

APPLICATION OF SELF CONSOLIDATING CONCRETE IN CONSTRUCTION INDUSTRY

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ABSTRACT

Self consolidating concrete (SCC) is a novel concrete which uses in many structures in all over on the world. It is a concrete which flows under own weight and completely fills the mold, passes from congested reinforcement without any bleeding or segregation. This type of concrete contains high range water reducing admixture and often viscosity modifying admixture also more fine aggregate compared to conventional concrete. It can reduce labor requirement, increase strength, durability and productivity, eliminate noise and hazard. For these good specifications, SCC uses in improper reach concreting, dense reinforcement elements, thin layer concrete construction and so on. Mahab Ghodss consultant engineering applied SCC in some Dams and tunneling projects. This article presented some executive experience of three projects which some structure of them constructed by SCC successfully. Finally some recommendation for mix design and whole scale construction SCC in site are proposed.

Keywords: self consolidating concrete, concrete, mix proportion, rheological tests

1. INTRODUCTION

Self Consolidating Concrete (SCC) is a concrete that able to flow under its weight and completely fill the formwork, even in the presence of dense reinforcement, without the need of any vibration, while maintaining homogeneity [1].

It was first developed in Japan in 1986 [2]. SCC is used mainly for repair applications and for casting concrete in restricted areas [3]. Though showing good performance, SCC used in Japan, America and Europe and many countries in buildings, bridges, tunneling and other applications [4].

SCC can accelerate placing and reduce labor requirement, increase strength, durability and productivity, eliminate noise and hazard, but little increasing in material cost [3]. Mahab Ghodss consultant engineering as a pioneer in application of novel technology uses SCC in some project such as Karoon III Dam and power plant, Resalat tunnel and Gotvand dam and power plant. In this article specification of these SCC concrete are presented.

2. APPLICATION OF SCC IN KAROON III DAM AND POWER PLANT

Project of Karoon III Dam and power plant sited in 28 Km east of Izeh city. The main objects of this project are:

- Supply 4172 Gw.hr power in year



- Supply agricultural water for 120 Km² land
- Flood control of Karoon river

SCC is used in entrance structure of orifice in this dam. This structure located out of reach of cable crane and because the level of around blocks is lower than this block, pumping concrete rate is low and so, it might create cold joint in the structure. Also this structure had congested reinforcement. For whole above reasons, this structure must construct with SCC. Figure 1 shows the plan of this structure.

The cement used was type II. Maximum size of aggregates was 19 mm, sand to total aggregates ratio, water to cement ratio and paste amount were 0.58, 0.42 and about 300 respectively.

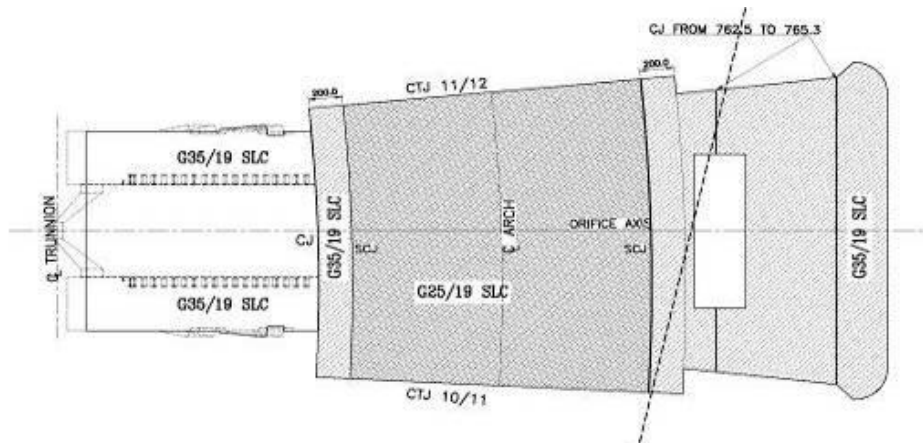


Figure 1. Plan of structure

A high range water reducing admixture which is type A, F according ASTM C494 [5] with density of 1050 also was used. The mixture proportions are presented in Table 1.

Table 1: Mixture proportions

Description	Coarse Agg.	Fine Agg.	Cement	Water	HRWR
Unit	Kg	Kg	Kg	m ³	% by weight of cement
Amount	775	1080	380	0.160	1

For shortening concrete placing area and avoiding large movement of concrete in the forms, temporary construction joints were applied.

V- Funnel and T-50 tests were drawn for fresh concrete according EFNARC [1]. Figure 2 and 3 shows the V-Funnel and T-50 tests apparatus. Compressive strength of 28 days concrete was tested according ASTM C39 [6]. Table 2 shows average of test results. The orifice concreting is shown in Figure 4.



