rigid pavement in the Petamanan - Sidomulyo Road Rehabilitation project, Limpung sub-district, Batang Regency by comparing the laboratory test results with the 2018 Bina Marga General Specifications (revision 2) and job specifications, the objectives of this research are: (1) Knowing the slump value of the concrete mixture $f_s' 45 \text{ kg/cm}^2$ in the implementation of rigid pavement on the rehabilitation of the petamanan road - sidomulyo limpung sub-district. (2) Knowing the uniformity of concrete test results from the standard deviation and coefficient of variation for concrete testing $f_s' 45 \text{ kg/cm}^2$.

II. LITERATURE REVIEW

Road Infrastructure and Its Importance

Roads are a crucial part of transportation infrastructure that support the mobility of people and goods. According to the Ministry of Public Works and Housing (PUPR, 2018), roads encompass all components of transportation

pathways, including the surface, supporting structures, and facilities, both above and below the ground. Roads play a significant role in connecting regions and facilitating socioeconomic activities. Poor road conditions can disrupt transportation, increase travel time, and negatively affect economic productivity (Susanto & Wicaksono, 2020).

In the case of the Petamanan–Sidomulyo road in Limpung Subdistrict, damage to the pavement surface has impeded community mobility and economic flow. Therefore, road rehabilitation efforts by the Department of Public Works and Spatial Planning (DPU) are vital to restore the functionality and reliability of this transportation route.

Types of Road Pavement

According to Bina Marga standards (PUPR, 2018), road structures are classified into three main types: flexible pavement, rigid pavement, and composite pavement. Flexible pavement typically uses asphalt as the binder, while rigid pavement utilizes Portland cement concrete as the primary structural material. Composite pavement combines both systems to optimize performance. Rigid pavement, also known as concrete pavement, has several advantages compared to flexible pavement, such as higher compressive and flexural strength, better load distribution, longer lifespan, and minimal maintenance requirements (Sukirman, 2010). Due to these advantages, rigid pavement is often used in high-load areas or where durability and stability are essential, such as highways and industrial roads (Clough & Sears, 1991).

Composition and Quality of Concrete

Concrete is a composite material consisting of cement, coarse aggregate, fine aggregate, water, and admixtures. The quality of concrete is influenced by the proportions of these materials and the mixing, curing, and placement processes. Portland cement is the main binder that contributes to the strength and durability of concrete (Iman, 1995).

Quality control of concrete during construction is essential to ensure that the produced concrete meets design specifications and standards. Parameters such as slump value, compressive strength, and flexural strength are commonly used to evaluate quality consistency (SNI 03-2834-2000; Hidayat & Ramadhany, 2021).

Flexural Strength and Bina Marga Specifications
According to the General Specifications of Bina Marga 2018 (Revision 2), the quality of concrete for rigid pavement is measured by flexural strength (f_s'), with a minimum requirement of 45 kg/cm² (4.41 MPa) at 28 days of age. If the target flexural strength is not achieved, the work can still be accepted with a minimum tolerance of 90% of the specified value, provided that deductions are applied to the payment for reduced quality (PUPR, 2018).

Flexural strength testing reflects the concrete's ability to resist bending or tensile stress on its surface. It is considered a more appropriate indicator of performance for rigid pavement compared to compressive strength, as pavement layers experience tensile stress due to vehicle loading (Purba, Sianturi, & Panjaitan, 2024).

In this context, evaluating the slump value, uniformity, and variation of concrete test results—using parameters such as standard deviation and coefficient of variation—is essential to determine the reliability of the concrete mixture and the quality consistency in field implementation (Aulia, 2021).

Research Relevance

This study focuses on assessing the quality control of concrete used in the rigid pavement of the Petamanan–Sidomulyo Road Rehabilitation Project, Limpung Subdistrict, Batang Regency. The evaluation compares laboratory test results with the standards stated in the General Specifications of Bina Marga 2018 (Revision 2) and job-specific technical documents. The analysis includes the slump value of the concrete mixture, the standard deviation, and the coefficient of variation to determine the uniformity and compliance of concrete quality with design requirements.

III. METHOD

This study was conducted on the rehabilitation work of Petamanan - Sidomulyo Road and vice versa located in Sidomulyo village, Limpung sub-district, Batang district. In this study, we investigated the effect of a concrete batching plant on the quality of concrete in the construction industry. Primary data collection includes field observations, and secondary data includes Laboratory Test Results, Job Mix Formula, Plans, and General Specifications of Bina Marga 2018

Revision 2. The method in quantitative research used is the comparative method. The comparative method is a research approach used to compare two or more phenomena or entities to identify similarities, differences, or patterns that may exist between them.

IV. RESULTS AND DISCUSSION

This research was conducted on road rehabilitation work located in Limpung District, Batang Regency, this road rehabilitation was carried out by CV. Mutiara Sejati as the Contractor and CV. Rajawali Mandiri Perkasa as the Consultant financed by the 2024 Regional

Budget (APBD). Rigid pavement planning technical data can be seen in table 1 below.

