Optimizing the use of natural gravel *Brantas* river as normal concrete mixed with quality fc = 19.3 Mpa

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Abstract. The use of natural gravel (rivers) as concrete mixtures is rarely encountered after days of demands for a higher strength of concrete. Moreover, today people have found High-Performance Concrete which, when viewed from the rough aggregate consisted mostly of broken stone, although the fine grain material still used natural sand. Is it possible that a mixture of concrete using natural gravel as a coarse aggregate is capable of producing concrete with compressive strength equivalent to a concrete mixture using crushed stone? To obtain information on this, a series of tests on concrete mixes with crude aggregates of *Kalitelu* Crusher, *Gondang, Tulungagung* and natural stone (river gravel) from the *Brantas* River, *Ngujang, Tulungagung* in the Materials Testing Laboratory *Tugu* Dam Construction Project, *Kab. Trenggalek.* From concrete strength test results using coarse material obtained value 19.47 Mpa, while the compressive strength of concrete with a mixture of crushed stone obtained the value of 21.12 Mpa.

1. Introduction

In general, concrete is a mixture of coarse aggregate (gravel), fine aggregate (sand), cement and water mixed with a certain ratio and molded in accordance with the planned shape. Gravel material commonly used as concrete is split (broken stone). However, in certain conditions, it takes an action where when the aggregate crushed stone is difficult to be due to the limited availability and price is relatively expensive so that the material required replacement of broken stone material using the materials available around us. Of course, with the material is still in accordance with the specifications of materials that can be used as a mixture of concrete.

1.1 Background and problems

In certain areas such as in Ngujang Village, Kedungwaru District, Tulungagung Regency, to get cracked stone material is quite difficult and the price is relatively expensive. While the availability of material of sand and gravel of nature quite a lot in the river that flows in the village. Based on the description above it can be formulated problems as follows:

a) How to plan a normal concrete mixture with the quality f'c=19.3 Mpa based on Indonesian National Standard (SNI)[1]?
b) What is the result of compressive strength achieved from mixed comparisons using rough aggregates of split rocks and by using rough aggregates of natural gravel (rivers)?

1.2 Limitation

The sand material used is obtained from mining in Brantas River, Ngujang Village, Tulungagung. Natural gravel material obtained from Brantas River, Ngujang Village, Tulungagung. Gravel is obtained from material retained in a sieve (# 4.76 mm) and passes a # 25.4 mm sieve. The broken stone material obtained from crusher machine (crusher) located in the Village Kalitelu, District Gondang, Tulungagung. The material used is Semen Gresik PPC cement production circulating on the market with 40 kg/zak packaging.
Testing of concrete material materials such as sand, crushed stone, natural gravel (rivers) and cement in accordance with Indonesian National Standard (SNI). Make concrete mix (job mix) plan with quality fc = 19,3 Mpa, based on Indonesian National Standard (SNI). Here the compiler performs two mix designs with the same mixture ratio, but for different rough aggregates. Test the compressive strength of the concrete test object that has been made in accordance with the job mix with the age of the test object 28 days.

1.3 Purpose and objectives of research

The purpose of this research are:

a) To determine the quality of natural gravel of Brantas River, Ngujang Village, Kedungwaru District, Tulungagung Regency and also the quality of crushed stone from Kalitelu crusher, Gondang District, Tulungagung District by conducting a series of material testing in laboratory based on Indonesian National Standard (SNI).
b) To determine the compressive strength of concrete reached from the natural gravel material of Brantas River, Ngujang Village, Kedungwaru Subdistrict, Tulungagung Regency and crushed stone material taken from crusher Kalitelu, Gondang Subdistrict, Tulungagung Regency with the same mixture ratio.

The benefits of this research are to understand the quality and performance of Brantas river sand, Brantas river gravel, and crushed stone from Kalitelu as a concrete aggregate with quality f'c=19.3 MPa.

