

The Effect of Mixed Composition Using Mix Design and Volume Ratio Towards the Strength of Concrete

Iskandar BP

Lecturer of Engineering Faculty, University of Muslim Makassar-South Sulawesi, Indonesia

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ABSTRACT

This research observed the concrete strength, which made using mixture composition with and without mix design analysis. Mixture base on mix design is measured base on weight comparison, and mixture without mix design analysis is measured base on volume comparison between cement, sand, crushed stones / aggregate, then the mixing process done in the field (*Site mix*). The fine aggregate used is the fine grain sand (gradation of zone 3). Mix design analysis used DOE method. The quality of plan concrete f_c' is 20 MPa and 25 MPa. Comparison of volume of cement: sand, crushed stones to the plan quality concrete f_c' 20 MPa and 25 MPa, respectively is 1: 2: 3 and 1: 2: 3.5. To know the development of concrete strength, it is done pressure strength test at age 7, 14, and 28 days. Else, also is done porosity test to the concrete at age 28 days. From testing result of concrete pressure strength at age 28 days was found value of pressure strength in all concrete test objects fulfilled plan pressure strength, either mix design concrete or volume comparison. The fine gradation grain sand (zone 3) was not reducing the concrete strength planned. Concrete pressure strength value based on volume comparison was higher than mix design concrete. The result of porosity test pointed out percentage rate of concrete cavity based on volume comparison was lower than mix design concrete.

KEYWORDS: concrete, mix design, volume comparison, concrete strength, smooth grain sand

INTRODUCTION

In the modern age, like nowadays, cement concrete or frequently was called concrete, has become part of infrastructure in the sector construction service. Concrete has become part, which is un-separated for the job - watery job like concrete weir, channel strength, canal, for road and bridge job like bridge structure and bridge substructure building, rigid pavement, for building job like the multistoried building, mall, hotel, and other multistoried building whether in the form pre-cast or cast in the site. Why concrete structure construction become choice? By used concrete structure construction the building could faster finished, grade and quality could watched carefully; the tool, the material and other resources used was provided and easy to get.

In the simple structure buildings yet much founded without have to using mix design but still using simple pattern, that is, with use mixture composition or volume comparison between cement, sand, and broken stones. In this research, the researcher will do the concrete strength analysis to mixture composition with mixture volume comparison mix design. The concrete which is made finely each aggregate grain, anyway, the rough and the smooth always is rounded by cement pasta. In the cement concrete is main basic material which as the binding material to the grain of broken stone become a strong and dense mass, where, the tightening was caused by chemical reaction between cement and sand, which, if cement and sand then cement paste plus CaO plus hot. This reaction need the good time which earlier take place with fast then slow in the longer time process.

Though relatively just a little water needed to it complete chemical reaction, but, the reality in the practice is used more water which is aimed to facilitate working. Furthermore, by the increase of water more, much the broken stone able to use so more economic. Excess of water able to decrease the pasta strength and resistance, therefore, the precise comparison between water and cement is strongly needed.

The concrete usually consist of:

Cement	:	07 – 14% concrete volume
Water	:	15 – 20% concrete volume
Aggregate	:	66 – 78% concrete volume [1].

Therefore the aggregate material as the biggest part of concrete, then selection of aggregate material which consist of broken stone and sand need to get attention. Depart from the thinking as well as called in the above, then in this research, either to mixture composition by used mix design or volume comparison to determine the concrete strength persistent to keep the provision.

The concrete will able to achieve precise quality according to the plan if the composition of the mixture material is analyzed by used mix design. Fact in the field, implementation of concrete mixture for simple building construction like residence, storehouse or offices has floor 2 up to 3, mixture composition of material

