INVESTIGATION OF
COARSE AGGREGATE SPECIAL GRADATION
ON CONCRETE STRENGTH

Submitted as partial for filling the requirement for bachelor degree
of Civil Engineering Program Engineering Faculty

By:

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MUHAMMADIYAH SURAKARTA UNIVERSITY
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INVESTIGATION OF COARSE AGGREGATE SPECIAL GRADATION ON CONCRETE STRENGTH

Abstrak

Perkembangan teknologi beton yang meningkat dari waktu ke waktu dan banyaknya pengguna beton dalam bidang konstruksi membuat upaya untuk menciptakan mutu beton yang baik dan ekonomis. Salah satu upaya untuk meningkatkan kuat tarik beton yaitu dengan menggunakan gradasi khusus pada agregat kasar (kerikil). Agregat kasar (kerikil) merupakan material beton yang memiliki strength tinggi dan memberikan kontribusi volume paling besar dalam komposisi beton. Komposisi ini harusnya agregat kasar (kerikil) mampu memberikan kontribusi yang optimal pada beton. Gradasi khusus pada agregat kasar (kerikil) merupakan gradasi dengan berbagai ukuran tertentu sehingga masa beton dapat berfungsi sebagai beton yang utuh dan padat, dimana agregat kasar (kerikil) dengan butiran lebih kecil dapat mengisi celah yang ada diantara agregat kasar (kerikil) dengan butiran yang lebih besar. Berdasarkan uraian di atas, tugas akhir ini menggunakan gradasi agregat kasar (kerikil). Ada 3 macam kriteria agregat kasar (kerikil) yang digunakan dibagi menjadi beton normal, gradasi agregat A, dan gradasi agregat B dengan perbandingan uji kuat tekan beton pada 7 hari, 14 hari, 21 hari dan 28 hari. Hasil penelitian menunjukkan bahwa rata-rata kuat tekan beton maksimum adalah 25,67 MPa yang terdapat pada gradasi agregat B dengan umur beton 28 hari. Hal ini menunjukkan bahwa dengan banyaknya variasi gradasi agregat kasar (kerikil) dapat mengisi celah kecil pada campuran beton dibandingkan dengan beton yang hanya memiliki satu variasi ukuran agregat kasar (kerikil).

Kata Kunci: Agregat Kasar (Kerikil), Beton, Gradasi Agregat

Abstract

The development of concrete technology that increases over time and the number of concrete users in the field of construction make an effort to create a good and economical concrete quality. One attempt to increase the tensile strength of concrete is by using special gradations on coarse aggregates (gravel). Coarse aggregate (gravel) is a concrete material that has high strength and contributes the greatest volume in the concrete composition. This composition should be a coarse aggregate (gravel) capable of contributing optimally to the concrete. Gradation specifically in coarse aggregate (gravel) is a gradation with a certain size range so that the future of concrete can serve as a concrete intact and solid, in which the coarse aggregate (gravel) with grains smaller to fill the gap that exists between the coarse aggregate (gravel) with grain greater than. Based on the explanation above, this final project uses coarse aggregate (gravel) gradations. There are 3 kinds criteria of coarse aggregate (gravel) used divided into normal concrete, gradation A, and gradation B with comparison of concrete compressive strength test at 7 days, 14 days, 21 days and 28 days. The results of the study showed that the

average maximum concrete compressive strength was 25,67 MPa which was found in gradation B with 28 days of concrete. This shows that with the many variations of coarse aggregate (gravel) gradations can fill a small gap in the concrete mixture compared to concrete which only has one variation of coarse aggregate (gravel) size.
Keywords: Aggregate Gradation, Coarse Aggregate (Gravel), Concrete

1. INTRODUCTION

1.1 Background

Concrete is the most important thing in a construction. Almost every aspect of development cannot be separated from a concrete. As an example of a construction work on roads, buildings, bridges and other construction work, almost all of these work structures or other works are of course made of concrete, so it can be concluded that all structural work or other construction work cannot be separated from the presence of a concrete. Concrete is a composite material comprising coarse and fine aggregates mixed with water and cement as a binder and filler between coarse and fine aggregates, sometimes added additive or admixture when necessary (Subakti, 1995).

The development of concrete technology that increases over time and the number of concrete users in the field of construction make an effort to create a good and economical concrete quality. One attempt to increase the tensile strength of concrete is by using special gradations on coarse aggregates (gravel).

Coarse aggregate (gravel) is a concrete material that has high strength and contributes the greatest volume in the concrete composition. This composition should be a coarse aggregate (gravel) capable of contributing optimally to the concrete. Gradation specifically in coarse aggregate (gravel) is a gradation with a certain size range so that the future of concrete can serve as a concrete intact and solid, in which the coarse aggregate (gravel) with grains smaller to fill the gap that exists between the coarse aggregate (gravel) with grain greater than.

Therefore, the authors conclude to use a coarse aggregate material (gravel) as the material to be made of special gradation. The existence of this

special graded research concrete, it is hoped that the possibility to design a structural element with a higher value of compressive strength.

1.2 Formulation of The Problem

Based on the background explanation of the research, it can be formulated some problems as follows:

1. What is the ratio of compressive strength of aggregate concrete to specific graded with conventional graded concrete compressive strength?
2. What is the correlation between the coarse aggregate (gravel) compositions to the strength of the concrete?

1.3 Purposes of Research

The purposes of research in this study are as follows:

1. To find out the result of compressive strength ratio of granular aggregate concrete (gravel) with a special graded with conventional graded concrete compressive strength.
2. To know the correlation between the aggregate composition (gravel) to the strength of the concrete.