2. Basic theory

2.1. General definitions

Concrete lately-widely used widely as one of the building materials. In contrast to other building materials, concrete is a building material that the way of manufacture is learned in the field of civil engineering. Normal concrete is obtained by mixing portland, water, and aggregate cement. As for special types of concrete (other than normal concrete) added additional materials, such as pozoland, auxiliary chemicals, fiber and so on. The purpose of adding materials is to produce better special concrete than normal concrete. Types of quality and specific types of concrete have evolved in accordance with the development of types of structures and types of buildings these days, for example, concrete for beams and columns must be a high concrete compressive strength. Concrete that is always associated with water must be waterproof concrete. Concrete that is always submerged in sulfate water should be sulfate-resistant concrete. Concrete for non-structural elements used lightweight concrete, and so on.

Concrete compared with other building materials has several advantages, among others, namely:

a) The price is relatively cheap because it uses basic materials that are generally available near construction sites, except cement. Only for certain areas that are difficult to get sand or gravel may be the price of concrete becomes rather expensive.
b) Includes materials that are durable, wear-resistant, fireproof, resistant to rusting or decay by environmental conditions, resulting in low maintenance costs.
c) The compressive strength is high enough that when combined with reinforcing steel (high tensile strength) can be said to be capable of being made of heavy structures.
d) Fresh concrete can be easily transported or printed in shape and size in accordance with the wishes. Molds can also be used several times so that it becomes economically cheap.
e) Although the concrete has advantages, the concrete also has shortcomings. Some of the shortcomings include:

    - The basic ingredients of concrete (fine aggregate as well as a coarse aggregate) vary according to the location of the collection so that the way of planning and the way of manufacture is also different.
    - Concrete has several classes of strength so it must be tailored to the part of the building that is made, so the way of planning and how the implementation of the various kinds too.
    - Concrete has a low tensile strength, so brittle/fragile and young cracks. Therefore, it is necessary to provide ways to overcome them, such as by providing steel reinforcement, fiber and so on.

In order to produce strongly pressed concrete in accordance with the plan, required mix design to determine the amount of each bundle needed. In addition, concrete slabs should be cultivated in completely homogeneous conditions with particular discomfort to avoid segregation (granular separation). In addition to the comparison of the stacking material, the strength of the concrete is determined by the solid or not the mixture of the constituent material. The smaller the cavity produced in the concrete mixture, the higher the strength of the resulting concrete pushes [2].

Cement and water in a concrete mix made a paste called cement paste. The cement paste in addition to functioning to fill the pores between fine aggregate grains (sand) and coarse aggregates (gravel) also has a function as a binder so as to form a mass that is compact and strong.
The properties of concrete are influenced by the following factors:

- Quality of cement, for reinforced concrete construction, in general, can be used types of cement that meet the conditions that have been set.
- Comparison of Portland and water cement mixtures.
- How to mix components.
- Rough aggregates (gravel or crushed stone).
- Care work accuracy.
- Age of concrete,
- Air temperature mixing time and hardening time of concrete.

2.2. *Material of Concrete*

2.2.1. *Cement*

Cement is a hydraulic material that can react chemically with water, thus forming a dense material. In general, the chemical composition of Portland cement is as shown in table 1.

Table 1. Portland cement limit composition.

Oxide	Composition (% weight)
Lime, Ca O	60 – 65
Silica, SiO_2	17 – 25
Alumina, Al_2O_3	1 – 8
Iron, Fe_2O_3	0,5 – 6
Magnesia, Mg O	0,5 – 4
Sulfur, SO_3	1 – 2
Potash, $Na_2O + K_2O$	0,5 – 1

In addition to portland cement, one type of cement on the market is portland cement pozoland. Portland Pozoland Cement (PPC) is a hydraulic adhesive material made with a fine grind of portland and pozoland cement clinker, or a uniform mixture between portland cement powder and pozolan powder during grinding or mixing. The pozolan portlane produces less hydration heat than ordinary cement [3]. The properties of resistance to impurities in water (eg salt content) are better, so it is suitable if used for:

a. Buildings in brackish or marine water that are always in contact with water containing sulfates.
b. Concrete buildings that require high water quality, such as basement wall, clean water storage, and sanitation.
c. Mass concrete (dams, dams, large foundations) that require low hydration heat.
d. Plastering work (mortar) that requires mortar (mortar/concrete) is plastic. (Tjokrodimulyo, K. *Teknologi Beton* 2007)[4].

