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Quality Analysis of The Road Widening Project Towards Standards for The Grobogan Road Section - Jember District Limit (Link. 199)

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ABSTRACT

Roads are a land transportation route that has been used since ancient times as a means for people to move places using existing transportation. In road construction efforts, it is necessary to have Standard Operating Procedures, or SOPs, that are used with the aim of improving worker performance, ensuring road quality, increasing profits, and company development. SOP is a method or work flow that has been standardized, is used as binding and directive instructions, and covers things from an activity that has steps or procedures. Currently, there are still many road work projects that are carried out without paying attention to existing SOPs, and this means that the quality of the concrete roads being made does not comply with applicable standards, which means that some parties may experience losses. There needs to be a good understanding of how SOPs comply with standards so that they can produce concrete of maximum quality. This writing was prepared using an analytical method using a literature study that refers to the Indonesian National Standards (SNI) and the PUPR Ministerial Regulation (Regulation of the Minister of Public Works and Public Housing).

Keywords: *SOP; Quality; Concrete; Roads.*

INTRODUCTION

On display, street transportation is the main mode of transportation in Indonesia compared to other accessible modes, i.e., 90% of all merchandise and more than 95% of all travelers in Indonesia utilize street transportation. [1] Roads are one of the land transportation routes that have been used since ancient times as a means for people to move places using existing transportation. Roads have an important role for humans, namely supporting all human activities and needs in terms of mobility so that humans can achieve economic and non-economic goals. [2] Based on Law of the Republic of Indonesia number 38 of 2004, roads are a means of land transportation that covers all parts of the road, including complementary buildings and equipment used for traffic, both above the land and water surface and below the land and/or water surface. However, exceptions for railways, truck roads, and cable roads remain in effect. [3] Based on the Ministry of Public Works and Public Housing's Directorate General of Highways in 2016, roads have various types, such as public roads, special roads, arterial roads, collector roads, toll roads, provincial roads, and others. [4]

Roadwork projects are an important construction element in accelerating the development of land transportation infrastructure. Roadwork projects are divided into several types, one of which is rigid pavement. Rigid pavement is a type of pavement that has a relatively high level of strength because it uses aggregate as the main raw material and is mixed with cement as the

binding material, often called concrete road. [5] In rigid pavement work, there are work procedures that must be fulfilled by referring to existing work standards so that the work results can be in accordance with the plan with maximum quality. [2] Concrete roads have several advantages, such as being resistant to standing water and flooding, being able to withstand heavy vehicle loads, having cheaper maintenance costs, being easier to obtain, and being used on weak soil structures. Concrete roads also have several weaknesses, namely: the quality depends on the implementation process; the color of the concrete makes the road look hard and barren; it can increase the elevation of the land during the road repair process by riding on the old road; the heavier the vehicle capacity, the higher the construction costs will be; as well as the smoothness and Road flatness really depends on the casting process.[6]

The work implementation method is a method that can systematically describe the technical completion of work from start to finish, including the main work and work procedures for each type of series of main work activities that can be technically accounted for. Concrete roads, or what is usually called rigid pavement, generally include concrete plates, which are also used as a foundation layer and a sub-base layer (if any) on the surface of the subgrade layer. Concrete work has an implementation method that must be carried out based on applicable standards to produce quality concrete according to plan. Concrete work starts with:

1. Preparing the road
   Road preparation includes land clearing work (clearing bushes, removing poles, etc.), excavation work, and compacting foundation soil. Excavation work is carried out until the height is reached according to the plan. [2]
2. Installation of formwork
   Formwork is a temporary mold that is used to hold concrete during the pouring process so that the resulting concrete has the desired shape. Formwork is a simple construction, but it must be sturdy and able to withstand the load during the casting process. Formwork is generally plywood, supported by wood behind it. Before casting, the formwork must be clean so that the resulting concrete can be neat in accordance with the desired shape and ensure that it is strong enough to support the load during casting[2]
3. Casting
   According to the Ministry of Public Works in 2016, casting is the process of pouring concrete onto a surface. Before casting is carried out, the concrete is first tested to determine its suitability using a slump test. Concrete is declared to have passed the slump test if the difference in concrete height is 8–12 cm from the height of the cone used. [7]
4. Compaction
   Concrete compaction is carried out using a concrete vibrator. This tool is used to compact the concrete mixture by inserting the tool into the poured concrete, then lifting it and doing this periodically without touching the base of the formwork surface. This is done so that the air contained in the concrete mixture can escape through vibrations originating from the concrete vibrator. Then the surface is leveled manually. [8]
5. Treatment
   Concrete that has hardened must be treated by covering it with cloth and then filtering it periodically so that the concrete can be properly dehydrated.

The quality of concrete can change during work in the field due to various influencing factors. This can be determined by carrying out several tests, namely:

1. CBR (California Bearing Ratio) Testing
   Concrete pavement has a higher stiffness and modulus of elasticity compared to flexible pavement. The load received will be distributed to the layers below it, up to the base soil

layer. With high concrete stiffness, the pressure on the distributed load is reduced because the larger the area that can withstand the load pressure, the more the load will be borne by the layer below (subgrade) in accordance with the CBR capacity. [9] According to the Ministry of Public Works and Public Housing, Directorate General of Highways, in 2020, before casting concrete, a test is first carried out on the subgrade because the density of the subgrade can affect the quality of the concrete. The type of soil that meets the requirements for embankment material according to Bina Marga standards, namely the soil chosen, must not include soil with high plasticity or soil with a CBR value of at least 6% after being soaked for 4 days. [10]

2. Compressive strength testing
   According to the National Standardization Agency in 2011, compressive strength is a description of concrete quality. According to SNI 03-1974-1990, concrete compressive strength is the amount of load that causes a test object to crumble when given a certain compressive load generated by a compression testing machine and is calculated per unit area. The compressive strength of concrete is considered to meet the standard if the value reaches or exceeds the design compressive strength value, namely 20 MPa. The amount of compressive strength can be determined by dividing the maximum load value that the concrete can accept by the cross-sectional area of the concrete. The maximum load value that concrete can accept can be measured using a compression testing machine. Concrete is declared to be at the point of receiving maximum load if there is any form of destruction.[11]
3. Flexural Strength Testing
   Flexural strength of concrete is the ability of a concrete block placed in two places to withstand forces whose direction is perpendicular to the axis of the test object acting on it until the test object breaks and is expressed in MPa force per unit area. Calculation of plate flexural strength to achieve maximum deflection with two-point loading, based on SNI 03-4431-1997. The formula for calculating flexural strength can be seen in the equation below: [5]

$$\sigma l = \frac{PL}{bh^2} \quad (1)$$

   Information:
   σl = flexural strength (MPa)
   P = maximum load (N)
   L = span length (mm)
   b = width of the test object (mm)
   h = height of the test object (mm)

Currently, there are still many road work projects that are carried out without paying attention to existing SOPs, and this means that the quality of the concrete roads being made does not comply with applicable standards, which means that some parties may experience losses. This shows the importance of implementing SOPs on roadwork projects. Based on the problem description above, the researcher will discuss SOPs for methods of carrying out concrete work on road projects, quality standards for road work SOPs, and examples of concrete quality results if the work does not comply with the SOP.

METHOD

Type of Research

The research method in this study uses literature studies as a reference, which is obtained by looking for reference data, methods, and theories that are appropriate to the research. Among the data in question, there is some data obtained and collected by researchers during the

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activity. Based on existing data, researchers tried to compare concrete work carried out based on quality standards with concrete work in the field.