Figure 2. V-Funnel tests apparatus



Figure 3. T-50 tests apparatus

Table 2: Average of test results

Description	T-50	V- Funnel	Compressive strength
Unit	Sec	Sec	Mpa
Amount	3.5	9	35



Figure 4. Orifice concreting



3. APPLICATION OF SCC IN RESALAT TUNNEL

Resalat tunnel is a key project which relating east and west section of Resalat highway. In this project B section of lining was built lastly and it hadn't proper access. Construction of this section with conventional concrete might cause many voids and this structure would be very weak. So we had to create SCC to build this section. Figure 5 shows the section of the tunnel lining.

In situ piles were constructed by SCC because of improper reach, congested reinforcement, and lack of vibration and also long height of concrete shooting. The SCC pile is shown in Figure 6.

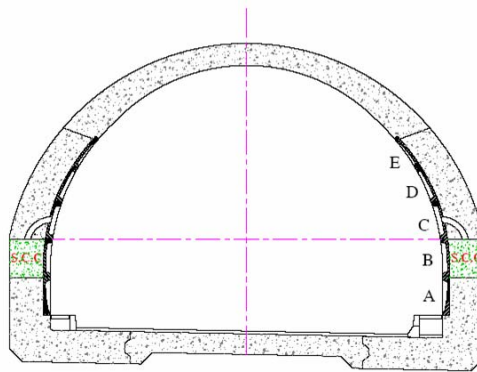


Figure 5. Lining section



Figure 6. The SCC pile

Maximum size of aggregates was 20mm and sand to total aggregates ratio, volume of paste and water to cement ratio were 0.69, about 360lit/m³ and 0.42 respectively. High range water reducing admixture, viscosity modifying admixture were used for achieving SCC with good rheology. Also for increasing stability of fresh concrete and resistant against segregation and bleeding inert filler was added to mixture. For compensating shrinkage strain of concrete an expanding admixture also added to SCC mixture. The mixture proportions are shown in Table 3.

Table 3: Mixture proportions

Description	Coarse.Agg Agg.	Fine.Agg Agg.	Cement	Water	Filler	HRWR	VMA	EX.A
Unit	Kg	Kg	Kg	Kg	Kg	Lit	lit	lit
Amount	530	1200	400	167	100	3.6	2.0	2.7



Slump flow and V-Funnel tests were drawn for fresh concrete according EFNARC[1]. The Result of tests is presented in table 4.

Table 4: Test results

Description	Slump flow	V-Funnel
Unit	mm	Sec
Amount	680	9

4. APPLICATION OF SCC IN GOTVAND DAM AND POWER PLANT

Gotvand dam and power plant project located in 25 Km north of shooshtar city. The major objects of this project are:

- Supply 4250 Gw.hr power in year.
- Supply agricultural water
- Flood control of Karoon river

SCC is used in some structure of this project such as around of steel lining, around of penstocks, around of spiral cases, paving of seal beam and etc. In this article concreting around of steel lining is described.

In this structure because of erection of steel pipes and multiplicity of stiffeners, there is no proper reach to molding. In such cases application of conventional concrete may cause poor concrete with many entrapped air and voids. For preventing this disease, SCC is used to concreting the structure.

Maximum size of aggregates was 19mm and sand to total aggregates ratio, volume of paste and water to cement ratio were 0.58, about 310lit/m³ and 0.43 respectively. A high range water reducing admixture also was used to increase filling ability of concrete. The mixture proportions are shown in Table 5.

Because fine aggregate used in this project had proper grading, additional fillers or mineral additive wasn't required.

The slump flow test [1] and visual inspection were drawn for fresh concrete. The average of slump flow test was 675mm. Slump flow spread is shown in Figure 7.



Figure 7. Slump flow spread

**Table 5: Mixture proportions**

Description	Coarse Agg.	Fine Agg.	Cement	Water	HRWR
Unit	Kg	Kg	Kg	m^3	% by weight of cement
Amount	796	1082	380	0.164	1

5. SUMMARIZE

According to large scale SCC experience, the following recommendations are proposed:

- SCC used where it is required such as improper reach to formwork, congested reinforced concrete, thin layer concreting and so on.
- For decreasing loss of workability by time, water to cement ratio must select more than 0.4 but for increasing workability, it doesn't require increasing free water and it can accomplish by use of chemical admixtures.
- The sand used in SCC has lower fineness modulus than conventional concrete.
- Total volume of aggregates, maximum size of aggregates, average diameters of aggregates and sand grading are the significance parameters in SCC mix design.
- SCC requires curing much than conventional concrete to prevent plastic shrinkage, loss of strength and cracking.
- SCC is more sensitive to aggregate grading especially fine aggregate, amount of cement and mineral additive of filler and amount of HRWR.
- Application of SCC in construction requires more strength and no leaking formwork than conventional concrete.

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