2.2.2. *Aggregate*

Explanations in SNI-15-1991-03, aggregates are defined as granular materials, eg sand, gravel and crushed stone used together with a binder to form concrete or mortar. In a concrete structure usually, an ordinary aggregate occupies approximately 70% - 75% of the hardened concrete volume. In general, the more dense the aggregates are arranged, the stronger the concrete they produce, the durability of the weather and the economic value of the concrete. It is on this basis that the gradations of particle sizes in aggregates have a very important role to produce a solid concrete arrangement.

Another important factor is that the surface must be free of impurities such as clay, mud and organic substances that will obtain bonding with cement and also no unwanted chemical reaction between the material and the cement. By size, aggregates can be divided into:

a) Fine aggregate, diameter 0.0074 mm (sieve no 200) - 4.76 mm (sieve no 4) is called sand [5].
b) Crude aggregate, ≥ 4.76 mm in diameter (stifled sieve no. 4), usually measuring between 4.75 mm - 38.1 mm called gravel.

Aggregates in concrete mixtures are the largest part, so before being used for the concrete mixture the quality of (aggregate) quality should take precedence. Aggregate quality requirements can be seen in tables 2 and 3 as below:

Table 2. Aggregate fine quality requirements.

Test item	Specification	Testing Period	Frequency
Specific gravity	2.5 or more	JIS A 1109 or ASTM C128	Once month or more
Absorption	3% or less	-do-	-do-
Grading	Fineness modulus 2.5 to 3.3	JIS A 1102 or ASTM C136	One week or more
Solid volume content	53% or more	JIS A 1104 or ASRM C117	One month or more
Washing	5% or less	JIS A 1103 or ASTM C117	One month or more
Clay content	1% or less	JIS A 1137	-do-
Organic impurity	Success	JIS A 1105 or ASTM C40	-do
Soundness	10% or less	JSI A 1122 or ASTM C88	Twice year or more

Table 3. Coarse Aggregate quality requirements

Test item	Specification	Testing Method	Frequency
Specific gravity	2.5 or more	JIS A 1110 or ASTM C127	Once month or more
Absorption	3% or less	-do-	-do-
Grading		JIS A 1102 or ASTM C136	One week or more
Solid volume content	Max size 40 mm; 58 5 or more	JIS A 1104 or ASRM C29	-do-
Washing	1.5% or less	JIS A 1103 or ASTM C117	One month or more
Clay content	0.25 % or less	JIS A 1137	-do-
Soft particles	5 % or less	JIS A 1126	Twice/year
Soundness	12 % or less	JSI A 1122 or ASTM C88	-do-
Abrasion	10% or less by weight at 100 revolutions	JIS A 1121 or ASTM C131	-do-

Water is meant here is water used as a mixture of building materials, must be clean water and does not contain ingredients that can reduce the quality of concrete.
According to PBI 1971[6], the requirements of water used as a mixture of building materials are as follows:

1) Water for the manufacture and maintenance of concrete shall not contain oil, alkaline acids, salts, organic materials or other harmful materials than concrete.
2) If deemed necessary then the water samples may be brought to the Materials Investigation Laboratory to obtain the tests as required.
3) The amount of water used for concrete mixture can be determined by weight size and must be done exactly.

Water used for the best concrete-making process is clean water that meets drinking water requirements. Water used in the process of making concrete if too little it will cause the concrete will be difficult to work, but if the water content used is too much then the strength of the concrete will decrease and there is shrinkage after the concrete hardens. To obtain a concrete density with the low water-cement ratio you should use a vibrator. Maintain moisture and heat to keep it constant during the hydration process, for example by covering the surface with a wet sack.

