EFFECT OF BENTONITE ON FRESH AND HARDENED PROPERTY OIF SELF COMPACTING CONCRETE

Muhammad Ali Musarat, Sanaullah, Sikandar Hayat Khan, & Kifayat Ullah
Department of Civil Engineering, Sarhad University of Science & Information Technology, Peshawar, Pakistan
E.mail: muhammadalimusarat@yahoo.com

Abstract

Self compacting concrete can be described as a high performance material which flows under its own weight without requiring vibrators to achieve consolidation by complete filling of formworks even when access is hindered by narrow gaps between reinforcement bars. Self compacting concrete required a large amount of binder (paste) and chemical admixtures. This paper presents the use of bentonite in self compacting concrete as viscosity modifying agent (VMA). Bentonite as VMA and other chemical admixture which are liquid form of VMA are compared to check the fresh and hardened properties of self compacting concrete such as, Slump flow, funnel, L-box , sieve stability tests, further compressive strength of the self compacting concrete at the age of 28 days was determined.

1. Introduction

Self-Compacting Concrete (SCC), which flows under its own weight and does not require any external vibration for compaction, has revolutionized concrete placement. SCC, was first introduced in the late 1980's by Japanese researchers, is highly workable concrete that can flow under its own weight through restricted sections without segregation and bleeding [1]. The constituent materials used for the production of SCC are the same as those for conventionally vibrated normal concrete except that SCC contains a lesser amount of aggregates and larger amount of powder (cement and filler particles smaller than 0.125 mm) and special plasticizer to enhance flowability. Fly ash, glass filler, limestone powder, silica fume, etc. are used as the filler materials. High flowability and high segregation resistance of SCC are obtained by using: (i) a larger quantity of fine particles, i.e. a limited aggregate content (coarse aggregate: 50% of the concrete volume and sand: 40% of the mortar volume) (ii) a low water/powder ratio; and (iii) a higher dosage of superplasticizer and stabilizer [2]SCC is defined by two primary properties: Deformability and Segregation resistance. Deformability or flowability is the ability of SCC to flow or deform under its own weight (with or without obstructions). Segregation resistance or stability is the ability to remain homogeneous while doing so. High range water reducing admixtures are utilized to develop sufficient deformability. At the same time, segregation resistance is ensured, which is accomplished either by introducing a chemical VMA or by increasing the amount of fines in the concrete. These viscosity modifying admixtures are very expensive and the main cause of increase in the cost of SCC [3].

For concrete to be self-compacting it should have filling ability, passing ability and resistance against segregation. Self-compactability is obtained by limiting the coarse aggregate content and using lower water powder ratio together with the addition of super plasticizers [4].

In Pakistan Bentonite is present an abundance and are available in very low price in market.

This study focus on the suitability of bentonite as viscosity modifying agent in SCC. The use of bentonite in SCC mix produce desire result, reduce cost and green environment.

2. Materials

2.1 Cement

ASTM C150 TYPE 1 Ordinary Portland cement which is extensively used in (Pakistan) was used in this study. Its physical and chemical properties are as given in Table 1.

Table1 Chemical analysis of Bentonite

Oxides	%
L.O.I	2.805
SiO2	20.755
Al2O3	5.563
Fe2O3	3.349
CaO	62.301
MgO	1.495
SO3	2.555
I.R	0.688
C3A	9.075
L.S.F	0.904

2.2. Bentonite

Bentonite which have pozzolonic properties and is used as (VMA) ….. Its chemical properties are as given in Table 2.

Table 2 Chemical analysis of Bentonite

Oxides	%
SIO2	49.634
Al2O3	21.118
Fe2O3	3.235
CaO	12.563
MgO	3.591
SO3	0.163
K2O	2.091
Na2o	0.499
TiO2	0.498
MnO	0.07
P2O5	0.119

Cr2O3	0.007

2.3. Admixtures

Super plasticizer (SP) is an essential component of SCC to provide the necessary workability. The main purpose of using a super plasticizer is to produce flowing concrete with very high slump that is to be used in heavily reinforced structures and in places where adequate consolidation by vibration cannot be readily achieved. The other major application is the production of high-strength concrete at w/c's ranging from 0.3 to 0.4.alsoViscocrete a chemical admixture which is used as viscosity modifying agent to reduce segregation and made the concrete viscous and flow able.

2.4. Aggregates

Locally available natural sand (Derwazgai Nizampoor) with 4.75 mm maximum size was used as fine aggregate.Crushed stone (Margala Islamabad) with 19mm maximum size was used as coarse aggregate.

Table3. Physical properties of aggregate

Physical tests	Coarse aggregate	Fine aggregate
Specific gravity	2.7	2.6
Fineness modulus	-	2.77
Bulk density(kg/m)	1560	-

2.5. Water

Drinking water is used for mixing and curing.

Mix design for self- compacting concrete.

