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The Effect of Hot Sun on the Compressive Strength of Concrete on the Sukoharjo – Hargosari Road Section

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A B S T R A C T

This study discusses how much influence the hot sun has on the strength of concrete. Concrete is widely used in construction, because it is cheap and easy to implement. Still, it also requires extensive knowledge regarding the nature of the basic concrete material, how to make it, and when to lay it so that it can produce maximum quality and quality when the concrete is laid. The research aims to find out how much influence the hot sun during casting has on the compressive strength of concrete. In this research, test specimens were made for the concrete mixture with a design compressive strength of f'c = 20 MPa, using a cylinder with a diameter of 15 cm and a height of 30 cm, and strength testing. press approach using hammer test. Casting was carried out in the morning, afternoon, and evening with different types of sunlight on one road section. The results of this research show that the hot sun during casting affects the compressive strength of the concrete produced. The heat of the sun is too hot, causing the concrete that is laid to crack easily and its compressive strength is low even though the concrete has been covered with geoteck and watered regularly.

1. Introduction

Concrete is a material that is generally needed by society for infrastructure facilities which are increasing along with the times [1]. This is the thing that causes concrete as a building material to remain the main choice of planners in designing and planning civil engineering buildings [2]. The choice of concrete as the main raw material for construction is very important. Several things that need to be considered in making concrete are that the price is relatively cheap, the material is easy to obtain, has high compressive strength and is resistant to environmental factors

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With the level of people's economic needs increasing day by day, they have to think about creating alternative solutions to meet these economic needs. One of the things they have to pay attention to is the cost of construction. This is a basic and fundamental problem because it must be supported by several elements, especially material matters [3]. We need to know that material prices are increasing every day in line with high economic needs.

The people of Wonogiri experienced incidents like this, where the price level for materials for sand and crushed stone was getting higher. This is because the material used, especially the sand, is Merapi sand. For the upper economic community, perhaps this is not a problem, but for the lower middle economic level, they think twice about using this sand. This is because the price of Merapi sand can reach four times the price of local sand with the same volume [4]. The quality of Merapi sand itself has been tested, but for local sand they use experience by seeing what has been done before. So research is needed to determine the quality of the material. Some things to consider in concrete with local aggregate are:

1. The quality and quantity have not been tested.
2. The compressive strength of the concrete may not produce the results they expected.
3. Mud content which may affect the quality of the concrete.
4. The problem of mix design/proportion to obtain a certain quality with adequate feasibility needs to be researched.

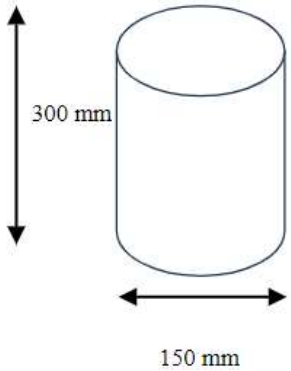
This research is located in Sukoharjo Village and Hargosari Village, Tirtomoyo District, Wonogiri Regency, where this area is a highland area with different heat from the sun between segment 1 and segment 2. This research aims to find out how much compressive strength of the concrete has when it is exposed to different types of solar heat .

2. Research Method

The method used in making this final assignment is literature study. The literature study was carried out by reading journals or references regarding concrete compressive strength quality analysis [5], the research object was the Sukoharjo Hargosari road construction project, and the data obtained were the Cost Budget Plan (RAB), Working Drawings, technical specifications, job mix design [6].

3. Description and Technical

This research was carried out by testing concrete cylinders in the laboratory and also using an approach using a hammer test [7], [8], [9]. The sample used is a cylinder with a diameter of 15 cm and a height of 30 cm [10]. With the expected concrete quality, namely K-250.



Source : Excel 2021

Figure 1. Cylinder Test 150 mm x 300 mm

All aggregate materials in this research are standards that have been required in the technical specifications for the work. Where the gravel used comes from Karangturi, the sand uses Merapi sand and Nguneng Puh Pelem sand, Wonogiri Regency. This aggregate is often used in construction projects, both buildings and roads, in Wonogiri Regency [11].

