MEDWIN PUBLISHERS
Committed to Create Value for Researchers

Open Access Journal of Waste Management & Xenobiotics
ISSN: 2640-2718

Concrete Pump Transport of Concrete Mixes

Komarinsky MV and Gorodishenina AY*

St. Petersburg Polytechnic University, Russia

***Corresponding author:** Anna Gorodishenina, Peter the Great St. Petersburg Polytechnic University, Polytechnicheskaya, 29, St. Petersburg, 195251, Russia, Email: kostyukova85@yandex.ru

Review Article
Volume 3 Issue 4
Received Date: October 20, 2020
Published Date: November 28, 2020
DOI: 10.23880/oajwx-16000150

Abstract

The article presents a study of innovative materials in the field of highly mobile and cast concrete mixtures using pipeline transport. The studies were carried out on mixtures with a complex additive based on S-3 superplasticizer. The complex included a plasticizing-air-entraining additive LHD with an air-entraining effect. Studies of the effects of S-3 and LHD additives on the construction and technical properties were carried out on mixtures with different cement flow rates and the same initial mobility. Studies of the rheological parameters of the mixtures were carried out using the mathematical theory of experimental design; measurements of resistivities were performed depending on the flow velocity. The result of the work is a linear dependence of the change in resistivities along the length and height.

Keywords: Water Separation; Concrete Mixtures; Rheological Parameters; Hydraulic Structures

Introduction

At present, cast concrete mixtures are used in densely reinforced and thin-walled structures, in hard-to-reach elements of complex and critical structures without vibration, which is important in the construction of hydraulic structures, as well as thermal and nuclear power facilities. At the same time, the preparation of these mixtures is associated with increased cement consumption. The most important technological properties of the concrete mix: workability, air entrainment, resistance to water and solution separation, and preservation of properties over time [1]. The use of air-entraining additives together with superplasticizer is one of the ways to improve the technological properties of the concrete mixture, namely, its pumpability. The use of self-compacting concrete mixtures is a promising area in the development of concrete technology, however, the high cost and lack of a Russian regulatory and technical base reduces the possibility of their use [2].

Materials and Methods

The aim of this work is to study the rheological parameters of cast concrete mixtures with complex additives, different cement consumption and the same initial mobility, depending on the flow velocity. For an experimental study of the movement of concrete mixtures through pipelines in the laboratory of the department, a special universal stand was made (currently dismantled), capable of studying the rheological parameters of various compositions of the mixture when they move along a pipe with a diameter of 125 mm [3].

The change in pressure loss in the pipeline during the movement of the mixture was made using pressure sensors DD-10 induction type, mounted on the pipeline “flush” with the inner surface of the pipe. In addition to the sensors, the recording equipment set included an ID-2I indicator type station, which includes power supplies, an N-145 oscilloscope, an amplifier-converter, and a resistance bridge. Pressure recording was carried out continuously on UV-67 oscillographic ultraviolet photo paper. The studies were carried out on mixtures with a complex additive based on S-3 superplasticizer. The complex included a plasticizing-air-entraining additive LHD, which has an air-entraining effect at the level of start additives, 2-5 times increasing the frost resistance of concrete and the cohesion of the mixture [4]. The LHD additive has been successfully used in large hydraulic structures, such as the Sayano-Shushenskaya hydroelectric power station and flood protection facilities of Leningrad.

Studies of the effects of S-3 and LHD additives on the construction and technical properties were carried out on mixtures with different cement flow rates from 280 to 400 kg/m3 and the same initial mobility (OK = 4 cm). In this case, the mobility of the mixture was determined by the sediment of the normal cone and the diameter of the spread, the separability by water separation (solution separation) and air intake.

Results and Discussion

The analysis of experimental data showed that the S-3 superplasticizer strongly dilutes the concrete mix with OK = 4 cm to a mobility of more than 24 cm (at S-3 = 0,8%), and with an increase in cement consumption, the plasticization efficiency increases, and the delamination of the mixture decreases. The introduction of S-3 slightly (by 0,5-1,0%) increases the air content of the mixture. The introduction of LHD in dosages of 0,05% and 0,1% increases the cohesion (for example, with the same 24 cm OK mobility, the spreading diameter decreases from 60 cm to 50 cm while increasing the air content to 6,0-7,0%) and reduces stratification mixtures (no water separation) [5,6].