According to European guide line to achieve self compactability, the following principles will be followed;

- lower coarse aggregate content
- increased paste content
- low water/powder ratio
- increased superplasticiser
- sometimes a viscosity modifying admixture [5]

Okamura and Ozawa (1995) have employed the following methods to achieve self compactability of SCC:

1. Limited aggregate content (coarse aggregate 50% of the concrete volume and sand 40% of the mortar volume);
2. Low water/powder ratio; and
3. Use of higher dosage of superplastcizer [6]

- Initial mix design was carried out at coarse aggregate content of 50%by solid volume of concrete and fine aggregate 40% by volume of mortar in concrete and a water powder ratio was kept at 0.45 with super plasticizer content of (2%).
- Coarse aggregate content was further reduced and fine aggregate content was increased with different dosage of super plasticizer until a slump flow of 650-800mm is achieved by slump flow test. For each trial, test is carried out in order that the mix satisfies slump flow test, V-funnel test and L-box test.

- To proceed toward achieving SCC, the coarse aggregate content was reduce to 36% by volume of concrete, fine aggregate content at 49.5% by volume of mortar in concrete and super plasticizer content at 2 t0 3.5% of powder content i.e. cement and bentonite.

The water powder ratio was fixed at 0.4 by mass for all the trials as shown in the table below.

Table 4 Mix proportion

Mix name	Water (kg/m3)	Cement (kg/m3)	Bentonite (kg/m3)	Fine Aggregate (kg/m3)	Coarse Aggregate (kg/m3)	Super-Plasticizer (%)	Viscocrete (%)	w/powderby weight
SCC(Vis)	200	500	-	860	790	2.5	2	0.4
SCC	200	500	-	860	790	3	2	0.4
SCC	200	500	-	860	790	3.5	2	0.4
5%B								
SCC1	200	475	25	860	790	2.5	-	0.4
SCC2	200	475	25	860	790	3	-	0.4
SCC3	200	475	25	860	790	3.5	-	0.4
7%B								
SCC4	200	465	35	860	790	2.5	-	0.4
SCC5	200	465	35	860	790	3	-	0.4
SCC6	200	465	35	860	790	3.5	-	0.4
10%B								
SCC7	200	450	50	860	790	2.5	-	0.4
SCC8	200	450	50	860	790	3	-	0.4
SCC9	200	450	50	860	790	3.5	-	0.4

After trial mix the above mixes are selected for different %age of bentonite and vescocrete, in first three mixes the vescocrete was used as viscosity modifying agent and in the other mixes bentonite is used as viscosity modifying agent which fulfill the requirement of self compacting concrete mixes.

3. Fresh Properties

Fresh concrete tests: Once a satisfactory mix is arrived at, it is tested in the lab for properties like flowing ability, passing ability and blockage using Slump Cone, L-Box, U-Box and V-funnel apparatus [7].

Table 5 Recommended Limits for Different Properties of SCC

Sr. No.	Property	Range
1.	Slump Flow Diameter	500-700 mm
2.	T_{50cm}	2-5 sec
3.	V-funnel	6-12 sec
4.	L-Box H2/H1	≥ 0.8

3.1. Slump Flow

The slump flow test was carried out according to (EFNARC-2002). Figure shows the accessories used for the slump flow test. The dimensions of cone used in this test are same as that used for slump test (i.e. 200 mm bottom diameter, 100 mm top diameter and 300 mm height). The diameter of the concrete after allowing its full flow, as shown, was taken as slump flow value.

Table 5 Slump Flow Result

Mix name	Super plasticizer (%)	Slump flow(mm)
SCC (2%VIS)	2.5	600
SCC	3	680
SCC	3.5	720
SCC1 (5%B)	2.5	590
SCC2	3	565
SCC3	3.5	705
SCC4 (7%B)	2.5	575
SCC5	3	670
SCC6	3.5	690
SCC7 (10%B)	2.5	570
SCC8	3	655
SCC9	3.5	675

3.2. Slump T-50

It is the time noted when the slump cone is left upward and concrete cover 500mm 0r 50cm diameter.

Table 6 lump flow T50 (sec) Result

Mix name	Super plasticizer (%)	Slump T50(Sec)
SCC (2%VIS)	2.5	5
SCC	3	3
SCC	3.5	2
SCC1 (5%B)	2.5	6
SCC2	3	3
SCC3	3.5	2
SCC4 (7%B)	2.5	8
SCC5	3	4
SCC6	3.6	3
SCC7 (10%B)	2.5	9
SCC8	3	6
SCC9	3.5	4

3.3 V-Funnel test

V-funnel test is used to determine the filling ability (i.e. flow ability) of SCC. The test results are shown in Table7.

Table 7 V-Funnel Test Result

Mix name	Super plasticizer (%)	V-funnel(sec)
SCC (2%VIS)	2.5	13
SCC	3	7
SCC	3.5	5
SCC1 (5%B)	2.5	13
SCC2	3	10
SCC3	3.5	8
SCC4 (7%B)	2.5	14
SCC5	3	11
SCC6	3.5	9
SCC7 (10%B)	2.5	16
SCC8	3	12
SCC9	3.5	10

3.4 L-Box Test

The L-box test method uses a test apparatus Comprising a vertical section and a horizontal trough into which the concrete is allowed to flow on the release of a trap door from the vertical section passing through reinforcing bars placed at the intersection of the two areas of the apparatus (Figure 4)6. The concrete ends of the apparatus H1 and H2 measure the height of the concrete at both ends. The L-box test can give an indication as to the filling ability and passing ability. The test results are shown in Table 8.

