Assessment of Self Compacting Concrete in Sea Water Solutions

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Abstract- *Self compacting concrete has always been seen as a new era concrete since its beginning of evolution , it has surpassed many landmarks of concrete properties and characteristics which even the conventional concrete has not fulfilled in its life span . In this paper, we will be investigating the affect on its mechanical properties i.e Compressive , Sea water solution of concrete by involving sea water as mixing water and curing water also involving pure water as mixing and curing water and making combination of mixing and curing of both types of water(illustrated in the paper later) and noticing the their effect on the self compacting concrete . The purpose of involving sea water is to enlighten the fact that the fresh water in lakes, rivers and ponds have been depleting since ages and there is huge possibility of inadequacy in the amount of fresh water in the very near future , it is estimated that in the near future, fresh water will be very difficult to get and scarce. It is said that in 2025 nearly 50% of the human beings will live in the localities where fresh water is not enough. Also, UN and WMO are predicting 5 billion(nearly 80%)people will be in short of even drinking water. This paper will allow you an insight how self compacting concrete behaves in its fresh and hardened state when a water other fresh water is employed for the purpose of curing and mixing . The combinations used are as follows :*

a) Mixing water : Fresh , Curing water : Fresh
b) Mixing water :Fresh , Curing water : Sea water solution
c) Mixing water : Sea water , Curing water :Fresh Water
d) Mixing water : Sea water , Curing water : Sea Water

The following above combination would be tested for workability by Slump flow , L-Box and V-funnel Tests and their respective hardened properties of Compressive , Flexure strength using 150mm Cube , 100x100x500 Beam in 7 and 28 days curing with respective waters and analyzing their characteristics and working out for the data obtained from the specimens .

Keywords- Compressive strength ,Flexure, Sea water solution, Self compacting concrete, workability

I. INTRODUCTION

When we traverse through the analogy of the construction history we find concrete as a revolutionary milestone achieved through the centuries whether for its binding properties or hardening stature for acquiring a durable ,strong ,long lasting and withstanding structures in the coarse of the last century decades , but as we go minutely observing the inhibition how the concrete structures go through such transitions when we place the concrete work it through the formworks or the complete rheology of concrete's pathway we reach some strange problems of having " not enough workability " or unreliable , inadequate strength whether by involving water/cement ratio , aggregate sizing ,specification or by using admixture of different purposes . The major hindrances arises when the concrete is exposed in extreme environment such as heavy congested reinforcements ,sea water sprays ,extreme climatic conditions etc . This paper enlightens the effectiveness of a new age concrete referred as *"self compacting concrete"* , as the name suggests self compacting or self consolidating concrete is a new age concrete which has a capability of compaction through itself , its easiness in compacting make it highly workable concrete even in extreme conditions without sacrificing concrete's basic characteristics of strength and durability . Since its evolution and arrival in the 1980s, the use of SCC has grown enormously. The development of high performance *polycarboxylate polymers* and viscosity modifying admixtures have made this thing possible to create "flowing" concrete without compromising durability, cohesiveness, or compressive strength. The flowability of SCC is measured in terms of spread when using a modified version of the slump test (ASTM C 143). The spreading (slump flow) of SCC typically ranges from 455 to 810 mm depending on the requirements for the project. The viscosity, as visually observed by the rate at which concrete spreads, is an important characteristic of plastic SCC and can be controlled when designing the mix to suit the type of application being constructed.

In our paper, there is an intrusion of *sea/salt water solution* with the *self compacting concrete* and analyzing its basic mechanical and compressive strength by employing the use of cubes , beams and cylinder moulds and testing its compressive , flexural and split tensile strength respectively. The invention of *self compacting concrete* has brought new horizons of development in the infrastructure of any firms economy whether small scale , large scale or even the countries which demand a rapid fast exposure of evolving markets and their industrialization growth and increasing efficiency for high rate and quality construction and development works . Now coming back to our platform of interest is that how to measure the capability of concrete largely depends on its placement and rheology and if self compacting concrete comes as ultimate and non trivial solution of our problem then why not impleting it on larger basis which many countries like Japan, have already accepted self compacting concrete as an idealistic solution to construction processes also because of the susceptibility of earthquake in that whole region . As most of the countries have their important key and vital cities near the sea shores and even some countries like Singapore , Indonesia, Japan, Bali , Sri Lanka are islands in themselves which makes them remote position for acquiring fresh water as their main source of water supply because as described earlier world is reaching the threshold limit of availability of fresh water so as to come up with sea water usage in structural works would not be a hoax . Although sea water may in near future seem to be a vivid idea of holding the fresh water safely in natural deposits for basic daily life uses.