Place and Time of Research

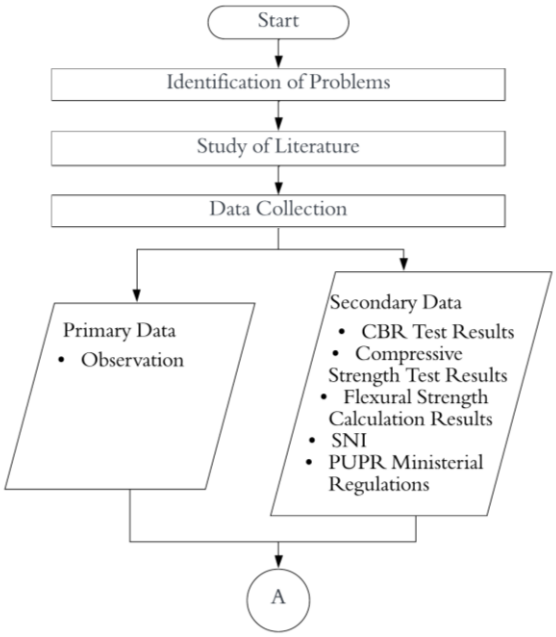
Data collection activities were carried out on the road widening project on the Grobogan Road section to the Jember Regency Border. This activity will last for 4 months, from early July 2022 to early November 2022.

Data Collection Method

Some data collection refers to existing concrete work standards and applicable regulations. Meanwhile, field data was taken and collected by the author while the project was in progress.

a. Primary data is data that leads to information obtained directly by the author. In this final assignment, the primary data used is the results of field research or observations in the field in the form of photo documentation of concrete work results.
b. secondary data or data obtained by the author through other people. In this final assignment, the secondary data used are the results of CBR (California Bearing Ratio) tests, compressive and flexural strength, as well as library research. The literature study obtained comes from several previous journals that are in accordance with the discussion of this final assignment: SNI (Indonesian National Standards) and also the PUPR Ministerial Regulation (Minister of Public Works and Public Housing Regulations). Through this literature study, the author tries to obtain as much information as possible to serve as a reference.

Flow Chart



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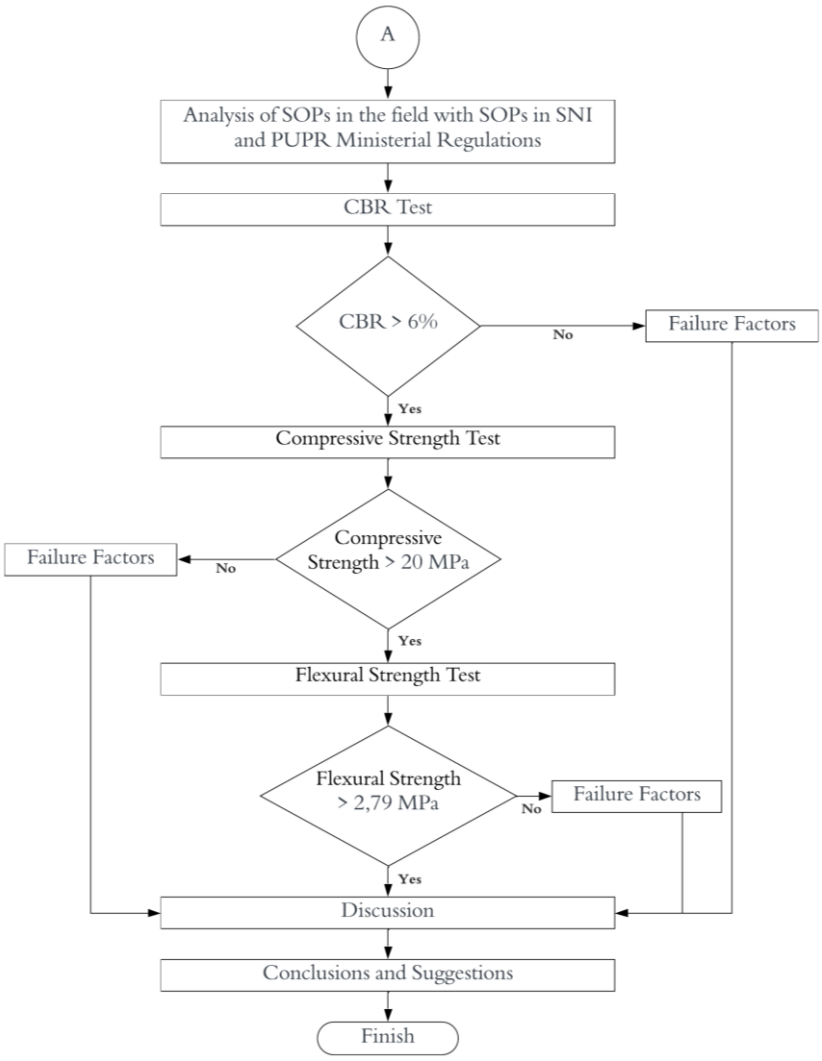