Table 1. Rigid pavement technical data

Road type	: District Road.
Road length	: 542 m.
Road type	: 1 lane 2 lanes.
Pavement type	: Rigid pavement.
Rigid concrete quality	: Fs 4.5 20 cm thick & 6 m wide.
Grade A aggregate	: 15 cm.

Concrete quality testing is carried out using the slump test method for fresh concrete in the field and laboratory testing using the concrete flexural strength method. The test results can be seen in Table 2 below.

Table 2. Concrete quality test results

No	Test Item Code	Date of Manufacture	Testing Date	Age (days)	Press Force (P) (kg)	Span Length Between 2 Piles (L) (cm)	Beam Width (b) (cm)	Beam Height (h) (cm)	Modulus Of Rupture $\sigma = \frac{PL}{bh^2}$ (Kg/cm ²)
1		04/03/2024	30/04/2024	57	5800	45,00	15,00	15,00	77,33
2		04/03/2024	30/04/2024	57	7000	45,00	15,00	15,00	93,33
3		04/03/2024	30/04/2024	57	6800	45,00	15,00	15,00	90,67
4		04/03/2024	30/04/2024	57	5600	45,00	15,00	15,00	74,67
5		04/03/2024	30/04/2024	57	4900	45,00	15,00	15,00	65,33
6		05/03/2024	30/04/2024	56	4900	45,00	15,00	15,00	65,33
7		05/03/2024	30/04/2024	56	9000	45,00	15,00	15,00	120,00
8		05/03/2024	30/04/2024	56	5800	45,00	15,00	15,00	77,33
9	CV	05/03/2024	30/04/2024	56	5000	45,00	15,00	15,00	66,67
10	MUTI	06/03/2024	30/04/2024	55	6200	45,00	15,00	15,00	82,67
11	ARA	06/03/2024	30/04/2024	55	6000	45,00	15,00	15,00	80,00
12	SEJAT	06/03/2024	30/04/2024	55	6200	45,00	15,00	15,00	82,67
13	I-FS	06/03/2024	30/04/2024	55	4800	45,00	15,00	15,00	64,00
14	45	06/03/2024	30/04/2024	55	5400	45,00	15,00	15,00	72,00
15		07/03/2024	30/04/2024	54	5200	45,00	15,00	15,00	69,33
16		07/03/2024	30/04/2024	54	5300	45,00	15,00	15,00	70,67
17		07/03/2024	30/04/2024	54	4000	45,00	15,00	15,00	53,33
18		07/03/2024	30/04/2024	54	5200	45,00	15,00	15,00	69,33
19		08/07/2024	30/04/2024	53	4700	45,00	15,00	15,00	62,67
20		08/07/2024	30/04/2024	53	6700	45,00	15,00	15,00	89,33
21		08/07/2024	30/04/2024	53	5000	45,00	15,00	15,00	66,67
22		08/07/2024	30/04/2024	53	5300	45,00	15,00	15,00	70,67

Furthermore, from the data, the concrete slump test is carried out with the proportion of the concrete mixture. Concrete batching plant is a kind of equipment used to mix cement, sand, water, aggregates and others together to produce concrete. The concrete slump test is to control the quality of fresh concrete by knowing how well the concrete mix is produced in the mixing unit or concrete batching plant. The mix proportions can be seen in Table 3 below.

No	Material Type	Quantity (kg)
1	a. Split coarse aggregate 2-3 (32%)	739,83
	b. coarse aggregate split 1-2 (33%)	316,54
2	Fine aggregate/sand	848,37
3	Cement	425
4	Water	153

The concrete batching plant is designed to produce concrete that is suitable for all kinds of construction projects. A concrete plant, also known as a batch plant or batching plant or a concrete batching plant, is equipment that combines various ingredients to form concrete. The observation results of the concrete slump test can be seen in Table 4 below.

Table 3. FS concrete mix proportions 4.5 kg/cm² per 1 m³

Table 4. Observation result of slump test

Slump Test Observation To	FAS	Slump Test Value	Description
1	0.38	6	Meets specifications
2	0.38	6	Meets specifications
3	0.38	7	Meets specifications
4	0.38	7	Meets specifications
5	0.38	4,5	Meets specifications
6	0.38	6	Meets specifications
7	0.38	5	Meets specifications
8	0.38	6	Meets specifications
9	0.38	5	Meets specifications
10	0.38	5	Meets specifications
11	0.38	5	Meets specifications
12	0.38	6,5	Meets specifications
13	0.38	5	Meets specifications
14	0.38	5,5	Meets specifications
15	0.38	7	Meets specifications
Average		5,76	Meets specifications

average slump value based on the results is 6.3 with a cement water factor (FAS) of 0.38. This shows that the slump value is within the specified specification range which is for standard concrete pavements the slump value is 5.0 cm to 7.5 cm. further calculations were carried out to determine the flexural strength of the concrete using the standard deviation and coefficient of variation. Calculations for the results of the flexural strength of concrete beams at each station are described using the following formula.

$$\sigma_1 (fs') = \frac{pL}{bh^2} \dots 1)$$

Conversion of fs' to fc' = fs' x 7.5

The results of concrete quality conversion on test data samples 1 to 22 can be seen in Table 5 below.