*Corresponding Author: Iskandar BP, Civil Engineering, University of Muslim Makasar-South Sulawesi, Indonesia.
Email: iskandarbp@gmail.com

without mix design analysis, but base on volume comparison between cement material, sand, and broken stone, and the mixing process done in the field (*site mix*), which is done by expert by way use cast bucket to measure the volume. The smooth aggregate which is used at the process of making concrete in the field (*site mix*) was generally used smooth grain sand (gradation of zone 3 or 4). Sand to fine aggregate has diameter 0.2 mm up to 5 mm. diameter of sand grain strongly influence to concrete quality achieving. If the used sand to mixing, the grain diameter is rough or included in gradation group of zone 1 will generally produce concrete with high quality achieving, [2]. Sand grouped in smooth aggregate, it is the grain able to penetrate the hole sieve 4.75 mm (ASTM C 33) or has grain diameter smaller than 5 mm. viewed from the grain diameter, according to ASTM C 33 standard, the sand was grouped in 4 grain gradation zone, that is 1) zone 1 is the sand grain diameter between 1 – 2 mm, 2). zone 2 is the sand grain diameter between 0.2 – 0.6 mm or sand which the grain diameter smoothest. The smooth aggregate in concrete mixture has role in up the problems of concrete features like segregations, *bleeding*, also waterproof. Using it has to limited, because if excessive, then water needed at the moment to mixing the concrete increase and cause need to add the cement in order to the concrete strength according to the planned. [3].

Problems watched at this research whether the concrete can reach the precise quality by composition of material based on volume comparison, using smooth aggregate of grain diameter gradation sand of zone 3, and measuring process of mixture is done by professional in the field. The purpose of this research among other to know the concrete aggregate on smooth gradation sand which the mixture composition using mix design analysis and based on volume comparison done by professional, viewed from side 1). appropriateness of concrete strength achieved through pressure strength test, and 2). absorption percentage rate.

MATERIALS AND METHODS

Mixing Method

Concrete mixing method to building structure like weir building structure, house building, and bridge building, and other building structure which is frequently used in Indonesian is using DOE method and ACI method, which both can be explained as follows:

a. DOE method

DOE method was developed by Department of Environment from United Kingdom of English which then was developed by a professional Prof. Torben C Hansen by conducted a little modification. Concrete which consist of mixture of water, cement, sand, and broken stone as mentioned, the goodness and badness dependent on quality concrete material and mixture proportion of each material. The main demand in concrete mixture there are 4 (four) things grounded; i. *Workability*, which in the practice is measured by *Slump*, ii, *Compressive strength*, which in 28 days have to ossified, iii, *Durability* where the concrete which able to ossified, iv, the price of the beating has to economic. The good concrete is meeting the strength wanted, using of cement as minimum as possible, its works easy, that is, easy to mixed, isn't happened decomposition and power needed as minimum as possible. In the using of DOE method found 2 (two) base argument, that is: 1). easy to it mixing job dependent on free water amount and independent from cement-content and cement water factor, 2). the strength of concrete dependent on free water amount and independent from excessively water and cement-content. Of those both base arguments, the calculation of design of concrete mixing was developed. [4][5].

b. ACI method

ACI method as mixing planning other alternative than DOE method is usually used all this time. Proportion or comparison of concrete mixture, more known by mix design is a process which consists of 2 (two) related phase: 1). election toward the appropriate material, to making concrete like cement, aggregate, sand, cement and admixture. 2). Determining relative amount from mixtures to produces economically concrete mixture, has workability, high strength, and long lasting. Proportion will depend mainly to the mixtures, used according with usage. Some case which become base consideration in the planning of mixing according to ACI method: economic, workability, strength and long lasting. Mix design of ACI method which is indirectly compared, which all give equality relative proportion approach of it material and it is all easy to do. Must to remembered in ACI method that few mix design method just only give first approach proportion, have to checked repeatedly at laboratory and in the field and could be regulated as needed to produce the concrete characteristic wanted. One day are founded an experience, ACI method is modified or changed based on nature and material amount. Which need to get attention are job specifications that enclose several mixing conditions like minimum cement content, cement water factor, slump, and aggregate maximum measure water content, the strength of using admixture or other conditions. It will keep that material characteristic which exist is properly to pay attention in the mixing until be founded good and proper concrete mixture. [4][6]

