Contribution of Microsilica of Silica Sand on High Strength Concrete

J. Tarigan[1], R. Karolina[1] and W. Muhammad[2]
[1]Lecturer of Department of Civil Engineering, University of Sumatera Utara, Jl. Perpustakaan, Medan, Indonesia
[2]Department of Civil Engineering, , University of Sumatera Utara, Jl. Perpustakaan, Medan, Indonesia

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Abstract: Various types of concrete have now been developed according to their needs, one of which is high strength concrete. In designing high strength concrete, it should be noted that several factors will influence the achievement of the quality of the plan, which are cement, water cement factor (FAS), concrete aggregates, and appropriate admixtures. In engineering a natural mineral, it is important for an engineer to find alternative materials to substitute Portland cement. So that the use of Portland cement can be reduced in the making of high strength concrete that usually uses Portland cement in large quantities. In this research, micro silica utilization as a substitute for Portland cement in concrete mixture is expected to create high strength concrete that is environmentally friendly. The use of micro silica is accompanied by the use of Master Ease 3029 super plasticizer. This research aims to compare high strength concrete variations of 0%, 5%, 10%, 15% and 20% micro silica substitution of Bangka. From the results of research that has been done on 28 days curing showed that normal concrete compressive strength / 0% variation is 61,296 Mpa while the concrete with substitution variation of 15% micro silica is the most optimum with a compressive strength of 66,684 Mpa. For the value of slump flow obtained from the five variations indicates that the higher the use of micro silica substitution, the smaller the diameter value is.

1 INTRODUCTION

High Strength Concrete is a concrete that has characteristics as a solid unit of material with a compressive strength ranging from 55.5 to 200 Mpa. This concrete allows the creation of a sleek, lightweight concrete structure that can also save energy and natural materials. High Strength Concrete Density also gives the advantage of a high resistance to the attack of dangerous liquid or gas. High Strength Concrete is generally used in high-rise buildings and bridges. In high buildings, High Strength Concrete is used to conserve dimensions of columns and beams, allowing wider space between columns to columns, as well as between beams that affect the elevation of each floor. The reduction of the structure component dimension itself will reduce the weight of the structure so that the load on the foundation becomes lighter. In long bridges that generally use pre-cast concrete, High Strength Concrete is required to support larger span loads due to bridge spans and also to overcome the possibility of precast concrete damage that often occurs in the mobilization of the precast concrete itself.

The need for these structural components leads to the use of high strength concrete which includes strength, durability, service life and efficiency. High strength concrete is greatly influenced by the constituent materials on the concrete. There are several factors that influence the achievement of high strength concrete compressive strength in its design. The preparation of qualified ingredients is one of the factors that can influence the manufacture of high strength concrete. Factors affecting the quality of a concrete are cement factors, cement water factors, aggregate factors, Micro silica usage and admixture materials usage.

The development of technology in the field of construction is very rapidly presents new innovations in the field of materials, one of them is concrete materials. Several types of added materials are often used for high strength concrete like Fly Ash and manufactured micro silica such as Silica Fume. The use of concrete added materials is intended to improve the quality and strength of concrete, Because the critical part of the concrete lies in the interfacial zone area between the paste of cement and the sand with a coarse aggregate, hence to increase the

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adhesiveness of the interfacial zone, an idea arises by using the most abundant natural materials in Indonesia which is micro silica from Bangka silica sand. The Micro silica is the result of fine processing of silica sand in the Bangka region with the size of 0.1 to 1 micrometers and has a cementations property because it has a content of Silicon Dioxide (SiO2) greater than 96% which can play an important role to the mechanical and chemical properties of the concrete, of the mechanical properties, geometrically, Micro silica can fill the cavities between the grain of cement, causing the pore size distribution to decrease as well as the total pore volume which is also reduced so that it can directly improve the strength of the concrete. Various levels of substitution of the most optimum Micro silica variations on Portland Cement Type I is starting from 0% - 20% (H. Mahyar, 2012)

Micro Silica is the well-performing natural material for the performance of high strength concrete compared to other materials such as silica nano, Fly ash and bottom ash (Thusara Priyadarshana & Ranjith, 2015)

The use of microsilica from the silica sand of Bangka as a Substitution of Portland Cement in a concrete mixture is an attempt to utilize the abundant amount of natural materials in Indonesia. Besides, the use of Microsilica from Bangka Silica sand as a substitution to Portland Cement in concrete mixture is expected to be a solution in achieving a high strength concrete that is environmentally friendly because it has the "Low Heat Hydration" feature that is produced by the substitution of Microsilica from Bangka Silica Sand at Portland Cement resulting in a low hydration heat and reducing CO_2 emissions because Microsilica from Bangka silica sand is a natural material without a manufacturing process and most importantly when applied in high strength concrete, it can reduce the use of cement.