[1]Okamura H., Ozawa K. and Ouchi M. were the very early of the investigators for determining the properties of self compacting concrete for main structural uses and establishing it as main commercial concrete of high quality construction applications such as dam, chimneys, aqueducts, high rise towers and construction involving excellent surface finish and strength and durability.

[2]N. Venkat Rao, M. Rajasekhar, studied on high durability of self compacting concrete which employed specimen cured in Sulphuric acid, HCl and Sodium Sulphate solution for its resistance against sulphate and acid attacks , Self compacting concrete specimen resulted in higher durability against sulphate attacks than the conventional concrete because of its high impermeability due to presence of finely powdered material which is a must for Self Compacting Concrete.

1.1 MATERIAL USED

1.1.1 CEMENT

Ordinary Portland Cement of grade 43 was employed of Ultratech Limited conforming to IS 12269 1987

1.1.2 FLY ASH

Fly ash conforming to IS 3812-2003 of class F of NTPC Power plant was used with a specific gravity of 2.12

1.1.3 FINE AGGREGATE

Fine aggregate used was coarse sand of Ganges river deposits falling in grading zone 3 with a fineness modulus of 2.367 of specific gravity of 2.61 and slit content 2% conforming to IS 383 1970

1.1.4 COARSE AGGREGATE

Coarse aggregate used was crushed granite of nominal size 16mm of specific gravity 2.655 which was in accordance with IS 383 1970 , with a equal proportion of 10mm and 12.5mm.

1.1.5 ADMIXTURE

Super plasticizer used was PCE(Polycarboxilic Ether) based plasticizer of MYK Schomburg named Myk Remicrete PC 20 which was a type F(ASTM standards) High Range water reducer admixture which has ability of reducing water 20 to 25 %.

II. TESTS ON FRESH SELF COMPACTING CONCRETE

2.1 SLUMP FLOW TEST :

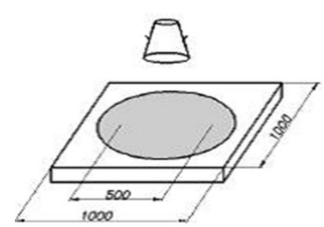


Fig.1. Slump flow test

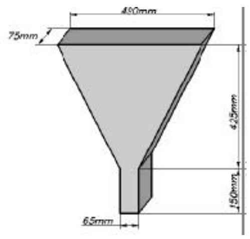
Slump flow test is one of the basic test method employed for SCC which requires an Abram cone or the conventional cone(inverted) ,concrete is poured from the top into the cone and lifted ghently to and concrete is allowed to flow through the cone after the final spreading the minimum and maximum dia of spread is measured and average is taken as final slump value .The value of slupm should vary between 450 to 850mm according EFNARC recommendations.

2.2 T50 TEST

T50 simply indicates the time taken by the mix to complete 500mm or 50cm spread dia . It is a measure of concrete’s flow ability as well as its viscosity because its rate at which the specified flow is completed. The time for T50 test should vary between 2 to 5 secs for the desired SCC requirements.

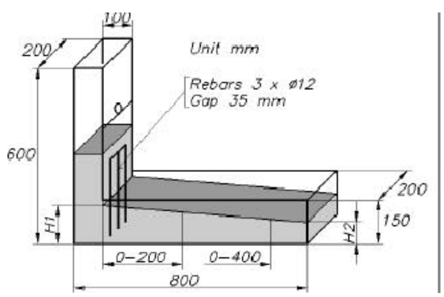
2.3 V-FUNNEL TEST

A V shaped funnel is filled with fresh concrete and the time is recorded for the concrete to flow out of the funnel is measured and recorded as the V-funnel flow time.V-Funnel test gives us the flow ability as well as the viscosity of the mix since it involves passing of the concrete through the opening within a required stipulated time.The time required fo the mix to flow thrugh the V Funnel is 6 to 12 secs for the high quality works such as slabs ,footings etc and 9 to 25 secs for normal works as ramps.