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The Portland cement used is OPC type I cement because it is easily available on the market and the quality falls within the specified specifications .

The water used is water that comes from a spring in the village. The water is used to mix the concrete ingredients as well as a maintenance medium for the concrete so that it doesn't crack easily [12], [13], [14]

The testing stages are carried out in 2 ways, namely with a compressive strength machine and a hammer test [6], [15]. With the following steps.

The general research stages are as follows :

a. Measuring materials for concrete quality fc'≤ 20 Mpa. All material components must be measured by weight. If cement is used in zak packaging, the measuring quantity must be such that the quantity of cement used is equivalent to one unit or whole of the number of cement zak.
b. Aggregates must be weighed separately. The total dosing weight must not exceed the capacity of the mixing tool.
c. After the mixture is mixed evenly, the mixture is subjected to a slump test first. This activity is carried out so that all the concrete used meets workability.
d. Next, part of it is put into a cylindrical mold to test the compressive strength of the concrete .
e. The concrete tested was aged 7, 14, 21 and 28 days [5].
f. The hammer test is carried out on concrete that has been laid and is at least 14 days old

Compressive strength machine testing steps [7]:

a. Record the dimensions of the test object, namely its diameter and height.
b. Weigh the test object.
c. Install the strain gauge at the specified position for 28 days.
d. Place the test object on the compression machine, then turn it on and gradually load it until the cylinder collapses [16].
e. Record the maximum load that occurs, when the test object is destroyed.
f. Record the strain, especially for compressive strength testing until it reaches maximum loading.

Test steps with hammer test [17]:

a. Touch the tip of the launcher on the surface of the test point with a position perpendicular to the test plane.
b. Slowly press the concrete hammer in a direction perpendicular to the test plane until a blow occurs at the test point.
c. Perform 16 blows at one location of the test plane with the closest distance between the blow points of 25 mm.
d. Record the compressive strength value read on the tool.

After making samples and testing the compressive strength of concrete with a compressive strength machine and hammer test, the results of the concrete quality are observed and entered into the test results. We can enter the test results into a table to get the results of the effects of solar radiation on the compressive strength of concrete [18], [19], [20]. The effect of the hot sun on the compressive strength of concrete is then analyzed with the planned job mix design can meet the expected concrete quality [21], [22]. Whether if the specified mix design requires additional materials in the concrete mixture. From the test tables a graph is made to draw final conclusions.

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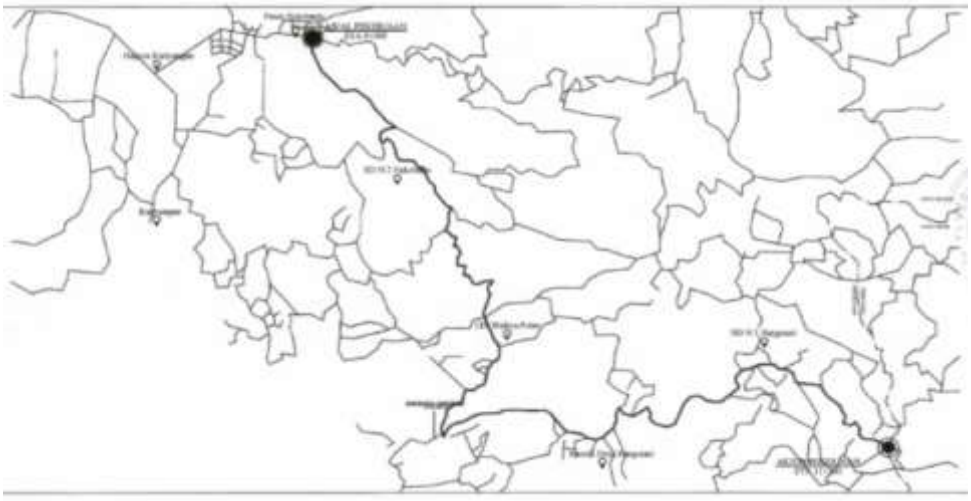
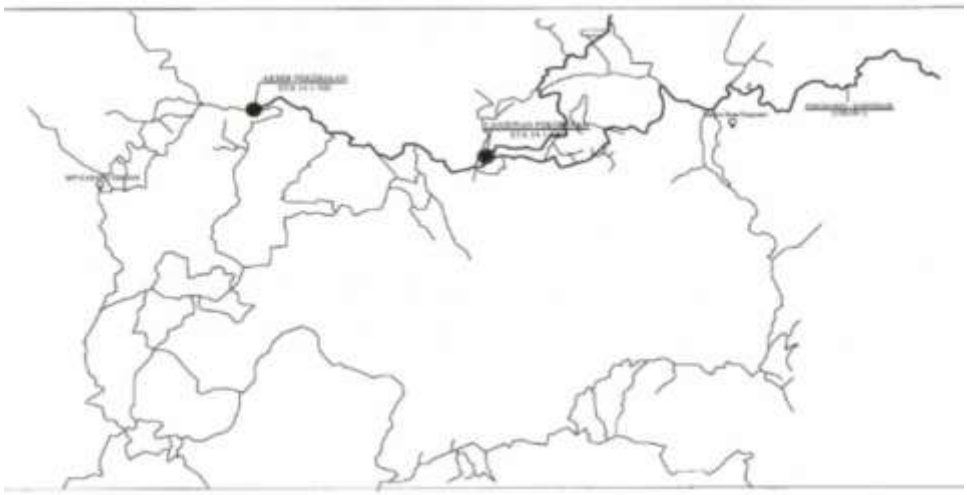
4. Results and Discussions