The use of microsilica in high strength concrete mixture other than improving the quality of concrete significantly, it also does not require a special treatment such as Dry Air Curing or Steam Curing, just do soaking in water like an ordinary concrete to get the most optimum concrete quality (Md. Safiuddin & Raman, 2007).

2 LITERATURE REVIEW

Microsilica of Bangka is the result of a fine processing of silica sand which is one of the common materials found in the earth's continental crust. This mineral has a hexagonal crystal form made of a crystallized trigonal silica. Micro Silica of Bangka is a smoothed glass material and has a size with a diameter of 0.1 - 1 micrometers so if it's viewed by the size of the small particles geometrically, Microsilica of Bangka can fill cavities between cement and aggregate particles so it minimizes air cavity in order to increase the density of concrete mixture.

Figure 1. Microsilica of Bangka

Micro Silica of Bangka has a very hard properties, insoluble in water and has boiling point of 1715^{O}C and has white color, White Color is produced from its high content of SiO_2 (Silicon Dioxide).

Table 1: Chemical contents of Microsilica of Bangka

Parameter	Unit	Result	Method
Iron Trioxide (Fe_2O_3)	%	0.03	SNI 15-0346-1989
Alumunium Trioxide (Al_2O_3)	%	0.17	SNI 15-0346-1989
Calcium Oxide (CaO)	%	< 0.01	SNI 15-0346-1989
Magnesium Oxide (MgO)	%	< 0.01	SNI 15-0346-1989
Manganese Dioxide (MnO_2)	%	< 0.01	SNI 15-0346-1989
Chromium Trioxide (Cr_2O_3)	%	< 0.01	SNI 15-0346-1989
Sodium Oxide (Na_2O)	%	< 0.01	SNI 15-0346-1989
Potassium Oxide (K_2O)	%	0.01	SNI 15-0346-1989
Silicon Dioxide (SiO_2)	%	99.09	SNI 15-0346-1989
Titanium Dioxide (TiO_2)	%	0.02	SNI 15-0346-1989
Loss On Ignition (LOI)	%	0.39	SNI 15-0346-1989
Moisture Content (MC)	%	0.06	SNI 15-0346-1989

Source: Superintending Company of Indonesia, Jakarta 2015

From above, it is seen that Microsilica of Bangka has a very high content of silicon dioxide (SiO_2). The percentage of this content indicates that Microsilica of Bangka can be made into added ingredients in high strength concrete mixing. Thus, it is possible to utilize Microsilica of Bangka as a filler and become a cement substitution so as to reduce the use of cement in concrete mixture.

3 RESULTS AND DISCUSSION

3.1 Slump Test

The test results of *slump flow* value for normal concrete and concrete with the variation of Microsilica of Bangka can be seen in the following table.

Table 2: Test results of *slump flow* value of fresh concrete

Variasi	Diameter 1 (cm)	Diameter 2 (cm)	Average (cm)
0%	76	73	74.5
5%	74	72	73
10%	71	69	70
15%	70	68	69
20%	65	63	64

From Table 2, it can be seen that the slump flow value of the five concrete variations shows a significant difference. High slump flow value is caused by the use of Superplasticizer which serves to improve the workability of fresh concrete.

Figure 2: Slump flow test

3.2 Concrete Absorption Test

The results of absorption test for normal and concrete with the variation of Microsilica of Bangka can be seen in the table.

Table 3: Test results of concrete absorption value

No	Variasi	Umur Beton (Hari)	Berat Basah (kg)	Berat Kering (kg)	Absorbsi (%)
1	BN/0%		3988	3974	0.35
2	BN/0%	28	3982	3966	0.40
3	BN/0%		3969	3954	0.38
4	5%		3699	3683	0.43
5	5%	28	3834	3821	0.34
6	5%		3716	3701	0.41
7	10%		3839	3823	0.42
8	10%	28	3752	3738	0.37
9	10%		3869	3853	0.42
10	15%		3879	3862	0.44
11	15%	28	3816	3798	0.47
12	15%		3848	3832	0.42
13	20%		3846	3831	0.39
14	20%	28	3833	3817	0.42
15	20%		3868	3851	0.44

From Table 3. it can be seen that the absorption value of the five variations of concrete shows a not very significant difference. The low absorption value is due to the heterogeneous size of concrete materials so that the concrete density is maximum.

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3.3 Compressive Strength of Cylinder Concrete

The tests performed at 3, 7, 14, and 28 days curing, and the results of the compressive strength listed on the table are the result of compressive strength that has been multiplied by correction factor for cylinder with a diameter of 10 cm and a height of 20 cm which is 1.04. The test is done based on SNI 1974: 2011, test method of concrete compressive strength with cylinder sample. Within 3 days the concrete reaches a high compressive strength, and continues to increase until 7 days curing, then the growth of compressive strength begins to slow down to the 14 days curing, and reaches the maximum compressive strength at 28 days curing. From the table of compressive strength test results above, it is seen that within 3 days the concrete reaches a high compressive strength, and continues to increase until 14 days curing and reaches the maximum compressive strength at 28 days curing.