2.4 L-BOX TEST

L-BOX test is one of the major tests for the measurement of quality of SCC , it requires an L shaped box whose vertical side is stuffed with concrete keeping the door closed ,the mix is filled upto a required mark and then gradually the slit below the vertical side is gently lifted up which has atleast 2 to 3 rebars of 12mm dia steel , which the concrete is required to pass , when the concrete is filled in horizontal side , the ends are measured with scale naming the side at rebar as H1 and the farther side as H2, the ratio of H2/H1 is noted .



Recommended limits for satisfaction of standards of SCC

Sr. No.	Tests method	Range
1	Slump Flow	450mm-850mm
2	T50	2-5 secs
3	L-Box (H2/H1)	>_0.8
4	V-Funnel	6_12 secs

III. MIX DESIGN APPROACH

Although there is no exact design mix method for preparation of SCC ,hence it is a concrete which instigates a lot of hit and trial methods, but if have certain standards constant for this concrete it is easier to resolve the design mix probe .

Some objectives of mix design approach to be employed are as follows:

a. The fluidity and viscosity of the paste is compensated and balanced by carefully selecting and proportioning of the cement and additions, by limiting the water/binder ratio and then by adding a superplasticiser and (optionally) a viscosity modifying admixture. Correctly controlling these components of SCC, their compatibility and interaction is the key to achieving good filling ability, passing ability and resistance to segregation.

b. In order to control temperature rise and thermal shrinkage cracking as well as strength, the fine powder content may contain a significant proportion of type l or ll additions to keep the cement content at an acceptable level.

c. The paste is the vehicle for the transport of the aggregate; therefore the volume of the paste must be greater than the void volume in the aggregate so that all individual aggregate particles are fully coated and lubricated by a layer of paste. This increases fluidity and reduces aggregate friction .

d. The coarse to fine aggregate ratio in the mix is reduced so that individual coarse aggregate particles are fully surrounded by a layer of mortar. This reduces aggregate interlock and bridging when the concrete passes through narrow openings or gaps between reinforcement and increases the passing ability of the SCC.

The key factors which are essential for an SCC mix and which differ from the conventional vibrated concrete are as follows :

- Limiting the value of coarse aggregate by volume of total aggregate.
- Use of finely powdered additive in replacement of SCC.
- Adjusting the value of paste for required robustness of SCC.
- Low water/powder ratio by mass.
- Increased HRWRA superplasticizer for high flow and passing ability.

Okamura, Ouchi studied on the mix design approach and worked over a rational mix design method, the steps and key points they analysed over were:

- The coarse aggregate content were fixed at 50% of solid volume.
- The fine aggregate content was fixed at 40% of the mortar volume.
- The water-powder ratio by volume was assumed between 0.9_1 depending on the properties of powder.
- The super plasticizer and final water-powder ratio were determined to achieve self compactibilty.

[3]Pratibha Agarwal ,Rafat Siddique adopted the Japanese method of mix design procedure their initial mix design was carried out at coarse aggregate content of 50 percent by volume of concrete and fine aggregate content of 40 percent by volume of mortar in concrete, the water/powder ratio was kept at 0.90. These Trial mixes were designed with superplasticizer content of 0%, 0.76% and 3.80%.

IV. USE OF SEA WATER

As described in the abstract , the instigation of our study using sea water has strong and concerning purpose towards the limitation of fresh water reserves also the study is carried out in the city of Lucknow (India) where there is no availability of sea water and it is quite uneconomical to fetch the sea water from a city near the shores of India.

For that reason , many investigators have developed different formulas and trends for the preparation of sea water.

4.1 Preparation of Sea Water

During physiochemical studies, ,we use artificial rather than natural sea water to minimize the biological effects and to provide a reproducible solution of known composition. Delibrate attention has been given for preparing artificial sea water in that process, we have been successful in producing sound artificial sea water for experimental purposes .Formula for artificial sea water in given in Table 1.