Figure 1. Flow Chart

RESULTS AND DISCUSSION

Established Procedures

1. Road body preparation
   The road preparation carried out in this project consists of removing electricity and telephone poles, clearing bushes, excavating soil, and also compacting excavations. Based on the Center for Research and Development of Transportation Infrastructure in 2004, before pouring the foundation concrete or cement layer, the slope of the foundation must be formed in accordance with the slope of the section specified in the plan drawing, with a maximum surface height tolerance of 2 cm. Deviations from surface flatness are not allowed to be greater than 1 cm when calculated with a 3m-long straight edge. The foundation surface must remain level and solid until the cement concrete is poured. Heavy equipment should not be used on previously finished surfaces. General implementing regulations that apply to the subgrade also apply to the foundation layer. The maximum tolerance for the height of the foundation layer is 1.5 cm, and the difference in surface flatness must be less than 1 cm when measured with a measuring ruler 3 m long. Subgrade compaction should be carried out in tandem, with up to 25 passes in each area used.
2. Formwork installation

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Formwork is a mold to hold concrete so that the size of the concrete can be adjusted according to the plan. The formwork is installed in the form of 2 mm-thick plywood supported by wooden blocks behind it. The installation of the formwork must be sturdy so that the concrete can form perfectly according to the plan, whereas in this road widening work, there are several parts of the formwork that are not strong enough to support the concrete mixture, so there are some parts that are not suitable, such as sloping, and some are loose, making the concrete results not match the original size.

3. Installation of plastic backing.
   According to the Center for Research and Development of Transportation Infrastructure in 2004, plastic backing must be placed on the prepared subgrade surface. [12] Each adjoining sheet must be placed overlapping, with a width of not less than 10cm and a length of 30 cm.
4. Installation of Spokes, Dowels, and Tie Bars
   Based on the 2004 Center for Research and Development of Transportation Infrastructure, spoke stands must be placed on the underlying foundation layer or prepared subgrade. The spoke joints must be placed perpendicular to the road axis. The spokes must be installed firmly in the specified position so that the pressure on the concrete does not disturb its position. Tie bars must be made from threaded steel rods that meet reinforcement specifications, have a have a minimum quality of BJTU-24, and have a minimum diameter of 16 mm. [12]
5. Casting concrete
   Before casting is carried out, the concrete mixture is first tested using a slump test. The slump test is carried out immediately after the mixer or molten truck arrives at the location. The slump test is carried out manually, namely with a plate and cone mold. The slump test is declared to meet the requirements if the concrete decreases 8–12 cm from the height of the cone mold in one trial.
6. Compression
   Compaction is carried out by vibrating the concrete that has been poured using a concrete vibrator on all sides so that it can remove air that is still trapped in the mixture and minimize the presence of voids between the aggregates.
7. Maintenance
   Caring for concrete in the field is done by covering the surface of the concrete with a cloth and then distilling it consistently on all sides so that all sides can get water evenly. Usually, distillation is done with a tool so that the water released is consistent so that all parts get the same amount of water.