The compressive strength above shows that within 3 days the concrete reaches a compressive strength that is not too high compared to other variations, and continues to increase until 14 days curing and reaches the maximum compressive strength at 28 days curing.

Of the five results of high strength concrete compressive strength with variation substitution of 0%, 5%, 10%, 15% and 20% Microsilica of Bangka to Portland Cement at a certain test age, the five compressive strength test results can be compared through Graph as follows.

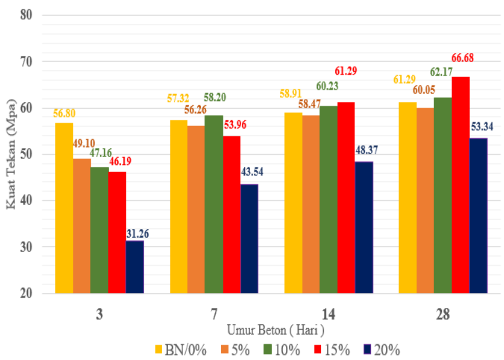

Figure 3: Graphical comparison of concrete compressive strength test results of Microsilica of Bangka Variations

From the results of concrete compressive strength test of Microsilica of Bangka variation, it can be concluded that high strength concrete with the substitution variation of 15% Microsilica of Bangka has the highest compressive strength compared with the high strength concrete compressive strength of other Microsilica of Bangka variations. With the average compressive strength of high strength concrete with substitution variation of 15% Micro Silica of Bangka at 28 curing is 66,684 Mpa and the compressive strength of high strength concrete with substitution variation of 0%, 5%, 10% and 20% Microsilica of Bangka at 28 days curing respectively are 61.296 Mpa, 60,059 Mpa, 62,179 Mpa and 53,347 Mpa. Increased compressive strength of concrete with substitution variation of 15% Microsilica of Bangka is 8.78% of concrete substitution of 0% Microsilica of Bangka variation.

4 CONCLUSIONS

Based on the research that has been done, it can be concluded that:

1. The average diameter of Slump Flow of high strength concrete substitution of 0%, 5%, 10%, 15% and 20% Microsilica of Bangka variations to Portland Cement respectively are 74.5cm, 73cm, 70cm, 69cm and 64cm. So it can be concluded that the higher use of substitution of Microsilica of Bangka variation to Portland cement, the lower the Slump Flow value is.
2. The average value of high strength concrete absorption substitution of 0%, 5%, 10%, 15% and 20% Microsilica of Bangka variations on Portland Cement are 0.39%, 0.39%, 0.40%, 0.44% and 0.42%, respectively. So it can be concluded that the higher use of substitution of Microsilica of Bangka variation to Portland cement, the lower the Absorption value is.
3. The normal high strength concrete substitution of 0% Microsilica of Bangka variation to Portland Cement at 3,7,14, and 28 days curing respectively are 56,880 Mpa, 57,321 Mpa, 58,911 Mpa and 61,296 Mpa. Furthermore, the normal high strength concrete compressive strength substitution of 5% Microsilica of Bangka variation to Portland Cement at 3,7,14, and 28 days curing respectively are 49,107 Mpa, 56,262 Mpa, 58,470 Mpa and 60,059 Mpa. Furthermore, the normal high strength concrete compressive strength substitution of 10% Microsilica of Bangka variation to Portland cement at 3,7,14, and 28 days curing respectively are 47,164 Mpa, 58,205 Mpa, 60,236 Mpa and 62,179

Mpa. Furthermore, the normal high strength concrete compressive strength substitution of 15% Microsilica of Bangka variation to Portland cement at 3,7,14, and 28 days curing respectively are 46,193 Mpa, 53,965 Mpa, 61,296 Mpa and 66,684 Mpa. Furthermore, the normal high strength concrete compressive strength substitution of 20% Microsilica of Bangka variation to Portland cement at 3,7,14, and 28 days curing respectively are 31,266 Mpa, 43,543 Mpa, 48,357 Mpa and 53,347 Mpa. So it can be concluded that high strength concrete substitution of 1% Microsilica of Bangka variation to Portland cement at 28 days curing has greater compressive strength than another high strength concrete substitution variation.

4. The use of Microsilica of Bangka as a variation of substitution to Portland Cement on high strength concrete is considered very effective because it reaches the optimum compressive strength of concrete at 28 days curing at 15% variation, thus reducing a very significant use of Portland Cement and it turns out 15% of Microsilica of Bangka substitution makes the Interfacial zone are to be better which is increasing the density between aggregates and paste so that the binding ability increases. This results is considered very good compared to the previous research conducted by V.Bhikshma, et al in 2009 which is the optimum compressive strength on 28 days curing is on the substitution of 12% of Microsilica (silica Fume) variation to Portland Cement.

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If any, should be placed before the references section without numbering.

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