V. EXPERIMENTAL STUDY

Basic Mix design method for self compacting qualities used in the study was the rational method with the following key parameters:

- Coarse aggregate content was kept between 43 to 50 % of aggregate volume to ensure fluidity in the mix.
- Water/Binder ratio was taken more than 0.9
- Coarse aggregate content was less than 35% of the total concrete volume.
- Fine Aggregate was more than 50% of the aggregate volume.
- Fine aggregate content was around 52% in mortar volume.

Paste volume (i.e.total volume -coarse aggregate-fine aggregate-mortar volume) was around 33% and different trial mixes were taken.

FORMULAE FOR ARTIFICIAL SEA WATER (Table 1)

Brujewicz (Subow,1931)

Salt	**g/kg**
NaCl	26.518
$MgCl_2$	2.447
$MgSO_4$	3.305
$CaCl_2$	1.141
KCl	0.725
$NaHCO_3$	0.202
NaBr	0.083
	34.421gm/1000 water

Table 2 The contents of trial mixes of SCC

Trial Mix	Binder(kg/m^3)	Cement (kg/m^3)	Flyash (kg/m^3)	Fine Aggregate (kg/m^3)	Coarse Aggregate (kg/m^3)	Water(litres)	S.P(% of binder)	W/powder ratio (by Vol)	W/P
TR1	480.39	408.33	72.05	951.7	863.9	172.9	1	1.04	0.36
TR2	511.07	434.4	76.66	946.8	852	182.5	1.36	1.049	0.38
TR3	511.07	434.4	76.66	897	807.30	182.5	1.36	1.049	0.38
TR4	504.58	428.89	75.8	928.61	722.56	206.5	1.1	1.2	0.41
TR5	504.58	428.89	75.68	878.105	683.26	206.5	0.7	1.2	0.41

The final trial mix(TR5) gave a comparable robust mix of SCC fulfilling of the criteria of Self compaction ,as content with higher percentages of Super placticizer starts setting early which created compaction problems but with 0.7% it gave a comparative good and highly workable mix.

The combinations used for mixing and curing of different types of SCC are given in Table 3

Table 3 showing combination of SCC used

SCC combination	Mixing Water	Curing Water
SCC1	Pure Water	Pure water
SCC2	Pure Water	Sea water
SCC3	Sea Water	Pure Water
SCC4	Sea Water	Sea Water

VI. TESTS AND RESULTS

TESTS CONDUCTED WITH TRIAL MIXES (Table 4)

MIX	SLUMP FLOW(mm)	T50(sec)	V-FUNNEL(Seconds)	L-BOX(H2/H1)
TR1	511	5.2	11.57	0.73
TR2	503	6.1	11.03	0.733
TR3	523	5.7	10.6	0.8033
TR4	606	4.87	9.6	0.8053
TR5	692	3.92	9.20	0.815

Slump flow test for fresh water

6.2 TESTS RESULTS FOR DIFFERENT SCC COMBINATIONS (Table 5)

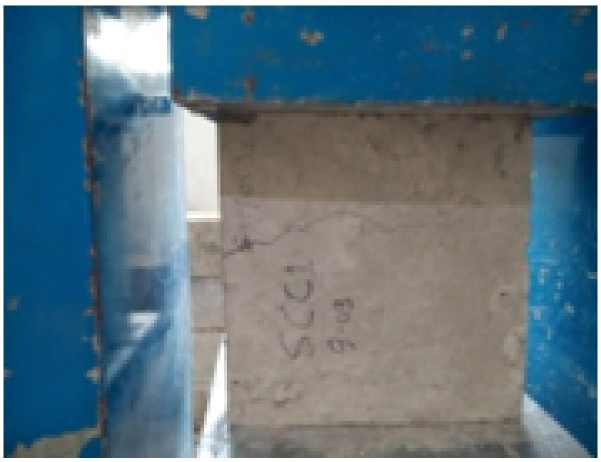
SCC MIX	(MIX/CURING)	SLUMP FLOW	T50	V-FUNNEL	L-BOX
SCC1	(PW/PW)	692	3.92	9.20	0.815
SCC2	(PW/SW)	675	4.68	9.30	0.82
SCC3	(SW/PW)	576	4.85	10.50	0.733
SCC4	(SW/SW)	560	5.33	10.70	0.74

L-Box test and casting specimen
V-Funnel Test

6.3 COMPRESSIVE STRENGTH TESTS AND RESULTS (Table 6)

A test result was taken as an average of at least three standard cured strength specimens made from the same concrete sample and tested after 7day and 28 day curing.Load was applied gradually as 140kg/m2 per minute.

