USING PLASTIC CONCRETE FOR CANAL LINING

UTILISATION DU BETON EN PLASTIQUE DANS LE REVETEMENT DES CANAUX

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ABSTRACT

Plastic concrete is made up of cement, sand, gravel, water and bentonite slurry and sometimes with additives like clay. This type concrete is commonly used in construction of diaphragm walls in earth dams to reduce seepage from their foundations. Improvement and modification of physical specifications of plastic concrete such as flexibility and formability coefficients for the purpose of similar behavior of soil bed mass under concrete canal reduces cracks and increases the operating life of concrete linings. Therefore this issue was taken into consideration to put different samples of variety of mix designs of plastic concrete under laboratory tests to determine the most suitable one for concrete lining of canals.

Key words: *Plastic concrete, Modulus, Density, Bentonite, Compressive strength.*

RESUME

Le béton en plastique est constitué de la boue de ciment, de sable, de gravier, d'eau et de bentonite, et parfois avec les additifs comme l'argile. Ce type de béton est couramment utilisé dans la construction de mur diaphragme des barrages en terre pour réduire les infiltrations de leurs fondations. L'amélioration et la modification des spécifications physiques du béton en plastique tels que la flexibilité et les coefficients de formabilité pour le comportement similaire de la masse du sol sous un lit du canal en béton réduit les fissures et augmente la durée de vie des revêtements en béton. Par conséquent, cette question a été prise en considération pour mettre différents échantillons de la variété de béton en plastique sous tests de laboratoire pour déterminer le revêtement en béton des canaux plus approprié.

Mots clés: *Béton en plastique, module, densité, bentonite, résistance à la compression.*

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1. INTRODUCTION

Iran is classified as an arid, semi arid region with discordant distribution of surface water, which has resulted in constraints in optimized usage of water. From the viewpoint of significance of water supply as a vital need of industrial, municipal, rural and agricultural sectors, conservation of water and prevention of its loss is considered as one of the foundational issues, and a lot of activities in this regard have been performed.

Since about 90 percent of the water in Iran is used for agriculture, definitely any type of conservation or optimized use can play a significant role in optimum consumption and sustainability of the water resource.

The irrigation and drainage networks in Iran convey large volumes of water. Therefore, better design of canals in the network is considered as a high priority issue, as conservation and prevention of water seepage and loss is one of the most important benefits.

Prevention of water loss can be achieved by minimizing the cracks and joints in canals including construction, contraction and expansion joints and discordance of the concrete lining material with the soil sub-base due to settlement. Therefore through controlling of these cracks while water loss is reduced, operating life of these canals are considerably increased.

The feasibility of replacing the common type of concrete with plastic concrete is addressed in this paper. Apart from normal mix of material (sand, gravel, cement and water) a type of clay called bentonite is added for the purpose of increasing the flexibility and formability coefficients to achieve similar behavior of soil bed mass under the concrete surface of the canal.

2. PLASTIC CONCRETE CHARACTRISTICS

Plastic concrete has a lower compressive strength but higher formability and lower permeability that is resulted from the usage of clay slurry in the concrete mix design. Also its flexibility is higher so more suitable for lining. One has to be careful however, that the compressive strength of the mix is not reduced as much as it becomes unsuitable for the lining execution.

In the selection of material type and in designing the mix of plastic concrete, many parameters play role including their amounts, elasticity modulus, compressive strength, permeability, slump and density. Change in any of these parameters from the design specification can harm the resulting concrete. For instance, reducing elasticity modulus and increasing flexibility, results in reduction of compressive strength. Therefore, their values should be chosen within a confined range that results in the best desired concrete.

Bentonite slurry or grout in plastic concrete keeps the sand, gravel and cement particles in a suspended mode during pouring of concrete, which results in higher formability and lower permeability. For the purpose of increasing the flexibility in concrete higher slump is needed in the mix design.

Cement is the gluing agent that causes the concrete aggregates to stick to each other.

