Applied Mechanics and Materials Vols. 174-177 (2012) pp 1067-1071
Online available since 2012/May/14 at www.scientific.net

doi:10.4028/www.scientific.net/AMM.174-177.1067

Development of Mix Proportion For High-Performance Concrete Using Locally Available Ingredients Based on Compressive Strength and Durability

Jonbi[1, a], Binsar Hariandja [1,b] Iswandi Imran[1,c], Ivindra Pane[1,d]

[1]Civil Engineering, Faculty of Civil and Environmental Engineering, ITB, Indonesia

[3a]nanojbg@gmail.com, [b]binsarhariandja@gmail.com, [c]iswandiimran@gmail.com, [d]ivpane@gmail.com

Keywords: High Performance Concrete, mix proportions, compressive strength , and durability

Abstract. The use of concrete materials to date, remain a key ingredient in such construction work on the construction of building, bridges and infrastructure. One indicator is the increased production of readymix concrete which is nearly 16 billion tons in 2010. But the increased used of concrete, apparently bring the impact of environmental damage. This is due to the fact that production of raw materials contributes greatly to CO_2 in the air. One effort to reduce such impact is to use of high performance concretes. Mix proportion of High Performance Concrete are strongly determined by the quality and availablity of local materials. The implications of research result from other countries can‘t be directly used. Therefore is need to the research on development of High Performance Concrete mix using locally available materials. In this research the mix proportions for f'c : 60 and 80 MPa are developed using local materials that are commonly used by readymix producers. The high Performance Concrete is developed based on compressive strength and durability. The result is expected to be applied to readymix industry particularly for construction use in Indonesia.

Introduction

Concrete is one of the most common material and widely used in construction work. Concrete production is estimated to increase from about 10 billion tons in 1995, to nearly 16 billions tons in 2010 (E.Gjorv and Koji Sakai, 2004). But such increase brings serious implications to the environmental. Today the emerging awareness to reduce the impact it had, through a sustained effort to make concrete. One effort is make concrete with higher quality and durable (Aichin dan Mindes, 2011; Schmidt, M Habil. 2008). Concrete that has these properties is High Performance Concrete (Sobolev, K.G. and Soboleva, S.V.1998). In the Strategic Highway Research Program (SHRP) , HPC was initially defined by three requirements : maximum water-cementitious material ratio of 0.35, minimum durability factor of 80%, as determined by ASTM C 666 method and 21 MPa within 4 hours after placement, 34 MPa within 24 hours and 69 MPa within 28 days. (Caijun Shi dan YL Mo, 2008). In 1998 ACI published HPC as concrete which meets special performance and uniformity requeriments that cannot always be achieved by using only the conventional materials and mixing, placing and curing practices. The performance requirements may involve enhancements of placement and compaction without segregation, long-term mechanical properties, early-age strength,toughness, volume stability, or service life in severe environment. Magee and Olek, (2000) Collected and analyzed approximately 260 HPC mixtures from more than 200 publications. The result that the range for water content (150-170 kg/m^3), high binder content (350-500 kg/m^3), fine aggregate and coarse aggegrat are (700 – 800) kg/m^3 and (1000-1100 kg/m^3. Mix proportions for HPC are influenced by many factors, including specified performance properties, locally available materials, local experience, personal and cost (Caijun Shi dan YL Mo, 2008; El-Reedy,2009). Research on High Performance Concrete mix proportions have been carried out in several countries, but unfortunately the result of research only applies to mixtures using local ingredients are the same. Therefore it is necessary to do research on development of High Performance mix proportions using local materials Indonesia, where until now general, used concrete with f'_c 35 MPa to f'_c 45 MPa.

In this study the proportion of the mixture which was developed for f'$_c$ 60 MPa, and f'$_c$ 80 MPa using local materials that have generally been used readymix producers. Basic development of High Performance Concrete on aspects of concrete compressive strength and durability.

Materials And Metodology

Cement material used is portland cement type I, chemical compositions and physical properties shown in table 1.