The Sukoharjo – Hargosari Road section is one of the connecting access points between Tirtomoyo District, Wonogiri Regency – Arjosari District, Pacitan Regency.



Source : Asbuilt of Street Sukoharjo - Hargosari
Figure 2. Street Sukoharjo Hargosari Segment 1



Source : Asbuilt of Street Sukoharjo - Hargosari
Figure 3. Street Sukoharjo Hargosari Segment 2

Concrete compressive strength testing is carried out according to predetermined variations, namely 7 days, 14 days, 21 days, and 28 days. From the results of research in the field, the compressive strength values of concrete were obtained as follows:

We can see the solar temperature in Tirtomoyo sub-district in table 1 as follows

Table 1. Tirtomoyo district air temperature July - December

Air Temperature	Month					
	July	August	September	October	November	December
Above Normal	33,42°C	34,30°C	35,10°C	35,70°C	34,90°C	35,10°C
Normal	27,82°C	26,50°C	27,70°C	29,60°C	30,00°C	29,40°C

Source : Tirtomoyo Regency Central Statistics Agency

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The following are the results of testing the compressive strength of concrete in normal sunlight:

Table 2. Compressive strength of concrete under normal sunlight

No	Age (day)	Burden (KN)	compressive load (MPa)	Age Factor (f)	compressive strength 28 days old Cylinder (MPa)	cube (Kg/cm2)
1	7	370	20,95	0,65	32,23	388,29
2	7	335	18,97	0,65	29,18	351,58
3	7	430	24,35	0,65	37,45	451,26
4	14	390	22,08	0,88	25,09	302,31
5	14	400	22,65	0,88	25,74	210,06
6	14	405	22,93	0,88	26,06	313,94
7	21	500	28,31	0,95	29,80	359,02
8	21	490	27,74	0,95	29,20	351,84
9	21	505	28,59	0,95	30,10	362,61
10	28	510	28,87	1,00	28,87	347,89
11	28	465	26,33	1,00	26,33	317,19
12	28	500	28,31	1,00	28,31	341,07

Source : Laboratorium PT. Tri Jaya Cipta Makmur

Testing the compressive strength of concrete using a hammer test. From the results of research in the field, the compressive strength values of concrete were obtained as follows:

Table 3. Average compressive strength of hammer test in normal sunlight

No	Compressive Strength Value			
1	31	29	29	27
2	34	30	30	29
3	28	28	28	28
4	28	26	27	29

Source : field test hammer shot results

From table 2 and table 3 we can see that fresh concrete that is spread in normal hot sun conditions has a compressive strength above 20 Mpa, which is in accordance with the expected technical specifications. Even with the right mix design mixture, it is able to obtain good concrete quality. with the highest value at the age of 28 days, namely 28,87 MPa and the lowest 26,33 MPa.