Table 8. L-Box test result

Mix name	Super plasticizer (%)	L-box
SCC (2%VIS)	2.5	0.8
SCC	3	0.9
SCC	3.5	1
SCC1 (5%B)	2.5	0.8
SCC2	3	0.8
SCC3	3.5	0.9
SCC4 (7%B)	2.5	0.7
SCC5	3	0.8
SCC6	3.6	0.9
SCC7 (10%B)	2.5	0.5
SCC8	3	0.8
SCC9	3.5	0.8

3.5. Sieve Stability Test

This test is use to check the resistance to segregation of self-compacting concrete .in this we check the passing percentage of SCC through a sieve size of 5mm. The test results are shown below in table 9.

Table 9 Sieve Stability Test Result

Mix Name	% PASSING(Avg)
SCC (2% VIS)	19.5
SCC (5%B)	19.1
SCC(7%B)	17.03
SCC(10%B)	15.5

4. Hardened Properties

In hardened properties of self compacting concrete only the compressive strength of self compacting concrete was determine.

4.1 Copressive strength

In hardened properties of (SCC) we checked the 28^{th} day strength of concrete cylinder in Universal testing machine. The test result are shown below in table 10.

Table 10 Compressive Strength Test Result

Mix name	Super plasticizer (%)	28^{th} day strength (psi)
SCC(2%VIS)	2.5	5850
SCC	3	5600
SCC	3.5	5800
SCC(5%B)	2.5	5400
SCC	3	5400
SCC	3.5	4800
SCC(7%B)	2.5	5050
SCC	3	4800
SCC	3.5	4950
SCC(10%B)	2.5	4850
SCC	3	4700
SCC	3.5	4800

5. Cost Comparison of Self Compacting Concrete per Cubic Meter

The cost comparison of self compacting concrete for viscocrete and Bentonite was determine. The cost of bentonite as viscosity modifying agent was 24.5% less than that of Viscocrete as both have the same properties. The cost comparison is shown in table 11.

Table11. Cost Comparison

Material	Weight(Kg)	Cost (Rs)	Material	Weight(Kg)	Cost (Rs)
Cement	500	4000	Cement	465	3720
Coarse Agg	790	310	Coarse Agg	790	310
Fine Agg	860	230	Fine Agg	860	230
Plasticizers	15	975	Plasticizers	15	975
Viscocrete	10	1700	Bentonite	35	210
Total		7215	Total		5445

Percent reduction in cost using bentonite =24.5%

1. Conclusion

- By using different percentages of bentonite we can improve 'the fresh properties of self compacting concrete. It increases resistance to segregation and viscosity.
- By using of bentonite we developed low cost self compacting concrete up to **24.5%** than other SCC. Low cost self compacting concrete can be made by adding different percentages of Bentonite (**5%**, **7%**, **and 10%**) along with the main ingredients of concrete (cement, fine aggregate and coarse aggregate) and super plasticizer for flow ability.
- As by increasing the % of bentonite it increase the viscosity which show poor fresh properties of self compacting concrete, upto 7% of bentonite we have achieve better fresh properties as we incrseas the % of bentonite causing poor fresh properties of SCC.
- Also replacing the bentonite with cement reduce the pollution that are produce during cement manufacturing.
- As we increasing the % of bentonite, it reduce the compressive strength of SCC

References

1) Paratibha Aggarwal, Rafat Siddique, Yogesh Aggarwal, Surinder M Gupta,Self-Compacting Concrete Procedure for Mix Design, Leonardo Electronic Journal of Practices and Technologies,2008
2) Shamsad Ahmad, AbulKalam Azad and Mohammed Abdul Hameed,A study of self compacting concrete made with marginal aggregates, King Fahd University of Petroleum & Minerals Dhahran, Saudi Arabia,2008
3) Shazim Ali Memon, Muhammad Ali Shaikh,and Hassan Akbar, Production of Low Cost Self Compacting Concrete Using Rice Husk Ash , First International Conference on Construction In Developing Countries,2008
4) B.H.V. Pai1, M. Nandy2, A. Krishnamoorthy, P.K.Sarkar., Philip George, Comparative study of Self Compacting Concrete mixes containing Fly Ash and Rice Husk Ash,20014
5) The European Guidelines for Self-Compacting Concrete, www.efnarc.com,2005
6) Mohammed Abdul Hameed, A study of mix design and durability of selfcompacting concrete, 2005.
7) B.H.V.Pai,M,Nandy,A.Krishnamoorthy,P.K.Sarkar Philip George, Comparative study of Self Compacting Concrete mixes containing Fly Ash and Rice Husk Ash,2014.