1.4 Benefits of Research

The benefits of this research include the following:

1. Know the correlation between the aggregate compositions (gravel) to the strength of the concrete.
2. Know the shortcomings and excesses of special graded concrete on coarse aggregates (gravel).
3. Providing benefits in the world of education and knowledge in the field of civil engineering especially regarding special graded concrete.

1.5 Limitation of Research

This research in order to be focused and in accordance with the purpose of the study then given the boundaries of the problem include:

1. The research was conducted at the Civil Engineering Laboratory of Muhammadiyah University of Surakarta.
2. Fresh concrete tests include:d
   a) Slump Test

3. Hard concrete tests include:
    a) Compressive Strength Test
4. Test objects used in this study include:
    a) Testing the compressive strength of the cylinder with a diameter of 15 cm and 30 cm in height.
5. Cement used is Portland cement with brand Holcim.
6. Water used from the Laboratory of Civil Engineering University of Muhammadiyah Surakarta.
7. Fine aggregate (sand) used is sand originating from Mount Merapi.
8. Coarse aggregates (gravel) used are gravels with a maximum gradation size of 20 mm from Mount Merapi.
9. The quality of concrete (f'c) planned in this study is 22 MPa.
10. The compressive strength test was performed at 7, 14, 21, and 28 days concrete.
11. Using the value of water cement ratio (fas) of 0,40.
12. Method of design of concrete mixture in this research using ACI method.

1.6 Test Objects

To minimize the scope of the research and form aggregates desired proportion, then it will only be used 4 coarse aggregate size described as follows:

Table 1. Aggregate Dimension Criteria

Code	Sieve	
	Passed	Failed
I	25,40	19,00
II	19,00	12,70
III	12,70	9,52
IV	9,52	4,75

In this research, I + II aggregate as the main aggregate with initial percentage is 100% (Table I). Gradually added percentages of III and IV aggregates are assumed as filler aggregates into the aggregate gradation composition of I + II (Wirawan, 2015).

Table 2. Explanation Percentage of Aggregate Gradation

Percentage of Aggregates (%)			
No.	I (25,40 - 19,00) + II (19,00 - 12,70)	III (12,70 - 9,52)	IV (9,52 - 4,75)
N	100	0	0
A	80	15	5
B	50	30	20

Based on the explanation of the percentage of aggregate gradation, the specimen is divided into 3 criteria.

Table 3. Totals of Research Objects

Testing	Aggregate Criteria	Total of Test Objects			
		7 Days	14 Days	21 Days	28 Days
Concrete Compressive Strength	Normal	3	3	3	3
	A	3	3	3	3
	B	3	3	3	3
Total		9	9	9	9