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With the road conditions we can see in Figure 4 as follows

Figure 4. Concrete condition in normal sunlight
Source : Personal documents

The following are the results of testing the compressive strength of concrete in abnormal sunlight:

Table 4. Compressive strength of concrete in the sun abnormal

No	Age (day)	Burden (KN)	compressive load (MPa)	Age Factor (f)	compressive strength 28 days old Cylinder (MPa)	cube (Kg/cm2)
1	7	265	15,00	0,65	23,08	278,10
2	7	250	14,15	0,65	21,78	262,36
3	7	235	13,31	0,65	20,47	246,52
4	14	325	18,40	0,88	20,91	251,92
5	14	340	19,25	0,88	21,87	263,55
6	14	345	19,53	0,88	22,20	267,43
7	21	450	25,48	0,95	26,82	323,12
8	21	460	26,04	0,95	27,41	330,30
9	21	420	23,78	0,95	25,03	301,58
10	28	425	24,06	1,00	24,06	289,91
11	28	450	25,48	1,00	25,48	306,96
12	28	445	25,19	1,00	25,19	303,55

Source : Laboratorium PT. Tri Jaya Cipta Makmur

Testing the compressive strength of concrete using a hammer test. From the results of research in the field, the compressive strength values of concrete were obtained as follows :

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Table 5. Average compressive strength of hammer test in hot sun abnormal

No	Compressive Strength Value			
1	25	23	25	25
2	25	26	25	26
3	25	25	25	27
4	26	27	26	26

Source : field test hammer shot results

After testing and the results can be seen in table 4 and table 5 where we can see that the concrete that was laid at abnormal sun temperatures experienced a decrease in compressive strength compared to the concrete that was laid at normal temperatures. Where the highest compressive strength was 25.48 MPa and the lowest was 24.06 MPa at the age of 28 days. which resulted in the concrete experiencing quite a lot of hairline cracks because it experienced a fairly rapid reduction in water.

Figure 5. Concrete condition with abnormal sunlight
Source : Personal documents

Based on the research results, it can be seen that the compressive strength value of concrete spread at normal temperature can reach the expected compressive strength. Of course, this is included in the required criteria because the work mix planning is fc'20. Where even if it is spread in normal or abnormal sunlight, the quality of the concrete can be achieved with the appropriate mixture ratio and good concrete maintenance. such as the results we can see in table 2 and table 4

5. Conclusion and Suggestion

5.1 Conclusion

The conclusions of the research are as follows:

a. The compressive strength value of concrete is affected by the heat of the sun during the concrete spreading process. Concrete that is spread under the hot sun with a temperature above 35°C (spreading segment 1) has a concrete quality that is less than expected because the hot sun reduces the water content in the concrete. In addition, it causes the concrete to crack easily even though it has been coated with geotech and watered regularly. At normal temperatures, the quality of concrete at the age of 28 days is 28.87 MPa, 26.33 MPa, and 28.31 MPa, while concrete at abnormal sun temperatures is 24.06 MPa, 25.48 MPa, and 25.19 MPa.

b. Concrete spread in segment 2 at a temperature of ±28-32°C has a compressive strength that meets the target and rarely experiences hairline cracks.

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5.2 Suggestion

In this research, several obstacles were found which resulted in the results obtained not being completely accurate. So it's a good idea to pay attention to the following things:

a. The process of mixing the ingredients is always consistent, with the weight of each ingredient following the existing mix design to maintain uniformity and the same treatment.
b. When spreading concrete, always check the temperature of the hot sun to ensure that the concrete being spread is of the same quality.
c. Made with additional additives if necessary so that concrete placed in the hot sun does not dry out and crack easily.
d. Similar research was carried out by adding or using other compressive strength testing methods.

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