The experiments to determine the resistivities during transportation of various mixtures of compounds through a pipeline showed a linear dependence on the speed V of the range 0,2–2,0 m/s [7-14]. This circumstance allowed us to use the Buckingham-Reiner equation to determine the rheological parameters (and) of the mixtures:

$$Q=\frac{\pi D^4}{128\eta}\Delta P\,[1-\frac{4}{3}\frac{D_0}{D}+\frac{1}{3}(\frac{D_0}{D})^4]\quad(1)$$

where:

Q is the flow rate of the mixture through a cylindrical pipe;
- is the pressure drop per 1 m length;
D- is the inner diameter of a cylindrical pipe;
- is the diameter of the flow core when the mixture moves along the pipe;
η - Structural viscosity of the mixture.

To determine and from equation (1), the third term in square brackets is usually neglected. This is permissible when the relative core of the flow is less than 0,4 – 0,5.

Studies of the movement of the above mixtures through a collapsible pipeline with preliminary tinting of the mixture layers and further consideration of their deformed state after pumping made it possible to draw a conclusion about their structural mode of motion with a relative flow core varying from

$$\frac{D_0}{D}=0{,}4\text{-}0{,}7$$

This allowed the expression in square brackets of equation (1) to be approximated by the expression:

$$0{,}91\text{-}1{,}1\frac{D_0}{D}\quad(2)$$

Then equation (1) takes the form:

$$Q=\frac{\pi D^4}{128\eta}\Delta P\,[0{,}91-1{,}1(\frac{D_0}{D})]\quad(3)$$

As $\frac{D_0}{D}=\frac{\Delta P_0}{\Delta P}$ under $\Delta P_0=\frac{4\tau_0}{D\Delta P'}$ where τ_0- is the ultimate shear stress, Pa.

After transformations and substitutions, we obtain from (3):

$$\Delta P=\frac{4}{0{,}91D}[\frac{8V}{D}\eta+1{,}1\tau_0]\quad(4)$$

where V – is the average speed of the mixture.

And since η and τ_0 located at any two points of the experimental curve, , giving two pairs of values ΔP_1-V_1 and ΔP_2-V_2, allowing to make two equations, then

$$ç=\frac{0{,}91D^2}{32}\frac{\Delta P_1-\Delta P_2}{V_1-V_2}\quad(5)$$

$$\hat{o}_0=\frac{1}{4}\frac{D}{1{,}1}\frac{\Delta P_2V_1-\Delta P_1V_2}{V_1-V_2}\quad(6)$$

Studies have confirmed the presence of a near-wall π -effect during the movement of concrete mixtures, including cast ones, through the pipeline.

The correction for wall glide derived by Buckingham is equal to:

$$\Delta Q=\frac{\pi D^3\rho}{16\eta_0}\Delta P\quad(7)$$

where
ρ - is the wall layer thickness;
η_0 - is the viscosity of this layer.

Komarinsky MV and Gorodishenina AY. Concrete Pump Transport of Concrete Mixes. J Waste Manage Xenobio 2020, 3(4): 000150.

Taking into account the wall sliding, the total flow rate through the cylindrical pipe will be equal to:

$$Q + \Delta Q = \frac{\pi D^4}{128\eta}\Delta P\left[a - b\frac{\Delta P_0}{\Delta P}\right] + \frac{\pi D^3 \rho}{16\eta_0}\Delta P \quad (8)$$

where a=0,91; b=1,1 – are the approximation coefficients.
Expressing ΔP through V after permutations and reductions we get:

Then, for example, for viscosity with an amendment similar to the above:

$$\Delta P = \frac{4l}{Da}\left[\frac{8V}{D\left(1+\frac{8\rho\eta}{Da\eta_0}\right)}\eta + \frac{b\tau_0}{1+\frac{8\rho\eta}{Da\eta_0}}\right] \quad (9)$$

$$\eta^* = \frac{D^2 a}{32}\left[\frac{\Delta P_1 - \Delta P_2}{(V_1 - V_2) - \frac{D\rho}{4\eta}(\Delta P_1 - \Delta P_2)}\right] \quad (10)$$

A comparison of formulas (5) and (10) and their analysis shows that, taking into account wall sliding, the viscosity increases. From (10) it follows:

$$\eta^* = \frac{\eta}{1 - \frac{8\eta\rho}{Da\eta_0}} \quad (11)$$

where - is the structural viscosity considering wall slip.
By $\tilde{n} = 0$, $ç^{*} = ç$, which is fair.