Procedures implemented

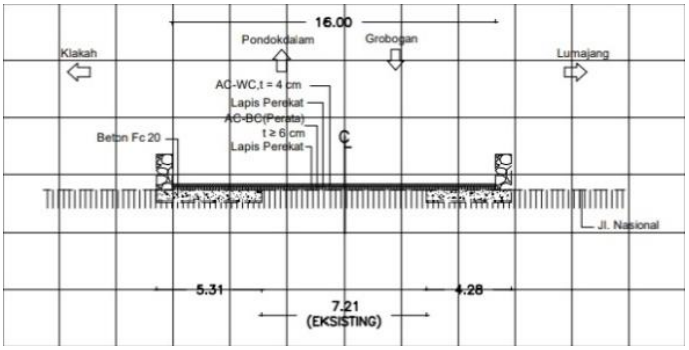

Figure 2. Road Widening Plan Drawing

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This road work project uses unreinforced concrete, which is placed on the surface of the subgrade, which has been prepared with a layer of asphalt as part of the surface layer. The procedures carried out on this project are:

1. Road body preparation
   Excavation of the soil was carried out to a depth of 30 cm using an excavator with a plan of 30 cm of concrete layer and 6 cm of asphalt layer, and then compaction of the subgrade was carried out in tandem for up to 15-20 passes.
2. Formwork installation
   In this road widening work, there are several parts of the formwork that are not strong enough to support the concrete mixture, so there are some parts that are not suitable, such as sloping, and some are loose, making the concrete results not match the original size.
3. Installation of plastic backing.
   The plastic base is installed after the depth is in accordance with the plan and the formwork has been installed.
4. Installation of Spokes, Dowels, and Tie Bars
   In this road work project, spokes, dowels, and tie bars are not used as a connection between the old road and the new road. This can cause a lack of strength on the road because there is nothing to support the shear load. The following is an illustration of the planning for using spokes, dowels, and tie rods or tie bars.

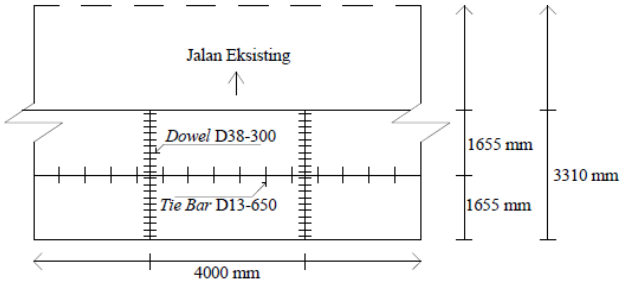

Figure 3. Drawing of Plan for Installation of Rods, Dowels, and Tie Bars

5. Casting concrete
   Ready-mix Concrete is defined as concrete produced in a concrete batching plant for delivery to the buyer or project site in a plastic and unhardened state involving mixer trucks, mixer trucks, concrete pumps, drains, belt conveyors, cranes, buckets, and other equipment that is used. In hot weather, the concrete mix experiences a very sharp decline in slump during the first 30 to 60 minutes, making mixing, placing, compacting, and finishing difficult or even impossible. High-temperature weather is known to affect the mixing process of concrete on its way from the batching plant to the work site, which reduces the workability of fresh concrete, thereby reducing the quality of hardened concrete. [13] In this road widening work, the slump test is carried out 30 minutes to 1.5 hours after the arrival of the mixer or molten truck, and the slump test is carried out in 2-3 trials until it meets the standards. Apart from that, various efforts were also made to ensure that the test results met the standards, such as hitting the plate to make the concrete pile lower, lifting the cone mold not straight up but rotating it, and doing the rojo less or more than 25–30 times.
6. Compression
   In this road widening project, there were shortcomings in the vibrator used, namely that it was not always available and could not function properly. So not all sides can be vibrated to release the air inside.