Mix Design

Mix design is concrete is broken stone mixing design (rough, medium, and smooth), and cement met the mixture property. Mix design is an analysis method to mixture which the standard have existed. For example, if quality of concrete K 200, so used comparison 1 cement: 2 sand: 3 broken stone or generally used weight or volume comparison with rough aggregate 40% and smooth aggregate 30% as the result of mix design. Mix design process, however, not all, fulfilled the condition simultaneously, but strength and workability is greatly needed. The perfect mix design, although, will not make the perfect result, moreover, if isn't supported by working, field execution, that is, water content and aggregate gradation. Much modern empirical design depended on 2 (two those consideration). Shortly, mix design procedure consists of: 1). provisioning job parameter, aggregate nature, aggregate maximum measure, slump, cement water factor, admixture, 2). weight calculation in Batching Plant, 3), adjustment into total weight based on mixture trial have been made. As earlier information that is needed to do mix design about the used material, aggregate sieve analysis, smooth and rough aggregate, aggregate volume weight, specific gravity, and aggregate absorption water content. [4][7].

Mixture Composition in the Research

Research was done at concrete laboratory. Material used to concrete mixture is Portland Cement (PC) type I produced by PT Semen Gresik, sand from Mojokerto, and crushed stone / aggregate from Tulungagung. Before done mixing, firth done testing toward cement, sand, and crushed stone / aggregate to know physical nature and the appropriateness of condition according to the provisioned standard. Toward sand material and crushed stone was done filter analysis test (ASTM C136-2001), volume weight (ASTM C29-2003), specific weight (ASTM C128-2001), cleaning test to mud (ASTM C117-1995), water absorption test (ASTM C128-2001), humidity test (ASTM C556-2001), and worn out test to the broken stone (ASTM C131-2003). [3][7][8] Concrete quality f_c' was planned 20 MPa and 25 MPa, like is generally used to simple building. Mix design analysis used DOE method with slump 70-100 mm, cement water factor 0.5. Mix of material used the volume comparison was made by comparison among cement: sand: crushed stone is 1 : 2 : 3 to f_c' 20 MPa and 1 : 2 : 3.5 to f_c' 25 MPa, as is generally done in the field. Material volume contain used the cast bucket as shown in picture 1. Cast Bucket to Contain the Volume of Concrete mixture. Figure 1. Cast Bucket to Contain the Volume of Concrete Mixture

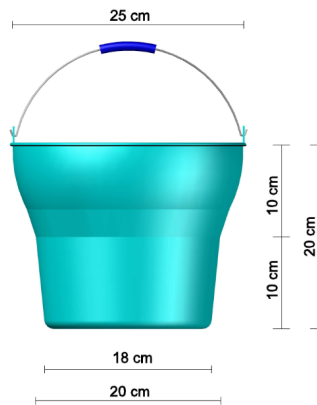


Figure 1. Cast Bucket to Contain the Volume of Concrete Mixture

Test object as cylinder on diameter 150 mm, high 300 mm, and treatment was immerse in water until test age. Each testing was done repeatedly toward three test object. Concrete test object A1, and A2 respectively is concrete quality mix design mixture f_c' 25 MPa, and f_c' 25 MPa, concrete test object B1 and B2 respectively is mixture based on volume comparison of cement : sand : broken stone is 1 : 2 : 3 for the planned quality f_c' 20 MPa, and comparison 1 : 2 : 3.5 for the planned quality f_c' 25 MPa. The materials of mixture based on mix design was founded by using weight contain found from analysis outcome. The materials of mixture based on volume comparison were done directly by the professional using the cast bucket, without conversion from weight contain. Water volume needed based on estimation so isn't known exactly the water volume used. Composition of material to concrete mixture is as the table 1. Table 1 Composition of Concrete Mixture Material. [9]. To know the concrete strength is done by the pressure strength test according to ASTM C39-94 procedure. Alternatively, is done porosity test as well according to ASTM C 138-92 procedure to know pores percentage founded in concrete. [10].