Table 5. Conversion of concrete grade fs to fc

No.	Modulus Of Rupture $\sigma = \frac{pL}{bh^2}$ (Kg/cm ²)	Mpa Conversion	Fs (Mpa)	Fc conversion	Fc (Mpa)
1	77,33	10,2	7,58	7,5	56,86
2	93,33	10,2	9,15	7,5	68,63
3	90,67	10,2	8,89	7,5	66,67
4	74,67	10,2	7,32	7,5	54,90
5	65,33	10,2	6,40	7,5	48,07
6	65,33	10,2	6,40	7,5	48,07
7	120	10,2	11,76	7,5	88,24
8	77,33	10,2	7,58	7,5	56,86
9	66,67	10,2	6,54	7,5	49,05
10	82,67	10,2	8,10	7,5	60,75
11	80	10,2	7,84	7,5	58,82
12	82,67	10,2	8,10	7,5	60,75
13	64	10,2	6,27	7,5	47,03
14	72	10,2	7,06	7,5	52,85
15	69,33	10,2	6,80	7,5	51,00
16	70,67	10,2	6,93	7,5	51,97
17	53,33	10,2	5,23	7,5	39,21
18	69,33	10,2	6,80	7,5	50,98
19	62,67	10,2	6,14	7,5	46,05
20	89,33	10,2	8,76	7,5	65,70
21	66,67	10,2	6,54	7,5	49,05
22	70,67	10,2	6,93	7,5	51,97

Furthermore, after converting the quality of concrete, the deviation calculation of sample 1 to sample 22 is carried out with the results that can be seen in Table 6 below.

Table 6. Standard deviation and coefficient of variation of concrete flexural strength results

No	Average flexural strength (fs') test results >28 days		Conversion to fc'	(fc'-fc'r)	(fc'-fc'r) ²
	Kg/	Mpa	(MPa) (xi)	(x̄)	(x̄) ²
1	77,33	7,58	56,86	1,25	1,56
2	93,33	9,15	68,63	13,01	169,32
3	90,67	8,89	66,67	11,06	122,24
4	74,67	7,32	54,90	-0,71	0,50
5	65,33	6,41	48,07	-7,54	56,89
6	65,33	6,41	48,07	-7,54	56,89
7	120,00	11,76	88,24	32,62	1064,23
8	77,33	7,58	56,86	1,25	1,56
9	66,67	6,54	49,05	-6,56	43,07
10	82,67	8,10	60,75	5,14	26,39
11	80,00	7,84	58,82	3,21	10,31
12	82,67	8,10	60,75	5,14	26,39
13	64,00	6,27	47,03	-8,58	73,66
14	72,00	7,06	52,85	-2,76	7,63
15	69,33	6,80	51,00	-4,61	21,28
16	70,67	6,93	51,97	-3,64	13,27
17	53,33	5,23	39,21	-16,40	268,94
18	69,33	6,21	50,98	-4,63	21,48
19	62,67	6,14	46,05	-9,56	91,44
20	89,33	8,76	65,70	10,09	101,75

No	Average flexural strength (fs') test results >28 days		Conversion to fc'	(fc'-fc'r)	(fc'-fc'r) ²
	Kg/	Mpa	(MPa) (xi)	(\bar{x})	(\bar{x}) ²
21	66,67	6,54	49,05	-6,56	43,07
22	70,67	6,93	51,97	-3,64	13,27
Total (Σ)			1223,48		2235,16
Average (\bar{x})			55,61		101,60

After calculating all samples, the standard deviation and coefficient of variation values were calculated with the following results.

$$\text{Average } (\bar{x}) = \frac{\sum x^i_{i=1}}{n} = \frac{1223,48}{22} = 55,61$$

$$\text{Standard Deviation } (s) = \sqrt{\frac{\sum (xi-\bar{x})^2}{n-1}} = \sqrt{\frac{101,60}{22-1}} = 2,2$$

$$\text{Coefficient of Variation } (v) = \frac{s}{\bar{x}} \times 100\% = \frac{2,2}{55,61} \times 100\% = 3,69\%$$

Based on Table 6 and these calculations, the standard deviation value of the flexural strength results converted to compressive strength obtained a value of 2.2 with a work volume of less than 1000 m³, then the quality of implementation is categorized as "very good" (PBI NI-2 1971). Then the coefficient of variation obtained a value of 3.69%, included in the category "very good" (SNI 03-6815-2002)

V. CONCLUSION

1. The Job Mix Formula used in the field shows that the average slump value of 5.76 meets the criteria;
2. The results of the concrete flexural strength test during implementation show the level of uniformity of the standard deviation value of 2.2 with cubication <1000 showing the classification of "Excellent" and the coefficient of variation value of 3.96% so that it is categorized as "Very Good";
3. Based on the results of flexural strength, standard deviation value and coefficient value of rigid pavement work from the results of

concrete quality meets the General Specifications of Bina Marga 2018 Revision 2 and the work can be accepted 100% without any reduction in unit price or total loss.

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