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# Experimental Approach for Underwater Concrete Formulations

**Chiranjit Samanta[1], Rabi Das[2], Kousik Sabui[3]**

*[1,2,3] Lecturer, Civil Engineering, Technique Polytechnic Institute, West Bengal, India*

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**Abstract -** *Underwater concreting is one of the oldest methods of placing concrete under the water for the construction of submerged structures like harbors, bridges, aqueducts and other similar structures. From the literatures, it is found that very few works has been done for promoting the underwater concrete (UWC) at present scenario. There is a global need for preparing the UWC which should have properties to suit the current requirements to withstand environmental needs, strength, anti-washout properties, quick setting and also to have bonding properties with existing old concretes for the repairing purposes.*

***Key Words***: **underwater concrete, bio-materials, mineral admixtures, spray test, flowability, bleeding, setting time**

## 1. INTRODUCTION

In ancient engineering, Roman builders discovered how to create hydraulic mortar, a building material which could potentially be used for the development of infrastructure of their country. For the Romans, the pozzolonic additive was sand like volcanic ash, pozzolonic materials which are composed of chemically reactive aluminosilicateswhich, when mixed with lime and water, produces a series of hydrated calcium-silicates and aluminates. These compounds caused the hydraulic mortar to set slowly, particularly under water and become extremely hard. Pollio Vitruvius, a Roman published many books on architecture circa 25 BC, describing the engineering and building methods practiced during the Roman period. He specified that pozzolona (quarry sand) from the area around Baiac, or from entire coastline of the Bay of Naples, had to be used to produce hydraulic concrete. The Roman structures made use of Pozzolona imported from the Bay of Naples, from the region around Puteoli. In the study of cores of concrete from underwater structures, it appeared that the pozzolona was shifted from the Bay of Naples to provide significant uniformity in maximum grain size. Although the exact ratio of pozzolona to lime in the mortar of the cores remained to be determined, it was clear that the mortar was very carefully measured and mixed.

### 1.1 Properties

The properties of underwater concrete as follows- (a)ability of concrete to flow, (b) retention of workability over a reasonable time, (c) self-compacting, (d)adequate cohesion to avoid segregation, (e) low heat of hydration, (f) low bleeding, (g) controlled set times, (h)development of adequate compressive strength, (i) adequate bond strength, (j) low creep and shrinkage, (k)resistance to washout by flowing water ,(l) abrasion resistance, and some more according to the condition in which the structure is to be built

### 1.2 Methods

The methods of underwater concrete placing as follows - (a) the pre-packed concrete method, (b)the tremie method, and(c)the concrete pump method. Use of the tremie is currently the most often utilized technique for placing concrete under water. To meet all the requirements of properties of underwater concrete, researchers have been extensively working on construction material to develop admixtures for use in concrete that permit the concrete to be placed underwater without the use of tremie. The admixture is used to prevent washout of cementitious material and dispersion of aggregate during underwater placement of concrete. Hydroxyethylcellulose (HEC), hydroxyethylmethylcellulose (HEMC), and hydroxypropylmethylcellulose (HPMC) are among the various admixtures used. The viscosities of the admixtures differ considerably according to polymerization, molecular weight and type of substituent, when they are dissolved. They dissolve in water rapidly when placed in an alkaline environment such as concrete.

## 2. EXPERIMENTAL FORMULATIONS ON UNDERWATER CONCRETE

UWC specimens based on the following formulations and materials:

1. OPC Concrete (Control mix)
2. OPC + SP + MS + SF
3. OPC + SP + VAJRAM + MS + SF
4. OPC + SP + WATER SOLUBLE ACRYLIC + MS + SF
5. OPC + SP + PISTA GUM + MS + SF
6. OPC + SP + JAGGERY + MS + SF
7. OPC + SP + FEVICOL RESIN + MS + SF
8. OPC + SP + ALUMINA CLAY + MS + SF
9. OPC + SP + ORDINARY CLAY + MS + SF
10. OPC + SP + ACETATES + MS + SF
11. OPC + SP + MURUNGAI GUM + MS + SF
12. OPC + SP + ASAEFOETIDA+ MS + SF
13. OPC + SP + KADUKKAI LIQUID + MS + SF
14. OPC + SP + STARCHES (MAIDA, VENDAYAPODI, TAPIACO POWDER) + MS + SF
15. OPC + SP + SUPER ABSORBENT POLYMERS + MS + SF

Where, OPC: Ordinary Portland cement SP: Super plasticizer MS: Micro Silica SF: Silica Fumes

## 3. CONSTITUENT MATERIALS IN UNDERWATER CONCRETE

Influence of cement: Portland cement influences the behavior of fresh concrete in three fundamental ways - (a)Cement hydration, refers to chemical and physical processes taking place. Cement containing high C3A content usually causes rapid hydration of cement and consumption of free water in the paste. (b)Water demand, the gradation of cement particles, the C3A content and the alkali content determines the water demand. The finer the cement, the higher the water demands. (c)Cement paste, the high cementitious material content is essential to enhance the cohesion and flowability of concrete, thereby reducing laitance and segregation.

Influence of cement paste: It is a mixture of cement,mineral binders, fines and water in concrete. Cement paste affects the workability of concrete in three ways: (a) the volume of cement paste, (b) the rheology of cement paste (it describes yield stress and plastic viscosity of concrete), and (c) the interaction between cement paste and aggregates. An increase in the cement paste often leads to more flowable concrete. If the ratio of water-tocementitious materials is kept constant, increasing cementitious materials generally improves workability of concrete.

