EFFECT OF SEA WATER ON FRESH AND HARDENED PROPERTIES OF CONCRETE

[1]Dr.Santhosh B S, [2]Chitra K R, [3]Deepthi K P, [4]Prabhavati, [5]Santoshakumar
[1]Associate Professor and Head, [2, 3, 4&5]U.G Students
[1] Department of Civil Engineering,
[1]JSS Academy of Technical Education, Bangalore, India

Abstract : Concrete has an excellent structural performance and durability, but is affected by early deterioration when subjected to a marine environment. Therefore, the selection of materials and mix design are essential parameters in producing a durable marine structure concrete. So Addition of fly ash to the concrete mix in order to increase Fresh and Hardened properties of concrete and making the concrete more durable against sea water attack. Study on fresh properties of concrete prepared with portable and sea water using the concept of Rheology. The workability of fresh concrete should be characterized by its rheological properties based on material science approach to overcome the inadequacies of empirical test and is generally described by Bingham parameters in terms of two physical quantities namely yield stress and plastic viscosity. Systematic study of rheological properties using concrete shear test with specially designed and fabricated tool, is employed in this study for the first time for the fresh Portland cement concrete. The uniqueness of the test is that the values of rheological properties were found at zero normal stress and zero displacement rate and the stimulus provided to concrete is similar to that experienced by the concrete in the field. The concrete shear box can be used as a new tool effectively as a static test.

***Index Terms* – Sea Water, Rheology, Yield Stress, Plastic Viscosity**

I. INTRODUCTION

Concrete has been employed in construction exposed to the action of sea water for as long as concrete has been used. When concrete is to be employed under conditions in which it will be exposed to the effects of sea water, awareness should be taken of these effects and appropriate precautions taken. However, generally, these precautions are not intense, and do not involve the selection and use of unusual materials or procedures nor cause any significant increase in cost of production. The effects of sea water on concrete may conveniently be examined by considering, first, the factors characteristic of the sea-water exposure that can affect concrete; second, the elements of the specific concrete involved that may be affected by these factors; third, the consequences of the interaction of sea water with the concrete; and finally the precautions that should be taken to avoid undesirable performance of the concrete due to its interaction with sea water.

Rheology in the broad sense is the science of flow and deformation of matter. The placing, spreading, pumping and compaction of any concrete depends on Rheology. Using the science of Rheology, it is becoming possible to predict fresh properties, select materials and model processes to achieve the required performance. Rheology is now seriously considered by concrete user, rather than being seen as an area of specialized domain of cement science. The basic key rheological parameters are yield stress and plastic viscosity.

II. EXPERIMENTAL PROGRAMME

It deals with a materials characterization, details of concrete mix proportions using IS codes, methodology of determining the rheological properties of concrete using direct shear box, hardened properties of concrete prepared with normal and sea water is presented.

2.1 Materials Characterization

The brief descriptions of materials used in the study of fresh concrete mixes are as follows:

2.1.1 Cement

The cement used in the study was ordinary Portland cement (53 grade) having the physical characteristics as shown in the table 1.

Table 1 Physical Characteristics of cement

Properties	Values For Normal Water	Values For Sea Water
Normal consistency	29%	30%
Specific gravity	3.13	-
Soundness test	0.1mm	1.2mm
Air Blaine's Fineness	3058.32 cm^2/g	-

2.1.2 Fly Ash

Fly ash used in this study was Class F. The specific gravity was found to be 2.1

2.1.3 Fine Aggregate

The fine aggregate used in the study was manufactured sand which is conforming to Zone II of Table 4 of IS: 383-1970. The specific gravity was found to be 2.4 and water absorption was found to be 7%.

2.1.4 Coarse Aggregate

Coarse aggregates used in this study are crushed granite stone of 10 mm downsize. The specific gravity was found to be 2.6 and water absorption was found to be 0.4%.

2.1.5 Sea Water

Water used to find the rheological properties along with normal water is sea water. Sea water was collected from Panambur Beach, Mangalore. The chemical characteristics of sea water are presented in the table 2.