Table 1. Composition of Concrete Mixture Material

Test object	Mixture analysis	Concrete quality f_c'	Cement	Sand	Crushed stone	Water (litre)	Concrete Volume Weight (kg/m ³)
A1	Mix design	20 MPa	285 kg	668.67 kg	1222.28 kg	199	2465
A2	Mix design	25 MPa	308 kg	567.42 kg	1304.22 kg	200.50	2467
B1	Volume comparison	20 MPa	1	2	3		2453
B2	Volume comparison	25 MPa	1	2	3.5		2459

Source: Result of Processing of Research

RESULTS AND DISCUSSION

Result of sand and crushed stone test has fulfilled the requisite according to standard. Found the sand at grain gradation of zone 3 by smoothness modulus 3.09%, specific weight as big as 2.6; humidity 2.25%, absorption 2%, volume weight 1391.90 gram/litre, sand cleaning toward mud 6.67%. result of material of broken stone was founded grain gradation at the zone 1 by smoothness modulus 7.11%, specific weight 2.83, volume weight 1611.30 gram/litre, humidity 0.98%, absorption 2.25%, and worn out 19.65%.

Result of Pressure Strength Test

Result of concrete pressure strength test by plan age 7 (seven) days, 14 (fourteen) days, and 28 (twenty eight) days by various pressure strength is as well as appeared at the Table 2. Result of Concrete Dissolved Pressure Strength and. Figure 2. Result of Pressure Strength Test.

Table 2. Result of Concrete Dissolved Pressure Strength

Test Object Age (days)	f_c' plan 20 MPa		f_c' plan 25 MPa	
	Test Object Pressure Strength A1 (MPa)	Test Object Pressure Strength B1 (MPa)	Test Object Pressure Strength A2 (MPa)	Test Object Pressure Strength B2 (MPa)
7	22.04	23.32	21.93	23.00
14	24.16	22.94	22.17	23.20
28	24.99	29.44	25.33	29.56

Source: Result of Processing of Research

Of all testing of test object, was founded that the concrete strength of mix design analysis and volume comparison reached the quality according to the plan. Concrete based on volume comparison reached the pressure strength rate higher round 15% compared with mix design concrete, either quality f_c' 20 MPa or f_c' 25 MPa. It is this can caused when mixing process of materials of concrete based on volume comparison done by professional in the field, material volume used bigger than mix design analysis measure. Example, to made the quality concrete 20 MPa, cement volume used more than mix design analysis cement, and cause the concrete strength become higher. Or sand volume and broken stone mixed by professional smaller than needed, but cement volume higher, until the concrete strength become higher.

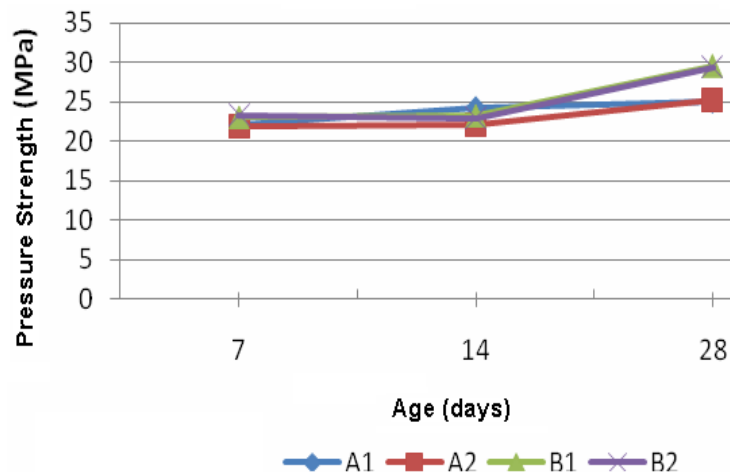


Figure 2 Result of Pressure Strength Test

Concrete based on volume ratio of the quality of the plan $f_c' = 20$ MPa obtained compressive strength values amounted to 29.44 MPa, 32% higher than the quality of the plan, and $f_c' = 25$ MPa higher 15% of the quality plan. The compressive strength of concrete mix design analysis obtained is not much different from the quality of the plan, because the materials used in accordance with the dosage so that its power in accordance with the quality plan. This suggests that the mix design analysis is essential to the manufacture of concrete so that the strength achieved in accordance with the quality of the plan, and the use of appropriate materials as needed, so that the fuel efficiency awake, not wasteful or less than the dose required. Concrete based on comparison of the volume, although can achieve strength even exceed the quality of the planned use of the materials for the mixture becomes inefficient.