Aggregates comprise more than 50% of concrete volume, and the harder and larger they are, the compressive strength is increased. But the maximum size is limited to 20 mm and the grading curve must be uniform and not containing high amount of small grains.

3. PLASTIC CONCRETE MIX DESIGN

To determine the initial mix design, more than a hundred mix designs used in other projects mainly relevant to curtain and diaphragm walls were considered. Reviewing the alterations in elasticity modulus, slump and permeability in these mixes, 25 design mixes were counted as the proposal mixes so as by scrutinizing their results, the best mix design that fulfills the desired qualities can be determined. In these mix designs the average of concrete materials are as below:

Bentonite	15 – 35 kg
Cement	200 – 300 kg
Sand & gravel	1600-1700 kg
Water	200-400 kg

Table 1. Samples of mix designs amounts in kg/m^3

Mix design	Water	Bentonite	Cement	Aggregates
1	210	15	200	1640
2	230	25	200	1670
3	240	30	200	1650
4	270	20	250	1650
5	300	25	250	1660
6	310	30	250	1665
7	320	25	270	1680
8	340	30	270	1690
9	370	30	300	1685
10	375	35	300	1600

4. PREPARATION OF PLASTIC CONCRETE AND LABORATORY TESTS

For the purpose of preparation of plastic concrete, first of all bentonite is mixed thoroughly with water and is mixed for 24 hours with a mixing blade of high rotation, then slurry is poured in the mixer and mixed for one minute, then cement is added and after another minute, the aggregates are added to the mixture and mixed for another 7 to 10 minutes.

Slump and density tests were performed on all the samples of fresh concrete.

To determine the compressive strength and elasticity modulus, concrete prepared according to specifications of mix design, is poured into the specimen and once kept in laboratory environment for 24 hours, they were put in the water.

To determine the compressive strength and elasticity modulus one axial laboratory tests were performed on the specimen. In this laboratory tests plastic concrete specimen was crushed under compressive jack in compliance with recommendations of standards ASTM-D2166, ASTM-C459 with speed of 0.05 percent per minute. Information regarding force and deflection were recorded continuously and the relevant stress-strain curves were drawn.

5. TESTS RESULTS

As it is shown in Table 2 below, for a constant amount of cement, increasing bentonite causes decrease in concrete elasticity and compressive strength. Also it is observed that increasing cement for a constant amount of bentonite, shall increase concrete elasticity and compressive strength.

The results therefore make it clear that bentonite shall increase concrete flexibility but decrease its elasticity and compressive strength

Table 2. Samples of mix designs: the effect of bentonite on concrete specifications.

Mix design	Slump	Compressive strength	Density (ton/m^3)	Elasticity modulus (mpn)
1	8	130	2.12	11545
2	7	90	2.15	10800
3	9	70	2.18	9950
4	10	170	2.20	13440
5	10	145	2.22	12320
6	11	135	2.23	11800
7	10	195	2.24	14530
8	12	170	2.26	14010
9	10	200	2.28	15910
10	8	180	2.29	15050

6. CONCLUSIONS

Considering the results in regard with the changes in compressive strength and elasticity modulus of concrete due to alterations in cement and bentonite amounts in the mix designs, we get the following results:

1. Compressive strength of plastic concrete is lower than normal concrete having the same amount of cement used. But by controlling a small strength reduction and acquiring a higher flexibility, plastic concrete would be suitable for concrete lining of canals

2. Preparation of plastic concrete although imposes some costs to project but this is quite low and ignorable when compared with the benefits gained from conservation of water due to reduction of cracks and joints and seepage.
3. Slump of plastic concrete is greater than normal concrete having the same amount of cement used, but this is easily controlled during execution of the concrete lining
4. Elasticity modulus of plastic concrete is lower than normal concrete and is closer to the soil bed under the lining, and this characteristic in fact makes the lining concrete to be more flexible and reduces the cracks that would otherwise be created due to differential settlements between concrete and the soil underneath, during operating time and creation of saturation status of the soil bed.

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