Table 2 Chemical Characteristics of Sea Water

Sl.No	Parameters	Result	Method of Test
1	pH	7.86	IS3025 (Part -11): 1983
2	Turbidity	<1	IS3025 (Part -10): 1984
3	Total Dissolved Solids	35558 mg/L	IS3025 (Part -16): 1984
4	Total Hardness	6440 mg/L as $CaCO_3$	IS3025 (Part - 21): 2009
5	Chlorides	19715 mg/L	IS3025 (Part -32): 1988
6	Fluorides	1.35 mg/L	IS3025 (Part -60): 2008
7	Iron	< 0.05 mg/L	IS3025 (Part -53): 2003
9	Nitrate	2.19 mg/L	IS3025 (Part -34): 1988

2.1.6 Normal Water

Normal water is used to find the rheological properties of fresh concrete mixes. Normal water was used from Jss Academy of Technical Education, Bangalore. The chemical characteristics of normal water are presented in the table 3.

Table 3 Chemical Characteristics of Normal Water

Sl.No	Parameters	IS Standards Drinking Water Specification		Result
		Acceptable	Permissible Limit	
1	pH	6.5 – 8.5	-	7.86
2	Turbidity	1 NTU	5 NTU	0.3 NTU
3	Total Dissolved Solids	500 mg/L	2000 mg/L	528 mg/L
4	Total Hardness	200 mg/L	600 mg/L	348 mg/L as $CaCO_3$
5	Conductivity	NS		1.341 ms
6	Chlorides	250 mg/L	1000 mg/L	191.44 mg/L
7	Sulphates	200 mg/L	400 mg/L	0.21 mg/L
8	Total alkalinity	200 mg/L	600 mg/L	88 mg/L as $CaCO_3$
9	Nitrate	45 mg/L	100 mg/L	2.6 mg/L
10	Fluoride	1.0	1.5 mg/L	0.2 mg/L
11	Iron	0.3 mg/L	1.0 mg/L	0.3 mg/L

2.2 Methodology

The direct shear box is used in this study for determining the rheological parameters. The medium direct shear apparatus is used for testing concrete samples of 60mm×60mm×20mm containing maximum size of 10mm.The apparatus consists of shear box assembly.

In this study, mixes with different cement content and water contents were used covering practically the range used in practice. The concrete mixes were proportioned based on absolute volume concept. Total number of trial consisting of three different displacement rates of 0.05, 0.25, 1.25 mm/min, in combinations with three different normal stress of 0.2, 0.7, 1.2 kg/cm^2, were used. The chemical admixture was used as it will influence and interfere in the test values. The procedure was followed for finding rheological properties. Average values of two trials were considered for finding out the maximum shear stress from the plots of shear stress versus shear strain.

2.2.1 Test Parameters used for the study

- Normal Stress : 0.2, 0.7, 1.2 kg/cm^2
- Displacement Rate : 0.05, 0.25, 1.25 mm/min
- Cement Content
- Water Content

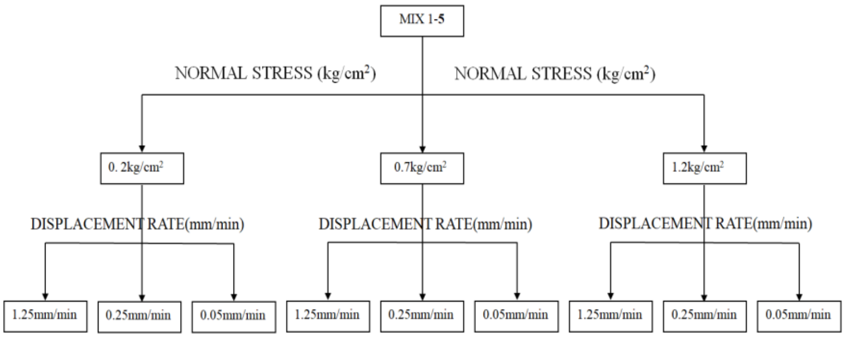

Figure 1 Methodology

Figure 2 Direct Shear Box

Figure 3 Placing of Sample

2.3 Mixes Design

The mix design is based on Concrete Mix Proportioning – Guidelines (IS 10262: 2009). Table 4 represents mix proportion

Table 4 Mix Proportion

Ingredients (kg/m³)	Grade Of Concrete (Without Mineral Admixture)			Grade Of Concrete (With Mineral Admixture)		
	M_{20}	M_{25}	M_{30}	M_{20}	M_{25}	M_{30}
Cement	304	337.7	380	289	289	340
Fly Ash	-	-	-	124	124	130
Fine Aggregate	972	941.28	907.3	786	786	775
Coarse Aggregate	897	904.28	907.3	954	954	940
Water	152	152	152	150	150	150
Free W-C ratio	0.50	0.45	0.40	0.40	0.40	0.38