Table 1. Chemical compositions and physical properties of Portland cement Type I

Coumpounds	Value %
SiO_2	19.0 -21.0
Al_2O_3	4.0 -6.0
Fe_2O_3	2.5 – 3.5
CaO	62.0 – 67.0
MgO	1.0 – 4.0
C_3S	55- 64
C_2S	9 - 20
C_3A	7- 11
C_4AF	9-11
Vicat Test	
Initial	$\geq$ 45 min
Final	$\leq$ 375min
Compressive Test (ASTM)	
3 day	$\geq$ 1740 psi
7 day	$\geq$ 2760 psi

Aggregate: In general, a smaller size aggregate will result in a higher compressive strength concrete. Commercial concretes with compressive strength of over 125 MPa have been produced with 10 to 14 mm maximum size coarse aggregate (Mehta P Kumar and Monteiro, 2006). In this research fine aggregate used was silica sand with specific gravity: 2.59, while the coarse aggregate using coarse aggregate with specific gravity 2,60. Silica fume is used as high effective additive for the production of high quality concrete complies with ASTM 1240-00. Bulk density : 0.60 kg/l. With a dosage that can be recommended 5 -15 % (ACI 211.4R-08). Superplastisizier : The use of superplasticier is essential to achive high strength, good workability and good durability. Sika Vistocrete-10 is third generation superplasticier for concrete and mortar, complies with ASTM C 494-92 type F. Based on existing HPC mix proportions is shown in Fig 1. and Fig 2, the developed approach with interpolation.

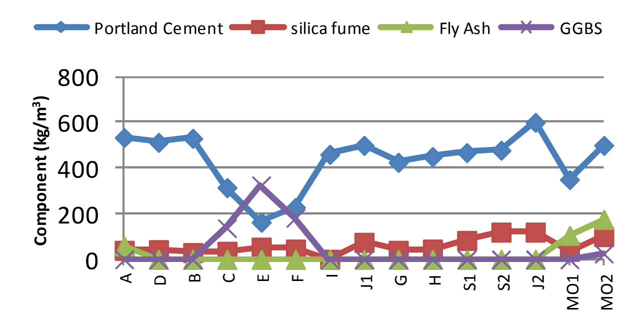


Fig. 1 : Mix Proportions for some HPC :
A,D: United States; B,C,E,F dan I : Canada; J1.2: Indonesia G: Marocco; H: France ; S 1.2: Sobolev; MO 1.2 : Magee and Olek

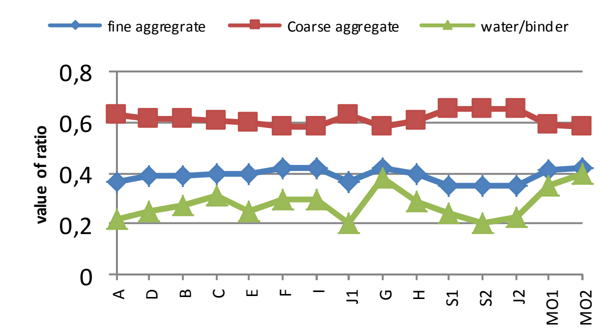


Fig. 2 : Ratio of fine aggregate, coarse aggregate and water binder of Mix Proportions for some HPC

Mix proportion obtained f'c 60 MPa and f'c 80 MPa as table 2. meanwhile f'c 40 MPa mix proportion by readymix producers are used on one project as a comparison.

Table 2. Mix proportions

Mixture Proportions Kg/m^3	f'$_c$ 40 MPa	f'$_c$ 60 MPa	f'$_c$ 80 MPa
Cement	412	500	600
Fly ash	73	-	
Silica fume	-	75	120
Ratio water /binder	0.39	0.20	0.23
Water	189	115	165,5
Sand	634	641	603
Gravel	1038	1092	1119
Superplastizier			
Pozzolith 100 Ri ex BASF	1,44	-	-
Viscocrete 10 ex Sika	-	3,45	15