According to [6], the viscosity of the solution component, on average, varies from 1 to 3,5 Pa·s depending on the W/C. A numerical analysis of formula (11) shows that taking the concrete viscosity equal $ç = 6$ Pa.s (see below), but

$\tilde{n} = 1$ mm,

$$\eta^* = \frac{6}{1 - \frac{8.6.0,001}{0,125.1}} = 9,74 \text{ Pa.s}$$

Adjusted viscosity is increased by $ç^{*}$ amendment up to 60%, i.e. wall slip can significantly affect the rheological parameters of the mixture. However, the experimental definition and is currently difficult. Therefore, rheological parameters are determined by formulas (5) and (6).

Studies of the rheological parameters of mixtures of various compositions with chemical additives S-3 and LHD were performed using the mathematical theory of experimental design (MPE).

The range of variation of the factors is assigned in such a way that the mixtures satisfy the requirements of pumpability, that is:

1. The consumption of cement varies from 280 to 400 kg/m^3 or which corresponds to W/C from 0,68 to 0,47.
2. S-3 varies from 0 to 0,85.
3. LHD varies from 0 to 0,1%.

Conclusion

The use of cast concrete mixtures allows you to create thin shells of high-strength concrete. And the use of superplasticizers makes it possible to dilute the concrete mixture to a precipitation of 24–26 cm cone with a spreading diameter of 60 cm. Laboratory studies have made it possible to investigate by measuring resistivity at a stand at speeds up to 2,5 m/s. Field studies have shown a linear dependence of the change in resistance along the length and height.

References

1. Drummers YuG, Komarinsky MV (2014) Superplasticizer S-3 and its effect on the technological properties of concrete mixtures. The construction of unique buildings and structures 6(21): 58-69.

2. Komarinsky MV, Smirnov SI, Burtseva DE (2015) Cast and self-compacting concrete mixtures. Construction of unique buildings and structures 11: 106.

3. Komarinsky MV (1989) The construction of reinforced concrete hydraulic structures using concrete pump technology. Abstract of dissertation for the degree of candidate of technical sciences. Leningrad Polytechnic Institute. M.I. Kalinina. Leningrad.

4. Ginzburg DG, Ivanov FM, Morozova GV (1984) High-frost-resistant concrete based on cast concrete mixtures. News of VNIIG them. B.E. Vedeneeva. Technology for the construction of concrete dams 177: 49-57.

5. Vatin NI, Drummers Yu G, Komarinsky MV, Smirnov SI (2015) Modification of cast concrete with an air-entraining admixture. Civil Engineering Journal 4(56): 3-10.

6. Barabanshchikov Yu, Komarinskiy M (2015) Effect of air-entraining agent LHD on the technological properties of concrete mix containing superplasticizer S-3. Applied Mechanics and Materials 725-726: 419-424.

7. Batarina IM (1985) Improving the technology of pneumatic conveying of concrete mixtures and mortars based on the use of plasticizing additives and taking into account local resistances: Abstract dis Cand tech sciences-M, pp: 24.
8. Komarinsky MV, Chervova NA (2015) Concrete mixture transport during the construction of unique buildings and structures. Construction of unique buildings and structures 1(28): 6-31.
9. Teleshev VI, Vatin NI, Marchuk AN, Komarinsky MV (2012) Production of hydraulic works. Textbook for universities: in two parts. Moscow, Part 1 General issues of construction. Earthwork and concrete work.
10. Teleshev VI, Danilov VM, Komarinsky MV (1986) Prospects for the use of concrete pump transport in hydraulic engineering. Hydraulic engineering 6: 34-38.
11. Teleshev VI, Komarinsky MV, Danilov VM, Ryzhov VA (1990) Research and experience in the use of concrete pump transport in the construction of the Shulbinsk hydroelectric power station. Hydrotechnical construction 10: 38-43.
12. Barabanshchikov Yu G, Komarinskiy MV (2014) Influence of superplasticizer S-3 on the technological properties of concrete mixtures. Advanced Materials Research 941-944: 780-785. Trans Tech Publications, Switzerland.
13. Zeng C, Gong M, Gui M (2012) Influence of superplasticizer on anti-carbonation property of concrete (Conference Paper). Applied Mechanics and Materials International 204-208: 3790-3794.
14. Golaszewski J (2012) Influence of cement properties on new generation superplasticizers performance. Construction and Building Materials 35: 586-596.