Finely graded sand granules (zone 3) is used as a fine aggregate does not affect the strength of concrete, either mix based on a comparison of volume or mix design, concrete is able to achieve planned compressive strength.

Results of Porosity Test

Results of Porosity test Figure 3. Result of Porosity Test obtained porosity percentage values of concrete mix design around 4.40% higher than concrete based on the volume ratio, either quality concrete $f_c' = 20$ MPa or $f_c' = 25$ MPa. This shows that the formed cavity in the concrete is influenced by the composition of the volume of the materials used.

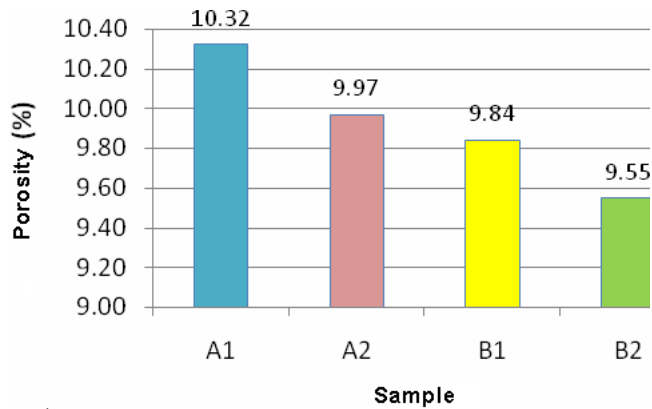


Figure 3. Result of Porosity Test

When viewed correlation of test results of the compressive strength and porosity as shown in Figure 4 relationship of porosity with the compressive strength of concrete the age of 28 day is known that compressive strength of concrete based on the volume ratio is higher than the concrete mix design. This shows that the percentage of cavity was affect the strength of concrete is higher cavity on the concrete, the smaller the compressive strength is generated, and conversely the smaller the percentage of cavity in the concrete, the greater the compressive strength is generated. On the concrete based on volume ratio, the material used in excess of the volume required when analyzed using a mix design and lead low cavity percentage is known of the compressive strength was increased significantly from planned quality.

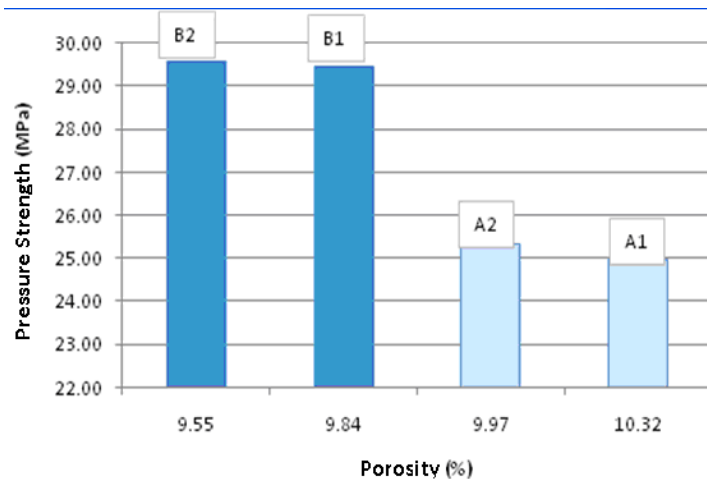


Figure 4 Porosity Correlation with Concrete Pressure Strength Age 28 Days.

CONCLUSION

From introduction, materials and methods, results and discussion above, can be took the conclusion of the research can be conclusions as follows:

1. Concrete pressure strength based on volume comparison can reached the concrete quality according to the planned, but higher round 15% up to 30% of the strength the planned.
2. Using of materials to mixing the concrete based on volume comparison become not efficient known of the increasing of pressure strength significantly from the quality planned.
3. Gradation grain sand of zone 3 used as fine aggregate able to reached the planned concrete pressure strength, either using mixture based on volume comparison or mix design.
4. Concrete porosity percentage rate based on volume comparison lower than mix design concrete and influenced to the concrete pressure strength higher than mix design concrete.

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