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7. Concrete Treatment
   In this road widening project, the cloth used was not able to cover all parts, and the distillation was carried out inconsistently and without using tools, so that each part received a different amount of water.

Difference between the Standard Procedures Established and the Procedures Implemented

There are several differences that can be found between the quality standards that have been set and the realization or quality produced in this road work project. The differences found in this road work project are shown in the following table:

Table 1. Differences between the Quality Standards Set and the Quality Produced

No.	Work	Quality Standards	
		Set	Realization
1.	Foundation compaction	25 passes	15-20 passes
2.	Formwork installation	Using 2mm-thick plywood that is supported firmly using wood and shaped according to plan	Using 2mm thick plywood, which is supported by wood, some of it is not according to plan (skewed), and the wood supporting it is not strong enough, so it falls off.
3.	Connecting the old road and the new road	The spokes or dowels must be placed perpendicular to the road axis and must be installed firmly in the specified position so that the pressure on the concrete does not disturb its position. Tie bars must be made from threaded steel rods that meet reinforcement specifications, have a have a minimum quality of BJTU-24, and have a minimum diameter of 16 mm.	Do not use spokes, dowels, or tie rods or tie bars.
4.	Slump Test	- Done immediately after the mixer truck arrives at the location. - It is declared to meet the requirements if the concrete decreases 8–12 cm from the height of the cone mold in one trial. - The cone mold is removed vertically in one slow movement. - Rojokan is done between 25 and 30 times.	- Carried out 30 minutes to 1.5 hours after the mixer truck arrives at the location. - Decrease the concrete by 8–12 cm from the height of the cone mold with 2-3 attempts and hitting the plate several times so that the results are satisfactory. - The cone mold is removed by rotating the cone. - Rojokan is done less or more than 25–30 times.
5.	Concrete compaction	This is done by giving vibrations to remove any air that is inside using a vibrator on each side evenly.	Vibrators are not always available and do not always function well, so not all sides are given vibrations to expel the air inside.
6.	Concrete maintenance	- The entire concrete surface is covered with cloth.	- Not all concrete surfaces can be covered by cloth.

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		- Distillation is carried out consistently and using tools so that the same amount of water comes out on each side.	- Distillation is not done consistently, and tools are not used so that the amount of water that comes out on each side is different.

Test Results

1. CBR Test Results

The CBR (California Bearing Ratio) value is obtained after carrying out a DCP (Dynamic Cone Penetration) test on the subgrade every 25 m. The CBR value of the bearing capacity of the base soil is declared to still be sufficient for use as road foundation material if the average is 6%. The CBR value is calculated using the formula:

log CBR = a-b log DCP

In this road widening work, the CBR value is calculated with a cone angle of 60° so that the value of a = 1.62 and the value of b = 1.27. The following are some of the results of CBR calculations for this road widening work project.