2.3. Testing of Concrete Pressure

According to SNI 1974_2011 the standard test for concrete compressive strength with cylindrical samples with diameter 15 cm and height of 30 cm calculated by dividing the maximum load achieved during testing with concrete sample surface area, can be systematically written as follows:

$$f'c = \frac{P}{A} \tag{1}$$

Information :
F'c = compressive strength of concrete (MPa)
P = maximum compressive load (N)
A = cross-sectional area (mm2)
Source: Indonesian National Standard no. 1974 year 2011 p. 8
From the results of this compressive strength test, we will get the collapse pattern and compressive strength obtained in accordance with the age of the test specimen. Further data obtained in the table and calculated the average compressive strength achieved [7].

3. Research Methodology

All material testing activities, mixed design (mix), concrete mixing and concrete compressive strength testing were conducted at the Tugu Forest Project Development Laboratory, Trenggalek District. References used as reference material testing, mix computation (job mix), and concrete compressive strength test with cylindrical test object sourced from Indonesian National Standard (SNI). The material of sand and natural gravel is taken from sand mining in Brantas River, Ngujang Village, Kedungwaru Subdistrict, Tulungagung Regency. Sand and natural stone (river) are taken from the same mining. For sand, in use aggregate that pass sieve no. 4 (4.76 mm) [8]. While being stuck on the sieve no. 4 (4.76 mm) to those who pass the 1 "(25.4 mm) sieve is set aside for use as a natural gravel material (river). While crushed stone material obtained from crusher Kalitelu, District Gondang, Tulungagung regency with maximum aggregate grain is 1 "(25.4 mm). The cement used is Portland Pozoland (PPC) cement produced by PT. Semen Gresik. This type of cement is widely circulated in building stores and can be obtained easily. Semen Gresik PPC type is circulating in the market in 40 kg/zak packaging. Water used as a mixer is water from a well around the study site.

Table 4. The result of aggregate checklist.

KIND OF EXAMINATION		SAND	Specification	GRAVEL	Specification	CRHUSHED STONE	Specification	PPC	Specification
1. The arrangement of granules									
% passing									
1 1/2"	#37.5								
1"	#25.4			100,00		100,00			
3/4"	#19			74,14		95,96			
3/8"	#9.52			20,68		11,84			
No. 4	# 4.75	100,00		1,90		0,42			
No.8	# 2.36	84,22							
No. 16	# 1.18	69,27							
No. 30	# 0.60	50,83							
No. 50	# 0.30	22,92							
No. 100	# 0.15	2,82							
No. 200	# 0.074	0,66							
Finess modulus		2,70	2.5 - 3.3	2,03		1,92			
2 Specific Gravity									
Saturated Survace Drained Specific Gravit		2,82	2.5 or more	2,49	2.5 or more	2,45	2.5 or more	3,09	3.05 or more
Apparent Specific Gravity		2,93		2,69		2,57			
absorption		2,15		5,17		3,19			
3 Abrasi	%			39,78	< 40	38,5	< 40		
4 Passing #200	%	2,10	< 5	0,87		1,71			

Furthermore, the calculation of concrete mixture based on Indonesian National Standard (SNI) number 03-2834-199. From the calculation of mixture of concrete/m³, the comparison of cement mixture = 325 kg, Water = 195 kg, fine aggregate (sand) = 732 kg/m³, Crude aggregate = 1098 kg/m³. Both mixtures using natural gravel or crushed stone aggregate with the same ratio shown in table 5 and table 6.

Table 5. Strength test of concrete optimization of the natural population using a coarse aggregate of natural gravel.