2. RESEARCH METHODS

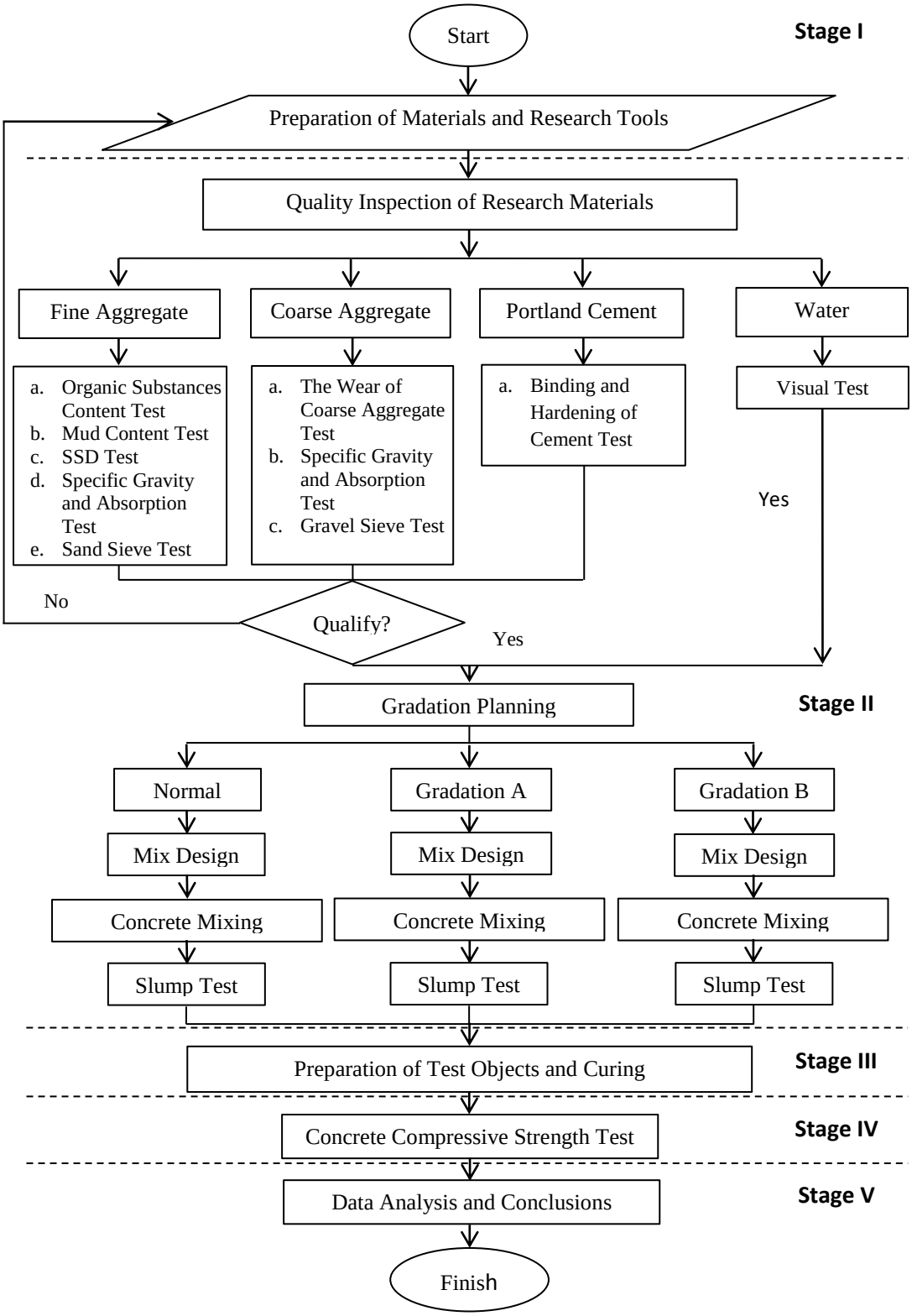

Figure 1. Flow Chart of Research

3. RESULTS AND DISCUSSION

3.1 Testing Material

3.1.1 Testing of Fine Aggregate

Testing of fine aggregate includes organic substances content, mud content, saturated surface dry, specific gravity and absorption, and sand gradation. The results of the fine aggregate test obtained during the test can be seen in table 4 and the complete test data is contained in the appendix.

Table 4. The Results of Fine Aggregate Testing

Type of Testing	Test Result	Requirement SNI 03-6821-2002	Information
Organic Substances Content	No. 2 (Brownish Yellow)	No. 1 – 3	Qualify
Mud Content	2,95%	5%	Qualify
Saturated Surface Dry	3,76	Half of The Cone Height	Qualify
Specific Gravity	2,50	2,50 – 2,70 gram/cm^3	Qualify
Absorption	3,31%	1% – 2%	Not Qualify
Fine Grain Modulus	3,77	1,50 – 3,80	Qualify

The results of fine aggregate testing in the above table can be explained as follows:

a) Test results of organic substances content in sand by adding 3% NaOH solution, silenced for 24 hours, and using hellige tester tool obtained colour number 2 (brownish yellow). In the limits of colour 1 to 3 show that the sand does not contain many organic substances and feasible to be used as a mixture of concrete because of the organic material in the sand will affect the quality of concrete. If the test results exceed the colour number 3, then the sand is not suitable for use as a mixture of concrete mixture, so the sand must be replaced with new sand.

b) Test results of the mud content showed 2,95% to meet the requirements in accordance with SNI 03-6821-2002. The intended requirement is a fine aggregate as a mixture of concrete mixture should not have a mud content of more than 5%. If the mud content exceeds 5%, then the sand must be washed or replaced with new sand.

c) To achieve a saturated surface dry state in the sand, the peak sand drop should be approximately half the height of the cone. In this test obtained average sand reductions of 3,76 cm, while the height of the sand at first 7,50 cm. This condition proves that the sand is in a state of saturated surface dry. If the sand has not reached half the height of the sand cone, the sand needs to be aerated before being used to allow the sand to reach a saturated surface dry state.

d) Based on the specific gravity, fine aggregate is divided into 2 kinds of lightweight aggregates (having a specific gravity of less than 2,00 gram/cm^3) and normal aggregate (having a specific gravity of 2,50 – 2,70 gram/cm^3). The results of fine aggregate testing obtained by sand density 2,50 gram/cm^3. Thus it can be concluded that this sand belongs to a normal aggregate. If the specific gravity of the sand exceeds that required, the sand shall be replaced with new sand.

e) Aggregate absorption affects the amount of water in the planned mixture. As large as the absorption, the amount of water used in the mixture decreases. The aggregate absorption requirements used in the concrete mix between 1% – 2%. From the results of the tests obtained sand absorption value of 3,31%. This shows that the absorption of sand exceeds the required limit, so before the preparation of the aggregate mixture it must be moistened with water in advance so that when mixing not much water is absorbed into the aggregate or does not increase the water requirement in the mixture.

f) The result of sand gradation test obtained by fine modulus of grain 3,77. In general, sand has a fine modulus value between 1,50 – 3,80 grains. Since the fine modulus of the sand grains used is within the limits of the

fine module of the grains in general, the sand is eligible for use as a constituent material. If the sand exceeds the required limit, then the sand must be replaced with new sand.

The results of complete aggregate gradation testing in accordance with the requirements of ASTM C33-97 can be seen in table 5.

Table 5. The Results of Fine Aggregate Gradation

No.	Sieve Size (mm)	Weight of Sand (gr)	Corrected Sand Weight (gr)	Sand Percentage Left Behind (%)	Cumulative Percentage (%)		Area (II)
					Left Behind	Passed	
1	9,50	0,00	0,00	0,00	0,00	100,00	100
2	4,75	0,00	0,00	0,00	0,00	100,00	90 – 100
3	2,36	104,00	104,00	23,11	23,11	76,89	75 – 100
4	1,18	49,00	49,00	10,89	34,00	66,00	55 – 90
5	0,60	84,00	84,00	18,67	52,67	47,33	35 – 59
6	0,30	105,00	105,00	23,33	76,00	24,00	8 – 30
7	0,15	70,00	70,00	15,56	91,56	8,44	0 – 10
8	Pan	38,00	38,00	8,44	100,00	0,00	-
Σ		450,00	450,00	100,00	377,33	422,67	

Based on table 5 the results of fine aggregate gradation testing can be described with gradation graph as follows:

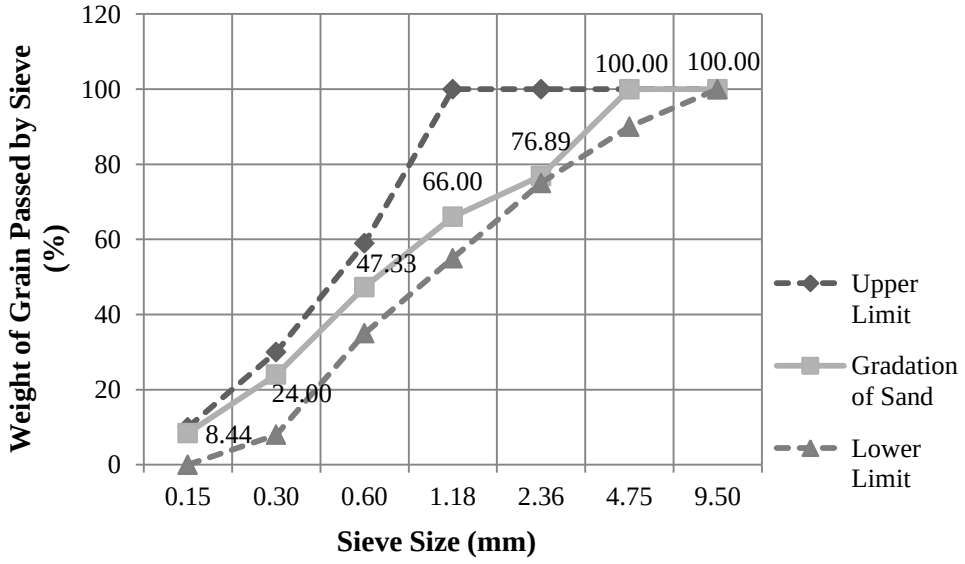

Figure 2. Fine Aggregate Gradation

3.1.2 Testing of Coarse Aggregate

Testing of coarse aggregate includes the wear of coarse aggregate, specific gravity and absorption, and gravel gradation. The results of the coarse aggregate test obtained during the test can be seen in table 6 and the complete test data is contained in the appendix.

Table 6. The Results of Coarse Aggregate Testing

Type of Testing	Test Result	Requirement SNI 15-1990-03	Information
The Wear of Coarse Aggregate Test	25%	40%	Qualify
Bulk Specific Gravity	2,66	2,50 – 2,70 gram/cm^3	Qualify
Absorption	3,27%	< 3%	Not Qualify
Fine Grain Modulus	7,28	5 – 8	Qualify

The results of coarse aggregate testing in the above table can be explained as follows:

a) The results of coarse aggregate wear test from Mount Merapi obtained 25%. This indicates that gravel can be used as a mixture of concrete, because it has a grain violence that still exists within the limits specified. If the wear of coarse aggregate exceeds 40%, then the coarse aggregate unfit for use and must be replaced with coarse aggregate from other areas.

b) The result of gravel density test used in this research is 2,66 gram/cm^3, it can be concluded that the coarse aggregate is included between the normal aggregates (2,50 gram/cm^3 – 2,70 gram/cm^3). If the specific gravity of the coarse aggregate exceeds that required, the coarse aggregate shall be replaced with coarse aggregate from the other region.

c) Gravel used in this research has the absorption of 3,27%, the coarse aggregate is not fit for use as a concrete mixture for absorption value exceeds 3%. This indicates that the gravel has a high absorption, so that

the gravel needs to be moistened with water to be used as a concrete mixture.

d) The result of gravel gradation test obtained by fine modulus of grain 7,28. In general, gravel has a fine modulus value between 5 – 8 grains. Since the fine modulus of the gravel grains used is within the limits of the fine module of the grains in general, the gravel is eligible for use as a constituent material. If aggregate gradation exceeds that required, the coarse aggregate shall be replaced with coarse aggregate from the other region.

The calculation of gradation of gravel can be seen in table 7 and for more details can be seen in the appendix.

Table 7 The Results of Coarse Aggregate Gradation

No.	Sieve Size (mm)	Weight of Gravel (gr)	Corrected Gravel Weight (gr)	Gravel Percentage Left Behind (%)	Cumulative Percentage (%)		Maximum Grain Percent (20 mm)
					Left Behind	Passed	
1	25,00	0,00	0,00	0,00	0,00	100,00	100
2	19,00	15,00	15,00	1,68	1,68	98,32	95 – 100
3	12,50	392,00	392,00	43,80	45,47	54,53	25 – 55
4	9,50	405,00	405,00	45,25	90,73	9,27	0 – 10
5	4,75	33,00	33,00	3,69	94,41	5,59	-
6	2,36	25,00	25,00	2,79	97,21	2,79	-
7	1,18	13,00	13,00	1,45	98,66	1,34	-
8	0,60	7,00	7,00	0,78	99,44	0,56	-
9	0,30	5,00	5,00	0,56	100,00	0,00	-
10	0,15	0,00	0,00	0,00	100,00	0,00	-
11	Pan	0,00	0,00	0,00	100,00	0,00	-
Σ		895,00	895,00	100,00	727,60	272,40	

Based on table 7 the results of coarse aggregate gradation testing can be described with gradation graph as follows:

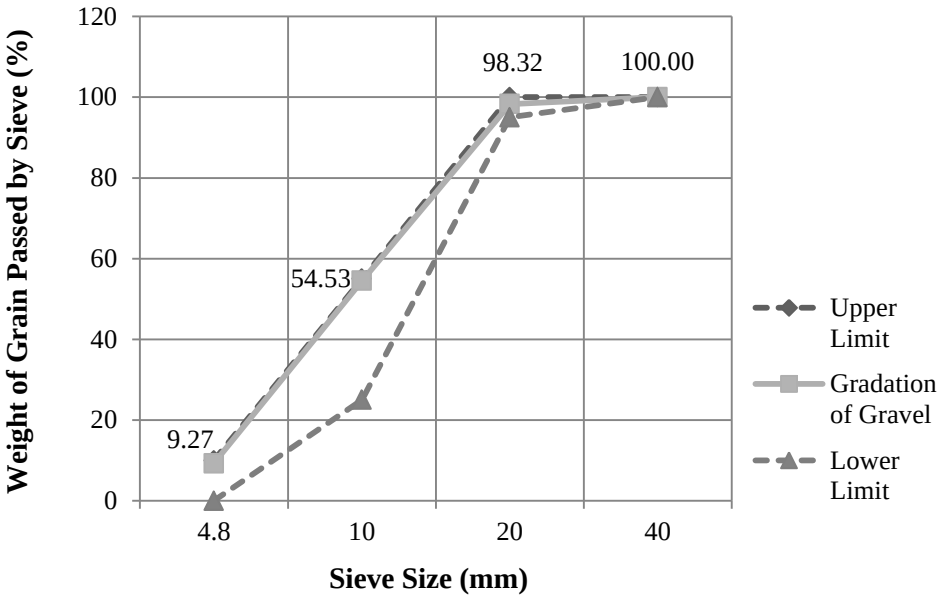

Figure 3. Coarse Aggregate Gradation

3.1.3 Testing of Cement

Testing of cement include binding and hardening of cement test. The results complete test data of the cement test obtained during the test can be seen in table 8 as follows:

Table 8. The Results of Binding and Hardening of Cement Test

Trial	1	2	3	4	5	6	7	8	9
Time (Minutes)	0	15	30	45	60	75	90	100	120
Decrease (mm)	50,0	43,0	40,5	37,5	37,0	36,5	36,0	35,5	35,0

Based on table 8 the results of binding and hardening of cement testing can be described with graph as follows:

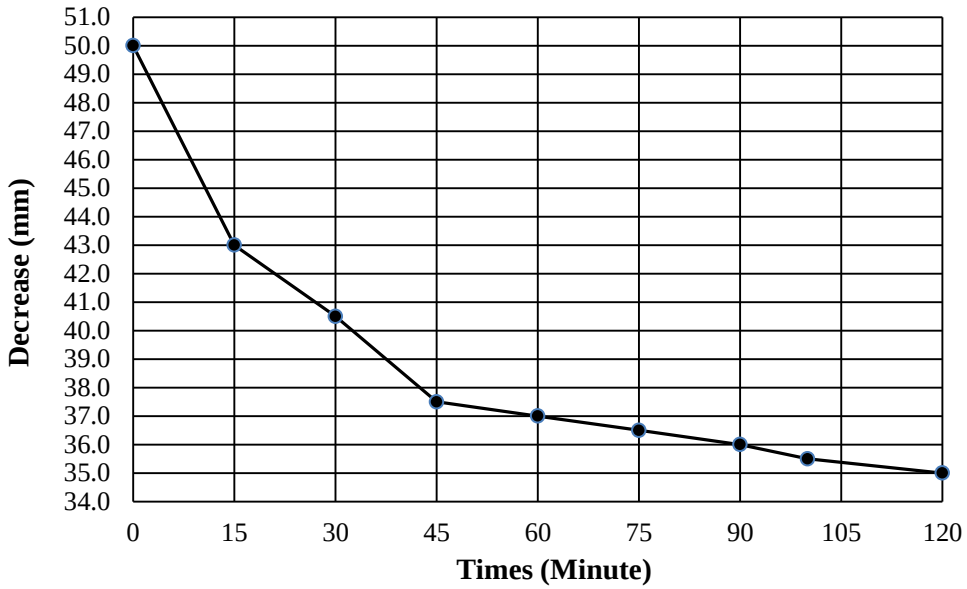

Figure 4. Binding and Hardening of Cement Test

From the experiments that have been carried out, the time of cement binding is 120 minutes. This shows that based on SNI 03-6827-2002 the initial binding time is at least 45 minutes after the specimen is stirred and the maximum should not exceed 480 minutes, from this it can be concluded that the cement is in good condition and in accordance with the standards.

3.2 Slump Test

The slump value test is performed before the concrete mix is poured in the mold. Slump testing is done to determine the workability and viscosity of concrete mixture that will be poured into the concrete mold.

In a concrete mixture, the moisture content is highly regarded because it determines its workability level or not. Concrete mixtures that are too liquid will cause low concrete and long drying quality. While the concrete mixture is too dry to cause uneven mixture and difficult to print.

The requirement of slump test result that slump value reached on concrete mix for concrete cylinder, that is 7,5 - 15 cm. But besides the amount of slump value, which must be considered to maintain the feasibility of fresh concrete work is the visual appearance of concrete, the type, and the nature of the collapse during slump testing is done. Slump test results can be seen in table 9.