Water/binder ratio is an important factor in success of HPC, previous research suggests that HPC water/binder ratio of 0.23- 0.25, gives the compressive strength 75-150 MPa (Aitchin and Mindes 2011; Sobolev, K.G. and Soboleva, S.V. 1998)
In making the test specimen, the following mixing procedure can be used obtain a very good workability with a good coating on the coarse aggregate to protect alkali reaction (Zongzin Li, 2011). Steps that done is preparing the specimens :

1. Coarse aggregate +50% water + 50% cement : mixing for 30 sec to 1 min.
2. Adding 50% cement + 25% water + superplasticier + fine aggregate: mixing for 2 min.
3. Adding 25% water : mixing for 3 min.

The specimen are demolded at 24 hour and then cured in a standard watering place at room temperature. The Compressive test using standard ASTM C 39/C 39M-04a with the specimen size 100 mm x 200 mm, testing for concrete ages 1, 3, 7,28, and 56 days. Meanwhile to test the permeability test DIN 1048 part 5, standard used specimen size 200mm x 200mm x120 mm. Rapid Chloride Permeability Test using the standard ASTM C 1202. A standard specimen has a nominal diameter of 100mm and thickness of 50 mm, cut from the center of a cylinder sampel.

Results And Discussion

The result for compressive strength is shown in Fig.3. This result shows that that local materials with similar composition of the mixture can produce compressive strength higher than f'$_c$ 60 MPa and f'$_c$ 80 MPa. While the RCPT result as in Fig. 4. For 40 MPa : 1050 coulombs, f'$_c$: 60 MPa : 990 Coulombs, and f'$_c$: 12,5 coulombs lower. Permeability test result as shown in Fig.5 for f'$_c$ 40MPa: 4.0 cm, f'$_c$ 60 MPa : 3.5 cm dan f'$_c$: 80 MPa : 2.4 cm. HPC produced a compressive strength and durability is good, because increasing dense and homogeneous concrete.

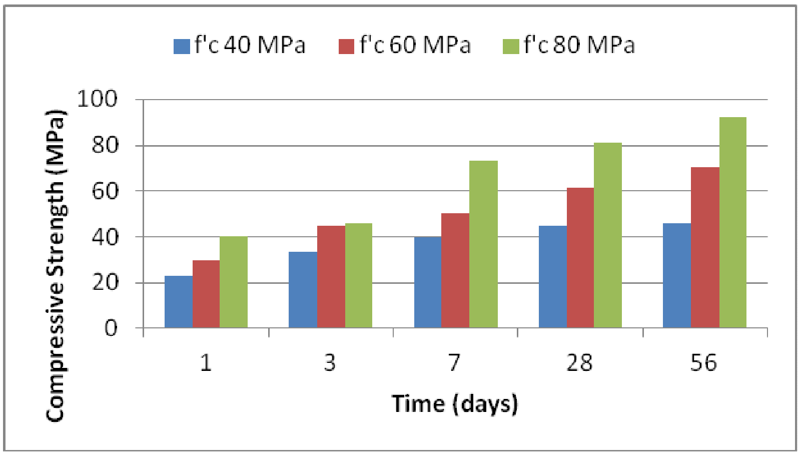
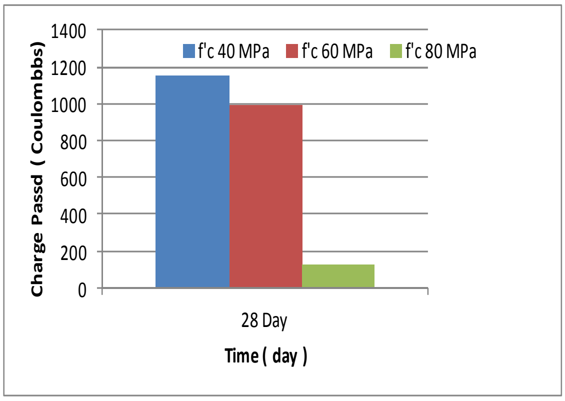