SCC mix	(Mixed/Cured)	Compressive strength 7-Days(Mpa)	Compressive strength 28 days(Mpa)
SCC1	(PW/PW)	25.5	38.27
SCC2	(PW/SW)	25.82	36.88
SCC3	(SW/PW)	26.81	37.77
SCC4	(PW/PW)	26.75	38.32



6.4 FLEXURAL STRENGTH TEST AND RESULTS

Flexural strength of any specimen can be expressed as :

$$F_f = F.l/bd^2 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

Where F = Load Applied inKN on Specimen, L=Length of Specimen(500mm std), b=Breadth of specimen (100mm std.),d=Depth of specimen(100mm std.)

SCC Mix	Flexural Strength after 7-Days(MPa)	Flexural Strength after 28-days (MPa)
SCC1	4.015	6.585
SCC2	3.715	6.25
SCC3	3.915	6.315
SCC4	4.13	6.665

The method of loading used was Two Point Loading system

V. CONCLUSIONS

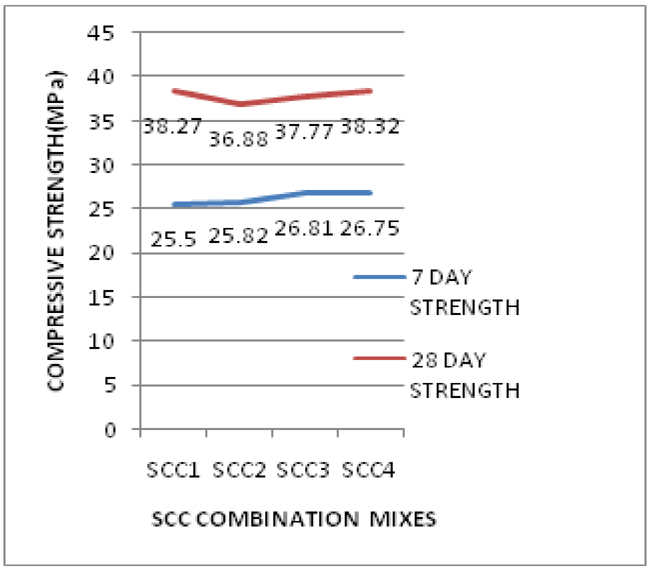
On Workability

- Slump Flow value of SCC mixed with sea water showed a decrease in the value by 16.76% with respect to the fresh water mixed SCC , this may due to the hardness in the presence of chlorides and sulphates present in sea water , this had quietly affect on the workability of the mix.
- T50 test value measured in seconds of SCC mixed with sea water showed an time increase of 23.72% with respect to the fresh water mixed sample which sufficient but not very good for workability purposes.
- V-Funnel test value in seconds noticed an increase of 14.13% with respect to fresh water mixed SCC which indicates a fall of passing ability as well as flow ability.
- L-Box test mix noticed a decrease in the value by 9.7% with respect to mix prepared by fresh water.

On Strength

- The early compressive strength in 7-day curing showed an increase in strength by a percentage of 1.2 for specimen cured with sea water with respect fresh water cured(SCC2) but the ultimate 28 day strength fell by 3.1% with respect to the specimen of SCC1 i.e. mixed andcured with fresh water.

- In case of SCC3 specimen i.e .mixed with sea water and cured by fresh water reflected an increase in early strength by 5.13% because of the possibility of salt content in sea water which initiates the formation of crystals which gives an strong intact reaction to compressive loads and makes concrete more dense as studied by [4]Pruckner, F and Gjorv, OE (2003) but the 28 day strength decreased by 0.7% of fresh water mixed specimen(SCC1).
- For Flexural strength behaviour early strength had loss of 7.2% and also it noticed a loss of 5.08% in 28 day flexural strength.
- For specimen SCC4 i.e. cured and mixed with sea water showed a gain in early strength by 2.8% and also seen an increase of 1.2% in 28 day cured strength.



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