Table 2. CBR Value

First Point				Second Point				Third Point			
No. Blow	DCP mm	Decrease Difference	CBR (%)	No. Blow	DCP mm	Decrease Difference	CBR (%)	No. Blow	DCP (mm)	Decrease Difference	CBR (%)
0	0			0	0			0	0		
1	8	8	**30**	1	40	40	**4**	1	8	8	**30**
2	23	15	**13**	2	70	30	**6**	2	21	13	**16**
3	46	23	**8**	3	99	29	**6**	3	40	19	**10**
4	59	13	**16**	4	129	30	**6**	4	54	14	**15**
5	71	12	**18**	5	161	32	**5**	5	71	17	**11**
6	90	19	**10**	6	200	39	**4**	6	94	23	**8**
7	104	14	**15**	7	241	41	**4**	7	114	20	**9**
8	121	17	**11**	8	270	29	**6**	8	136	22	**8**
9	143	22	**8**	9	291	21	**9**	9	163	27	**6**
10	166	23	**8**	10	322	31	**5**	10	193	30	**6**
11	194	28	**6**	11	351	29	**6**	11	227	34	**5**
12	233	39	**4**	12	381	30	**6**	12	265	38	**4**
13	255	22	**8**	13	412	31	**5**	13	309	44	**3**
14	265	10	**22**	14	443	31	**5**	14	350	41	**4**
15	275	10	**22**	15	475	32	**5**	15	383	33	**5**
16	290	15	**13**	16	502	27	**6**	16	420	37	**4**
17	317	27	**6**	17	529	27	**6**	17	455	35	**5**
18	340	23	**8**	18	554	25	**7**	18	490	35	**5**
19	370	30	**6**	19	580	26	**7**	19	520	30	**6**
20	400	30	**6**	20	604	24	**7**	20	556	36	**4**
21	430	30	**6**	21	631	27	**6**	21	590	34	**5**
22	460	30	**6**	22	660	29	**6**	22	624	34	**5**
23	490	30	**6**	23	685	25	**7**	23	656	32	**5**
24	520	30	**6**	24	710	25	**7**	24	690	34	**5**

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25	541	21	**9**	25	732	22	**8**	25	725	35	**5**
26	579	38	**4**	26	755	23	**8**				
27	603	24	**7**								

From the data above, it was found that the average CBR value at the first point was 10%, the average CBR value at the second point was 6%, and the average CBR value at the third point was 7%. From these three points, it can be seen that the carrying capacity of the subgrade at the road widening work site is above 6%, so it can be said that the carrying capacity of the subgrade is still good enough to be used as road foundation material.

2. Compressive Strength Test Results

The concrete compressive strength test is carried out by placing the test object on a pressing machine and continuing to add load until there are cracks in the test object. The design concrete quality is 20 MPa, so the concrete compressive strength test is considered satisfactory if the value is more than 20 MPa. Some results of compressive strength tests on concrete carried out in this road widening work are shown in the following table:

Table 3. Compressive Strength Test Result

Collection Date	Test Date	Diameter	Height	Width	Load	Quality
		mm	mm	g	N	MPa
5 July 2022	23 September 2022	150	300	13170	450	24,9
20 July 2022	23 September 2022	150	300	12815	450	24,9
28 July 2022	23 September 2022	150	300	12585	360	19,9
30 July 2022	23 September 2022	150	300	11995	340	18,8
1 August 2022	23 September 2022	150	300	12685	280	15,5
2 August 2022	23 September 2022	150	300	12455	280	15,5
4 August 2022	23 September 2022	150	300	11920	330	18,3
13 August 2022	23 September 2022	150	300	12635	420	23,3
18 August 2022	23 September 2022	150	300	12995	330	18,3
19 August 2022	23 September 2022	150	300	12620	210	11,6
23 August 2022	23 September 2022	150	300	12520	300	16,6
23 August 2022	23 September 2022	150	300	12780	600	33,3
24 August 2022	23 September 2022	150	300	11460	250	13,8

Source: Jember University Structures and Materials Laboratory

Each test object has the same size, namely a cylindrical shape with a diameter of 15 cm and a height of 30 cm. In Table 4.5, it can be seen that there are many test objects whose quality results are less than 20 MPa.

3. Flexural Strength Calculation Results

By entering the compressive strength test result data, the flexural strength results of the concrete can be obtained. The following is an example of calculating the flexural strength of concrete.