Coarse Aggregate = Gravel
Area = 176,714 cm2

No	Creation Date	Date Testing	Age of Sample (day)	Weight of sample (gr)	Dial (kN)	Corrections Age	Strenght of 28 day (kN/cm²) (Fc)	Strenght of 28 day (kg/cm²) (Fc)	Strenght of 28 day (mPa) (Fc)	Average of Strenght of 28 day (mPa) (Fer)
	A	B	C	D	E	F	G	H	I	J
1	21 Mei 2017	28 Mei 2017	7	12530	270	0,65	2,35	235,06	19,51	
2	21 Mei 2017	19 Juni 2017	28	12705	425	1	2,41	240,50	19,96	
3	21 Mei 2017	19 Juni 2017	28	12760	455	1	2,57	257,48	21,37	
4	21 Mei 2017	19 Juni 2017	28	12420	305	1	1,73	172,60	14,33	
5	21 Mei 2017	19 Juni 2017	28	12405	345	1	1,95	195,23	16,20	
6	21 Mei 2017	19 Juni 2017	28	12610	460	1	2,60	260,31	21,61	
7	21 Mei 2017	19 Juni 2017	28	12430	355	1	2,01	200,89	16,67	
8	21 Mei 2017	19 Juni 2017	28	12415	340	1	1,92	192,40	15,97	18,48
9	21 Mei 2017	19 Juni 2017	28	12310	350	1	1,98	198,06	16,44	
10	21 Mei 2017	19 Juni 2017	28	12825	440	1	2,49	248,99	20,67	
11	21 Mei 2017	19 Juni 2017	28	12395	350	1	1,98	198,06	16,44	
12	21 Mei 2017	19 Juni 2017	28	12450	280	1	1,58	158,45	13,15	
13	24 Mei 2017	21 Juni 2017	28	12460	425	1	2,41	240,50	19,96	
14	24 Mei 2017	21 Juni 2017	28	12420	455	1	2,57	257,48	21,37	
15	24 Mei 2017	21 Juni 2017	28	12445	500	1	2,83	282,94	23,48	

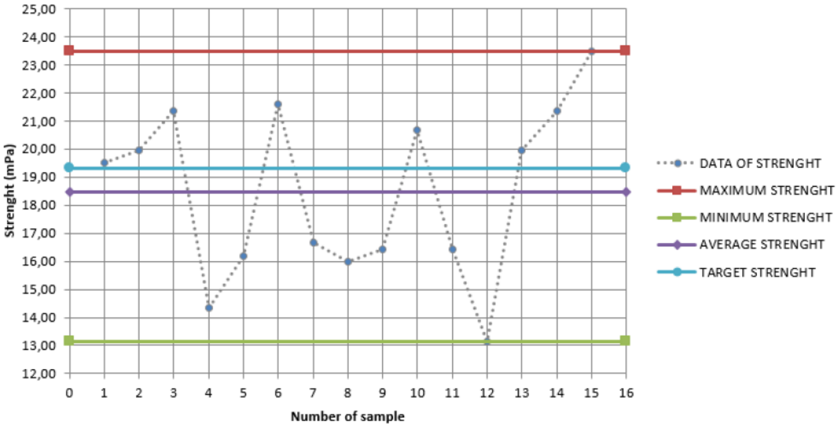

Figure 1. Graph of strength test results with a coarse aggregate of natural gravel.

Table 6. Strength test of concrete optimization of the natural population using a coarse aggregate of crushed stone.

Coarse Aggregate = Crushed Stone
Area = 176,714 cm2

No	Creation Date	Date Testing	Age of Sample (day)	Weight of sample (gr)	Dial (kN)	Corrections Age	Strenght of 28 day (kN/cm^2) (Fc)	Strenght of 28 day (kg/cm^2) (Fc)	Strenght of 28 day (mPa) (Fc)	Average of Strenght of 28 day (mPa) (Fer)
	A	B	C	D	E	F	G	H	I	J
1	21 Mei 2017	28 Mei 2017	7	12,265	350	0,65	3,05	304,71	25,29	
2	21 Mei 2017	19 Juni 2017	28	12,415	480	1	2,72	271,63	22,54	
3	21 Mei 2017	19 Juni 2017	28	12,305	410	1	2,32	232,01	19,26	
4	21 Mei 2017	19 Juni 2017	28	12,615	430	1	2,43	243,33	20,20	
5	21 Mei 2017	19 Juni 2017	28	12,325	425	1	2,41	240,50	19,96	
6	21 Mei 2017	19 Juni 2017	28	12,305	400	1	2,26	226,35	18,79	
7	21 Mei 2017	19 Juni 2017	28	12,465	325	1	1,84	183,91	15,26	
8	21 Mei 2017	19 Juni 2017	28	12,56	520	1	2,94	294,26	24,42	21,32
9	21 Mei 2017	19 Juni 2017	28	12,425	460	1	2,60	260,31	21,61	
10	21 Mei 2017	19 Juni 2017	28	12,385	430	1	2,43	243,33	20,20	
11	21 Mei 2017	19 Juni 2017	28	12,325	380	1	2,15	215,04	17,85	
12	21 Mei 2017	19 Juni 2017	28	12,425	475	1	2,69	268,80	22,31	
13	24 Mei 2017	21 Juni 2017	28	12,415	505	1	2,86	285,77	23,72	
14	24 Mei 2017	21 Juni 2017	28	12,340	480	1	2,72	271,63	22,54	
15	24 Mei 2017	21 Juni 2017	28	12,420	550	1	3,11	311,24	25,83	