III. Results And Discussion

The rheological parameters namely yield stress and plastic viscosity is calculated. It may be recoiled that different types of concrete mixes with normal water and sea water have been used for the purpose of comparison. Three different normal stresses namely 0.2 kg/cm^2, 0.7 kg/cm^2 and 1.2 kg/cm^2 and three different displacement rates namely 0.05 mm/min, 0.25 mm/min and 1.25 mm/min have been used for each mix, hence 9 combinations trial were done on each type concrete. For an applied shear displacement rate and normal stresses, the direct shear box test gives shear stress and corresponding shear strain values.

Fig.3.1, Fig.3.2 and Fig.3.3which gives the relationship between shear stress and shear strain. The graph exhibits an increasing shear resistance as shear displacement is increased and a peak value of shear resistance is reached after which the material delights and the shear resistance drops on further straining. The peak value is noted. For each level of normal stress applied there is corresponding peak shear resistance expressed in terms of shear stress.

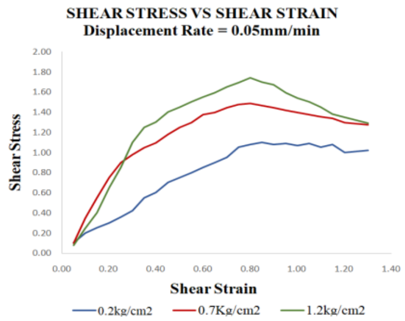

Figure 3.1

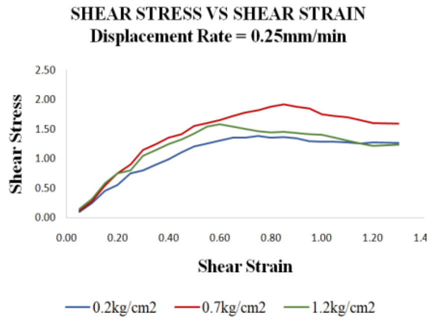

Figure 3.2

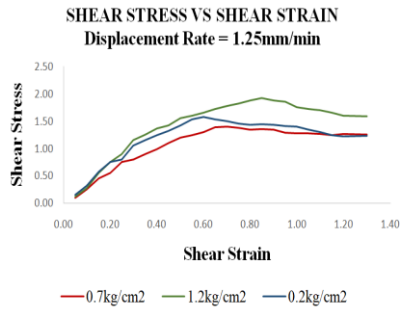

Figure 3.3

Fig.3.4, Fig.3.5 and Fig.3.6 which gives the model representation of peak stress and normal stress relationship for a particular displacement.

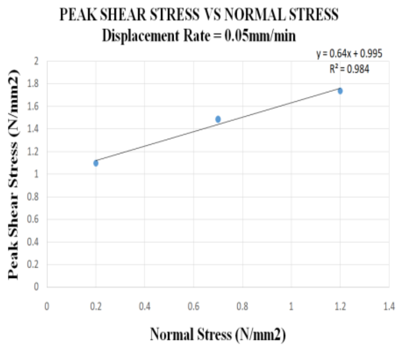

Figure 3.4

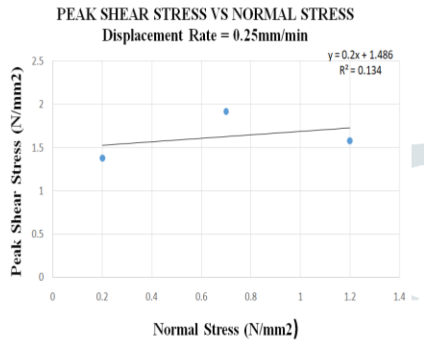

Figure 3.5

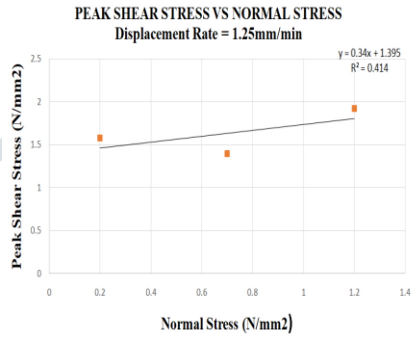

Figure 3.6

Fig.3.7 represents the point where linear line coincides with y-axis is the shear stress at zero normal stress.