With:

$P = 450$ N

$L = 7000$ mm

$b = 150$ mm

$h = 300$ mm

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Calculation:

$$\sigma l = \frac{PL}{bh^2} \quad (1)$$

$$\sigma l = \frac{450\text{x}7000}{150\text{x}300^2}$$

$$\sigma l = \frac{3150000}{13500000}$$

$$\sigma l = 0{,}23 \text{ MPa}$$

The next calculation was carried out using Excel, and the following results were obtained:

Table 4. Flexural Strength Calculation Result

Maximum Load (P)	Span Length (L)	Width of The Test Object (b)	Height of The Test Object (h)	Flexural Strength (σl)
N	mm	mm	mm	Mpa
450	7000	150	300	0,23
450	7000	150	300	0,23
360	7000	150	300	0,19
340	7000	150	300	0,18
280	7000	150	300	0,15
280	7000	150	300	0,15
330	7000	150	300	0,17
420	7000	150	300	0,22
330	7000	150	300	0,17
210	7000	150	300	0,11
300	7000	150	300	0,16
600	7000	150	300	0,31
250	7000	150	300	0,13

The maximum load is obtained from the maximum load that the test object can withstand during the compressive strength test. The span length uses the length of concrete spread on the field, namely 7 meters. In table 4.6, it can be seen that all test objects have quality results of less than 2.79 MP.

Identify Results

Based on the analysis carried out on the SOPs determined and implemented and the quality results produced, the results can be identified as follows:

Table 5. Identify Results

No.	Work	Quality Standards		Results
		Set	Realization	
1.	Foundation compaction	25 passes	15-20 passes	Based on the CBR results, the strength of the subgrade is still relatively good.
2.	Formwork installation	Using 2mm-thick plywood that is supported firmly using wood and shaped according to plan	Using 2mm thick plywood, which is supported by wood, some of it is not according to plan (skewed),	There are several points at which

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			and the wood supporting it is not strong enough, so it falls off.	pregnant concrete.
3.	Connecting the old road and the new road	The spokes or dowels must be placed perpendicular to the road axis and must be installed firmly in the specified position so that the pressure on the concrete does not disturb its position. Tie bars must be made from threaded steel rods that meet reinforcement specifications, have a have a minimum quality of BJTU-24, and have a minimum diameter of 16 mm.	Do not use spokes, dowels, or tie rods or tie bars.	The resulting concrete becomes susceptible to shifting because there is nothing to resist shifting both vertically and horizontally.
4.	Slump Test	- Done immediately after the mixer truck arrives at the location. - It is declared to meet the requirements if the concrete decreases 8–12 cm from the height of the cone mold in one trial. - The cone mold is removed vertically in one slow movement. - Rojokan is done between 25 and 30 times.	- Carried out 30 minutes to 1.5 hours after the mixer truck arrives at the location. - Decrease the concrete by 8–12 cm from the height of the cone mold with 2-3 attempts and hitting the plate several times so that the results are satisfactory. - The cone mold is removed by rotating the cone. - Rojokan is done less or more than 25–30 times.	The slump test results are not in accordance with the original conditions in the field.
5.	Concrete compaction	This is done by giving vibrations to remove any air that is inside using a vibrator on each side evenly.	Vibrators are not always available and do not always function well, so not all sides are given vibrations to expel the air inside.	There are air cavities found in the casting results.
6.	Concrete maintenance	- The entire concrete surface is covered with cloth. - Distillation is carried out consistently and using tools so that the same amount of water comes out on each side.	- Not all concrete surfaces can be covered by cloth. - Distillation is not done consistently, and tools are not used so that the amount of water that comes out on each side is different.	Water content becomes uneven.

CONCLUSION

The following are the conclusions that can be drawn based on the results of the analysis carried out:

1. Some of the SOPs carried out on this road work project are not in accordance with the established SOP standards, such as for subgrade compaction, connecting old roads and new roads, formwork installation, slump testing, concrete compaction, and also concrete maintenance.
2. The CBR results of the base soil meet the standard, namely more than equal to 6%, while the majority of compressive strength test results and flexural strength calculation results do not meet the established standards.
3. The work process carried out based on the correct SOP standards can produce quality that is in accordance with what has been determined, whereas if the SOP carried out does not comply with the workmanship standards, it can produce quality that does not comply with what has been determined.

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