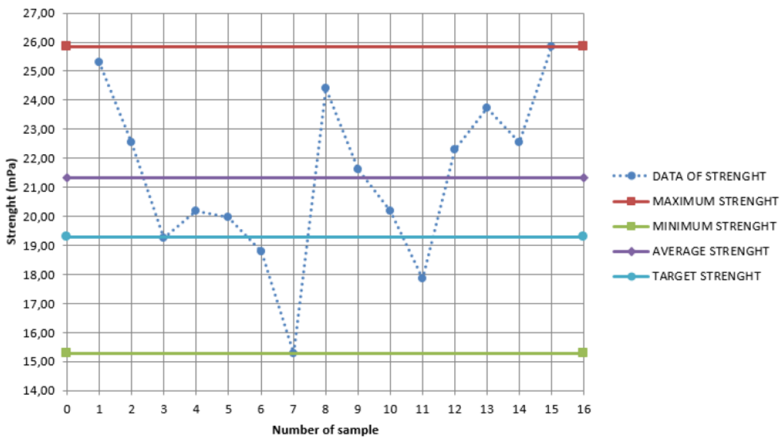

Figure 2. Graph of strength test results with a coarse aggregate of crushed stone.

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4. Conclusion

The process of plotting a normal concrete mixture begins with a series of material testing used as a concrete mixture material. Materials used include sand and natural gravel material taken from sand mining in Brantas River, Ngujang Village, Kedungwaru District, Tulungagung Regency. Sand and natural stone (river) are taken from the same mining. For sand, in use aggregate that pass sieve no. 4 (4.76 mm). While being stuck on the sieve no. 4 (4.76 mm) to those who pass the 1 "(25.4 mm) sieve is set aside for use as a natural gravel material (river).

In comparison, the broken stone material obtained from Kalitelu crusher, Gondang district, Tulungagung district with maximum aggregate grain is 1 "(25.4 mm). The cement used is Portland Pozoland (PPC) cement produced by PT. Semen Gresik. This type of cement is widely circulated in building stores and can be obtained easily. Semen Gresik PPC type is circulating in the market in 40 kg/zak packaging. Furthermore, the calculation of concrete mixture based on Indonesian National Standard number 03-2834-199. From the calculation of mixture of concrete/m³, the comparison of cement mixture = 325 kg, Water = 195 kg, fine aggregate (sand) = 732 kg/m³, Crude aggregate = 1098 kg/m³. Both mixtures that use natural aggregate gravel or crushed stone, use the same comparison.

From the concrete strength test results that have been done, obtained the concrete compressive strength of 18.48 MPa for a concrete mixture using natural aggregate gravel aggregate. As for the mixture of concrete using a rough aggregate of crushed stone obtained by compressive strength of concrete equal to 21,32 MPa. The concrete strength of the planned concrete is 19.3 MPa. Thus from the results of this test, it can be concluded that the rough aggregate of natural gravel from the take in Brantas River, Ngujang village, Tulungagung district if used as a normal concrete mixture is not achieved concrete quality f'c = 19.3 MPa. This is because in natural gravel there is a floating rock that has a high absorption and wear of a large so that it can become a weakness when mixed in a concrete mortar.

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