Fig. 3: Result of Compressive Strength



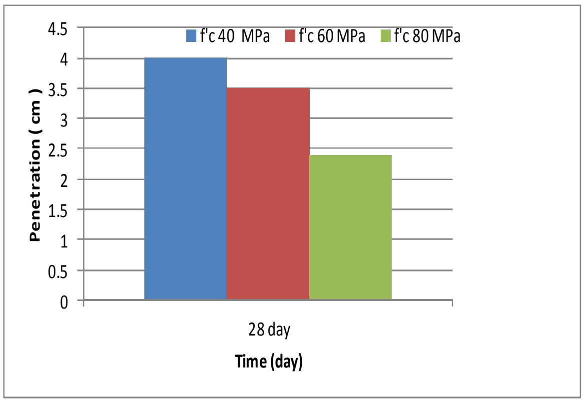


Fig. 4 : Result of RCPT

Fig. 5: Result of Permeability

The maximum coarse aggregate size mainly influences the cement paste requirement in the concrete. The aggregate shape and texture can influence the workability, bonding , and compressive strength. At the same water/binder and with the same cement content, aggregate with angular shape and angular and rough surface texture result in lower workability but lead to better bond and better mechanical properties. Sand/coarse aggregate ratio will influence the packing of concrete. Increase of the sand to coarse aggregate ratio can lead to an increase of cohesiveness, but reduces the consistency. Of all the measure for improving the cohesiveness of concrete, increasing sand/coarse aggregate ratio has been proven to be the most effective one. The aggregate /cement ratio has an effect on the concrete cost, workability, mechanical properties, and volume stability. Increasing the aggregate/cement ratio will decrease the cost of concrete, and improve concrete's dimension stability due to reduction of shrinkage and creep. The concrete properties, both in fresh and hardened states, can be modified or improved by admixture, concrete strength can be improved by silica fume. For high performance concrete with f'_c 60 MPa, and f'_c 80 MPa, the strength of aggregate control the strength of aggregate. So the selection of high quality aggregate is critical to produce High performance concrete.

Conclusion

1. Locally available materials turned out to be development to produce High Performance Concrete satisfying the requirements for strength and durability.
2. High Performance Concrete can be produced quite easily in ready mix industry using similar process and locally available materials.

References

[1] Gjorv,E and Sakai, K. Concrete Technology for sustainable for Development in the 21st century. spon Press(UK). (2004).

[2] C Aitcin, Piere. And Mindess, S , C.W . Sustainability Of Concrete, Spon Press, 2011

[3] Schmidt, M Habil(2008), Concrete of Future-Highly Developed and sustainable, BBM Viena.

[4] Sobolev, K.G. dan Soboleva, S.V. High–Performance Concrete Mixture Proportioning. ACI Special Publication. (1998). SP179-26 .

[5] Shi, Caijun dan Y.L. Mo. High-Performance Construction Materials, Science and Aplications. World Scientific, New Jersey, 2008.

[6] El-Reedy, Mohammad (2009) Advanced Materials and Techniques for Reinforced Concrete Structures, GRC Press p 153-189

[7] Magee, B.J dan Olek, J. High-Performance Concrete for Higway Structures: A General Review of Definition, Mixture Proportion and Performance Levels, Symposium Proceedig of CI/FHWA/FIB International Symposium on High Performance Concrete, Ed Johal, L.S., Orlando, Florida, USA, 2000

[8] Li, Zongjin. *Advanced Concrete Technology.* John Wiley & Hoboken, New Jersey, 2011

[9] ACI 211.4 R-08. Guide for selecting proportions for High-Strength Concrete Using Portland Cement and other cementitious Materials.

[10] Mehta P. Kumar and Monteiro,JM Paulo, Concrete Microstructure, properties, and Materials, McGraw-Hill, third edition, 2006.

Advanced Building Materials and Sustainable Architecture
10.4028/www.scientific.net/AMM.174-177

Development of Mix Proportion for High-Performance Concrete Using Locally Available Ingredients Based on Compressive Strength and Durability
10.4028/www.scientific.net/AMM.174-177.1067