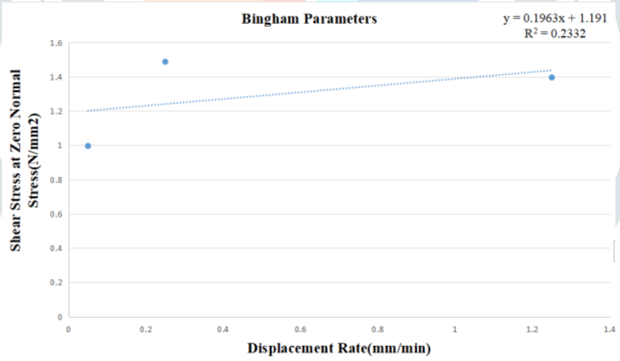

Figure 3.7

3.1 Determination of rheological parameters:

3.1.1 Yield Stress

The minimum stress to initiate or maintain flow. From the graph shown above the yield stress value can be read as 1.191N/mm^2

3.1.2 Plastic Viscosity

The resistance to flow once yield stress is exceeded. Plastic Viscosity is calculated for maximum displacement rate (1.25 mm/min). Table 5 represents the values of yield strength and plastic viscosity of different concrete mixes prepared with normal water and sea water.

Table 5 Values of Yield Strength and Plastic Viscosity of different mixes

Mix	W/C	Cement (kg/m^3)	Fly ash (kg/m^3)	Water (lt/m^3)	Yield Strength (Pa)	Plastic Viscosity (Pa-Sec)
Concrete mix with Normal water						
M_1	0.50	304	-	152	852	2.78
M_2	0.45	338	-	152	788	8.30

M_3	0.40	380	-	152	763	12.62
Concrete mix with Sea water						
M_4	0.51	279	114	145	644	31.60
M_5	0.40	289	124	150	784	18.65
M_6	0.38	340	130	150	754	21.24

3.2 Discussion

Plastic viscosity describes the resistance to flow once the yield stress is exceeded. The higher plastic viscosity, the greater is the resistance to flow concrete mixture with plastic viscosity is often described as "sticky" or "cohesive". As can be seen from the table 5 as the water to cement ratio increases relative yield strength also increases and relative plastic velocity decreases. Similarly an unusual trend is observed with the mixes prepared with sea water which clearly indicates the effect of salt content on the hydration process of concrete.

IV. Summary And Conclusions

4.1 Summary

Rheological properties of fresh concrete, namely plastic viscosity and yield stress are critical for the concrete industry because they affect placement and workability. Therefore proper characterization of these properties is needed to control the quality of fresh concrete and ensure sustainability of concrete structure. For this purpose the standard test methods as well as a fresh concrete rheometer, Direct Shear Box (servo controlled) an unique equipment in which data acquisition is done automatically, were used.

Direct shear box gives Bingham's parameter, namely yield stress and plastic viscosity. For normal concrete, flow measurement was done. Further, fresh concrete is subjected to Direct shear box test in which a series of normal stresses are applied for one displacement rate. By plotting the graphs and calculation, Bingham's parameters are obtained. Form the study it has been found that as the paste content increases the relative yield stress as well as plastic viscosity decreases.

4.2 Conclusions

From the experiments conducted during the present study the following are the conclusions arrived at:

- With the help of Direct shear box, test result in terms of shear stress vs strain of concrete at different displacements rates and normal stresses, it is possible to determine the relative yield strength and relative plastic viscosity.
- The relative values obtained in this study clearly distinguishing the different types of concrete mixes prepared with normal water and sea water in terms of yield strength and viscosity.
- As the water to cement ratio increases relative yield strength also increases and relative plastic velocity decreases.
- The test is uniqueness in the sense that the values of rheological properties arrived at are by considering both the normal stress and displacement rate at zero values and the stimulus provided to concrete is similar to the field practice.
- The fabricated concrete shear box can be used as a new tool to determine the rheological properties of fresh concrete similar to Bingham's parameters, effectively, as a static test and can be an alternative new tool in place of rheometers which use high shear rate.
- An unusual trend is observed with the mixes prepared with sea water which clearly indicates the effect of salt content on the hydration process of concrete.

V. Acknowledgment

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