Influence of mineral admixtures: Mineral admixtures refer to pozzolonic materials such as fly ash and silica fume. Pozzolona react with the by-products of the cementitious reaction at later stage. For massive underwater construction, adding mineral admixtures to the concrete mixture as partial replacement of Portland cement is important.

Proper use of mineral admixtures improves the quality of concrete in all the important aspects. It (a) improves workability, flowability, and pumpability, (b) improves homogeneity and uniformity of concrete mixes, (c) enhancing the resistance to segregation and erosion, (d) lower heat of hydration, (e) low bleeding, and (f) better control of setting time.

Influence of aggregates: Cement paste is the continuous paste that carries aggregates as suspended particles. The higher the friction force, the lower the slump. A concrete containing large and angular aggregate tends to be less workable and often has difficulty flowing through reinforcement cages. High content of fine aggregates tend to reduce segregation and bleeding. Modern underwater concrete usually contains fine aggregates in the range of 45 to 50 percent of total aggregates. The percentage of fine aggregates passing 75micron sieve is recommended to be about 10 percent of the aggregate volume. The amount of coarse aggregate is measured as the volume ratio of coarse aggregates to the total solids in concrete. A high ratio results in high yield stress and high viscosity. Since underwater concrete should be flowable and self-compacting, this ratio is usually limited within the range of 0.37 to 0.50.

Influence of water content: Water is the medium that carries aggregates and binders as suspended particles. The water coats and lubricates the suspended particles, resulting in the plasticity and flowability of concrete. The water content in a mix can be classified in two categories: (a) water absorbed in the aggregate, (b) free water that provides workability, and is the amount used in calculating water-cement ratio. The absorbed water generally does not contribute to the workability of concrete.

## 4. METHOD OF TEST FOR UNDERWATER CONCRETE

Some testing methods of underwater concrete are as follows-

CRD C61 test : This test uses a small basket with small diameter holes (3mm) and the basket full of concrete is immersed in water three times. It is possible to find washout resistance due to the aggregates in the mix by blocking the holes of the basket, using this method.

pH factor test : This procedure involves a beaker filled with water. A fresh concrete sample of an appropriate size is divided into several parts and then dropped into the beaker. It is allowed to settle and is observed after three minutes, and a unit volume of the supernatant solution (the water solution above, when concrete has precipitated at the bottom) is decanted into another beaker. The pH factor of the solution is determined and recorded. The higher the pH of the decanted solution, the higher is the washout loss.

Drop test : The basic equipment constitutes graduated cylinder filled with water. A small quantity of concrete (400-500g) is dropped through the water in the cylinder. The resultant turbidity of the water is visually assessed to determine the degree of washout. The degree of turbidity can be measured using turbidity meter.

## 5. ANTI-WASHOUT CHARACTER FOR UNDERWATER CONCRETE

Fresh UWC can be characterized by following properties:
Flowability: Due to the increased viscosity of anti-washout UWC, the slump transformation takes place over several minutes. The slump is ultimately 8 to 10 in. To have better understanding of the flowability of this type of concrete, a slump-flow value or a spread value is more suitable than a slump value. In general, slump test is done for stiff UWC. For such types of concrete, very minimal slump to zero slump is also adopted. In case of flowable UWC (self-compacting and flowable mix), a flow table test is conducted as per German standard DIN 1048, wherein diameter of the flow on the flow table on removal of the mould is measured to assess the quality of concrete.

Air content: Mortar and concrete mixed with cellulose ether have greatly increased air content, therefore, such anti washout admixtures contain an air-detraining admixture to reduce the air content of the concrete to between 3 to 5 %.

Bleeding: Concrete containing anti-washout admixture retains more of the mixing water. Because the normal amount of admixture used is more than double the amount required to prevent bleeding, thus very little bleeding occurs in anti-washout underwater concrete.

Setting time: Anti-washout admixtures contain an accelerating admixture, hence the setting time is greatly extended. Anti washout admixtures containing acrylics have no effect on the setting time. The most common accelerating admixture amounts are adjusted to result in a final setting time of from 5 to 12 hours.

## 6. CONCLUSION

The present work of construction of underwater structures has taken a leap. The procedure of formulating the concrete mixtures should be in such a way that they are easy to place and also withstand even in the adverse underwater conditions. The required properties are- (a)ability of concrete to flow, (b) retention of workability over a reasonable time, (c) self-compacting, (d)adequate cohesion to avoid segregation, (e) low heat of hydration, (f) low bleeding, (g) controlled set times, (h)development of adequate compressive strength, (i) adequate bond strength, (j) low creep and shrinkage, (k)resistance to washout by flowing water ,(l) abrasion resistance, and some more according to the condition in which the structure is to be built. In our present research work, it is proposed to make some trial mixes using bio-materials and viscosity enhancing natural materials which are inexpensive and are readily available in market. Out of all the mixes, the material which gives the best performance as an anti-washout admixture and optimization of the dosage of that material for specific volume of concrete will be carried out.

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## BIOGRAPHIES

Passed B.tech in Civil Engineering in the year of 2016. Presently working as a lecturer with 1.5 years of teaching experience.

Passed B.tech in Civil Engineering in the year of 2015. Presently working as a lecturer with 2.5 years of teaching experience.

Passed B.tech in Civil Engineering in the year of 2014. Presently working as a lecturer with 2 years of teaching experience.