Table 9. Test Result of Slump Mix Concrete

Variation Test Objects	Cement Water Factor	Test Object Size (cm)	Slump Value (cm)	Slump Average (cm)	Terms of Slump Test Value (PBI 1971)
Normal Concrete	0,4	Cylinder d = 15 ; h = 30	10,00	9,45	7,5 - 15 cm
			9,60		
			9,20		
			9,00		
Gradation A			10,10	9,50	
			9,50		
			9,20		
			9,20		
Gradation B			10,00	9,55	
			9,80		
			9,40		
			9,00		

Based on table 9 the results of slump mix concrete testing can be described with graph as follows:

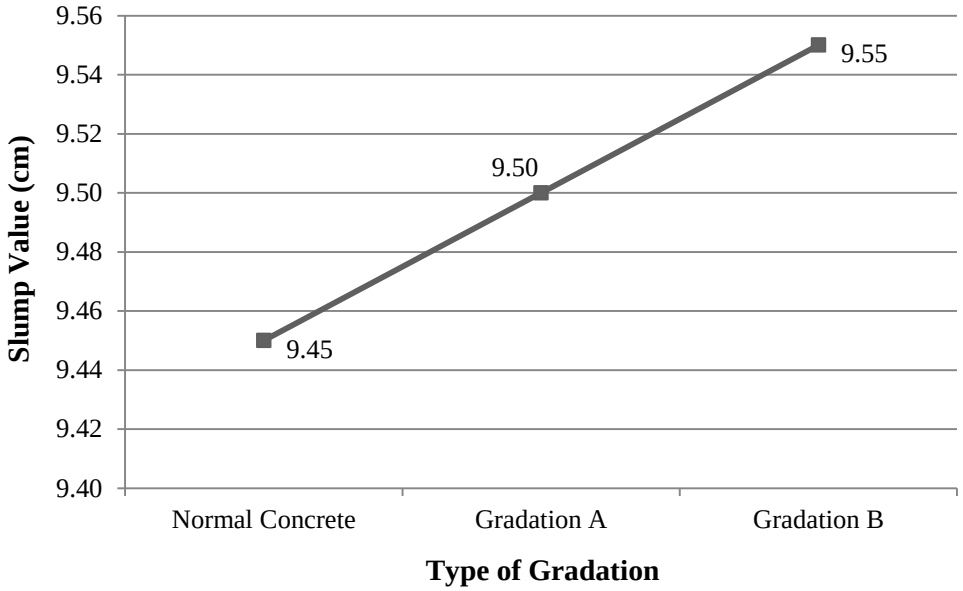

Figure 5. Slump Test

From the table of test result of slump value of concrete above, the mean slump value for cylindrical concrete is 9,45 cm, 9,50 cm, and 9,55 cm. For slump values for walls ranging from 7,5 to 15 cm, it can be concluded that the concrete mixture can be used as a concrete material.

3.3 Concrete Compressive Strength Testing

Testing of concrete compressive strength was carried out after the cylindrical test object was 7, 14, 21, and 28 days. A concrete compressive strength test was performed to obtain a compressive strength value of a concrete cylinder using a compression testing machine. The result of concrete strength test of concrete cylinder can be seen in table 10 up to table 13.

3.3.1 Test Results of Concrete Compressive Strength Test At 7 Days

The result of concrete compressive strength test on cylinder object age 7 days with diameter size 15 cm and height 30 cm can be seen in table 10 as follows:

Table 10. Test Results of Concrete Compressive Strength Test At 7 Days

Variation Test Objects	Age of Concrete	Cylinder Surface Area (A)	Maximum Load (P_{max})	Compressive Strength (f'_c)	Average Compressive Strength
		(cm^2)	(kg)	(MPa)	(MPa)
Normal Concrete	7 Days	176,63	35800	20,27	20,06
		176,63	35600	20,16	
		176,63	34900	19,76	
Gradation A		176,63	36600	20,72	20,50
		176,63	35700	20,21	
		176,63	36300	20,55	
Gradation B		176,63	36900	20,89	21,10
		176,63	37200	21,06	
		176,63	37700	21,34	

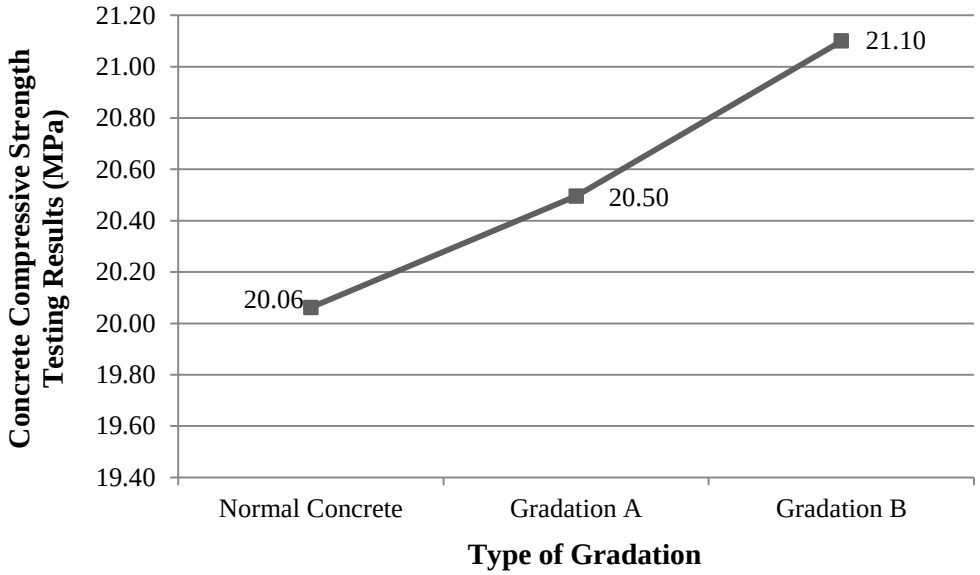

Figure 6. Concrete Compressive Strength Test (7 Days)

3.3.2 Test Results of Concrete Compressive Strength Test At 14 Days

The result of concrete compressive strength test on cylinder object age 14 days with diameter size 15 cm and height 30 cm can be seen in table 11 as follows:

Table 11. Test Results of Concrete Compressive Strength Test At 14 Days

Variation Test Objects	Age of Concrete	Cylinder Surface Area (A)	Maximum Load (P_{max})	Compressive Strength (f'_c)	Average Compressive Strength
		(cm^2)	(kg)	(MPa)	(MPa)
Normal Concrete	14 Days	176,63	38400	21,74	21,76
		176,63	38100	21,57	
		176,63	38800	21,97	
Gradation A		176,63	39600	22,42	22,14
		176,63	39000	22,08	
		176,63	38700	21,91	
Gradation B		176,63	40200	22,76	22,74
		176,63	39800	22,53	
		176,63	40500	22,93	

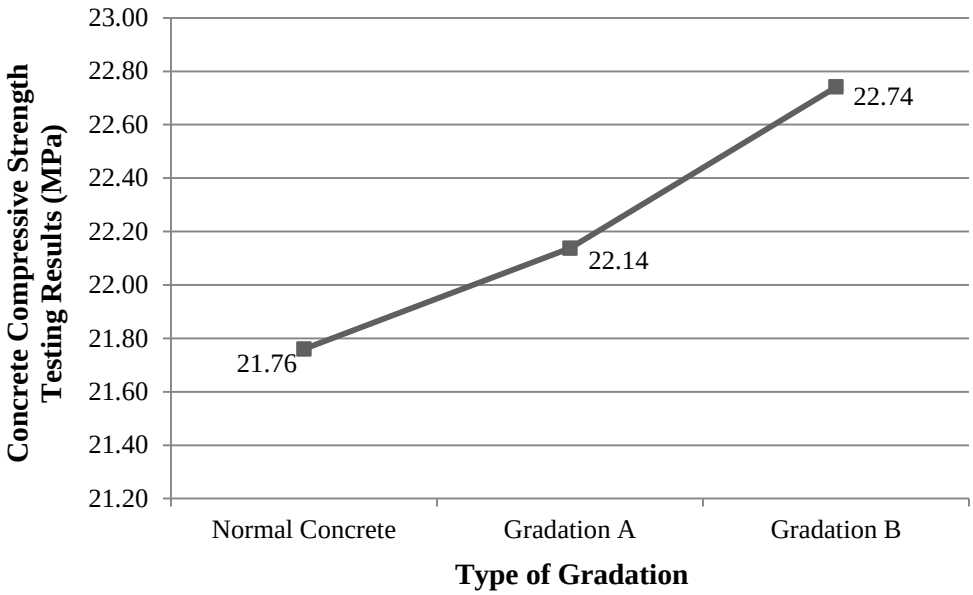

Figure 7. Concrete Compressive Strength Test (14 Days)

3.3.3 Test Results of Concrete Compressive Strength Test At 21 Days

The result of concrete compressive strength test on cylinder object age 21 days with diameter size 15 cm and height 30 cm can be seen in table 12 as follows:

Table 12 Test Results of Concrete Compressive Strength Test At 21 Days

Variation Test Objects	Age of Concrete	Cylinder Surface Area (A)	Maximum Load (P_{max})	Compressive Strength (f'_c)	Average Compressive Strength
		(cm^2)	(kg)	(MPa)	(MPa)
Normal Concrete	21 Days	176,63	40900	23,16	23,51
		176,63	41700	23,61	
		176,63	42000	23,78	
Gradation A		176,63	42200	23,89	23,67
		176,63	41900	23,72	
		176,63	41300	23,38	
Gradation B		176,63	42400	24,01	23,99
		176,63	41800	23,67	
		176,63	42900	24,29	

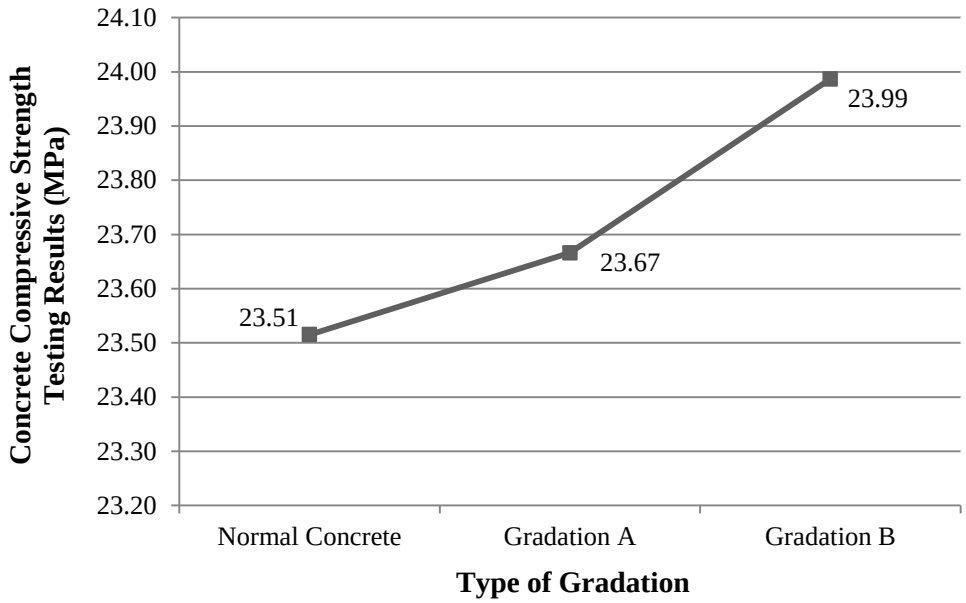

Figure 8. Concrete Compressive Strength Test (21 Days)

3.3.4 Test Results of Concrete Compressive Strength Test At 28 Days

The result of concrete compressive strength test on cylinder object age 28 days with diameter size 15 cm and height 30 cm can be seen in table 3.10 as follows:

Table 13. Test Results of Concrete Compressive Strength Test At 28 Days

Variation Test Objects	Age of Concrete	Cylinder Surface Area (A)	Maximum Load (P_{max})	Compressive Strength (f'_c)	Average Compressive Strength
		(cm^2)	(kg)	(MPa)	(MPa)
Normal Concrete	28 Days	176,63	44100	24,97	24,69
		176,63	43600	24,69	
		176,63	43100	24,40	
Gradation A		176,63	43200	24,46	24,82
		176,63	44600	25,25	
		176,63	43700	24,74	
Gradation B		176,63	45900	25,99	25,67
		176,63	44800	25,36	
		176,63	45300	25,65	

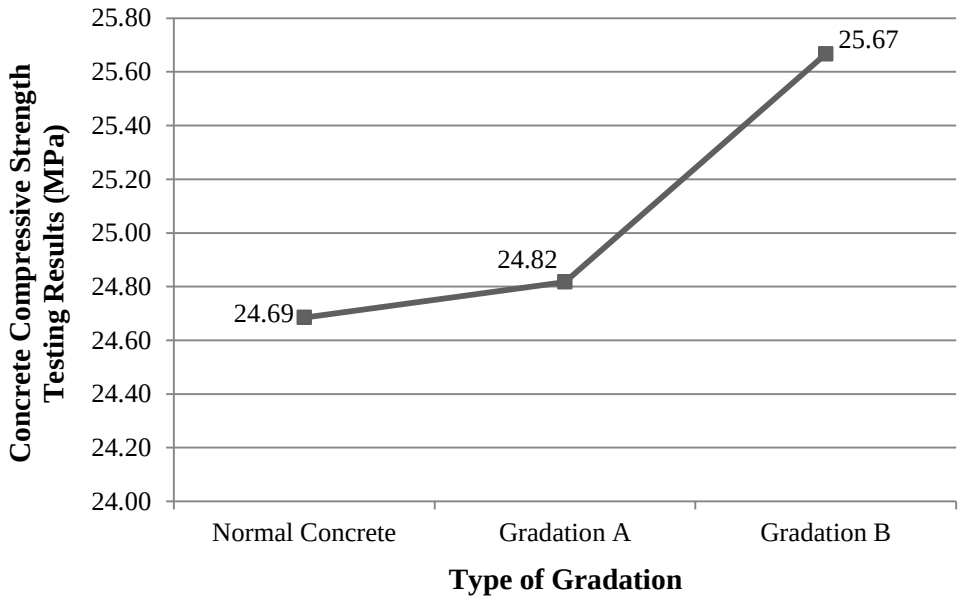

Figure 9. Concrete Compressive Strength Test (28 Days)

Based on the average of the compressive strength and the variation of the test objects can be concluded that the compressive strength maximum is 25,67 MPa in a variation of concrete B, the concrete 28 days with a variety of coarse aggregate 50% type of coarse aggregate I + II, 30% type of coarse aggregate III, and 20 % coarse aggregate type IV. This occurs because of the increasing amount of coarse aggregate used variations make concrete mixture into a solid as it can fill the empty cavities that can not be filled in concrete with coarse aggregates variation of one kind only. From the above results obtained percentage increase in the compressive strength of concrete at the concrete age of 28 days as follows:

Table 14. Compressive Strength Compare With Normal Concrete

Variation Test Objects	Compressive Strength (f'c) (28 Days)	Compressive Strength Compare With Normal Concrete (%)
Normal Concrete	24,69	-
Gradation A	24,82	0,54
Gradation B	25,67	3,98

From the percentage increase above it can be concluded that coarse aggregate (gravel) affects the increase in the compressive strength of concrete compared to normal concrete. This is because coarse aggregate (gravel) is a concrete material that has high strength and contributes the largest volume in concrete composition. Various compositions on coarse aggregates (gravel) are able to provide optimal contribution to concrete.

4. CONCLUSIONS

Based on the results of the research and discussion that has been described, it can be concluded to be among other things as follows:

1. Age of concrete treatment and coarse aggregate variations affect the compressive strength results.
2. At 7 days concrete maintenance age, the maximum average compressive strength value is 21,10 MPa obtained by variation of the test object gradation B. This is because many variations of coarse aggregate fill the cavities in the concrete mix, whereas for normal concrete only has one variant only so that there may be unevenness in the concrete mixture.
3. At 14 days concrete maintenance age, the maximum average compressive strength value is 22,74 MPa obtained by variation of the test object gradation B. This is because many variations of coarse aggregate fill the cavities in the concrete mix, whereas for normal concrete only has one variant only so that there may be unevenness in the concrete mixture.
4. At 21 days concrete maintenance age, the maximum average compressive strength value is 23,99 MPa obtained by variation of the test object gradation B. This is because many variations of coarse aggregate fill the cavities in the concrete mix, whereas for normal concrete only has one variant only so that there may be unevenness in the concrete mixture.
5. At 28 days concrete maintenance age, the maximum average compressive strength value is 25,67 MPa obtained by variation of the test object gradation B. This is because many variations of coarse aggregate fill the cavities in the concrete mix, whereas for normal concrete only has one variant only so that there may be unevenness in the concrete mixture.

Maximum compressive strength obtained at the age of 28 days with the type of gradation B.

6. The result of compressive strength compare with normal concrete is gradation A against normal concrete increased by 0,54%. While the gradation B against normal concrete increased by 3,98%. It can be concluded that coarse aggregate (gravel) affects the increase in the compressive strength of concrete compared to normal concrete. This is because coarse aggregate (gravel) is a concrete material that has high strength and contributes the largest volume in concrete composition. Various compositions on coarse aggregates (gravel) are able to provide optimal contribution to concrete.

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