On Efficient Use of Electric Treatment Methods in the Technology of Concrete Work

Antonina Judina and Vladimir Verstov

Department of Construction Materials and Technologies, Construction Faculty, St. Petersburg State University of Architecture and Civil Engineering, Vtoraja Krasnoarmejskaja ul. 4, St. Petersburg, 190005, Russia

Abstract: This article provides an analysis of practical use of electric treatment methods of solidifying concrete mix and its materials as well as theoretical and experimental research on how the electric field influences physical, mechanical and processing properties of concrete mix. The results of the experimental research on electric treatment of solidifying concrete mix have shown that treatment with a high-voltage electric field promotes intense hydration of clinkers that has an impact on cement stone strength. When articles made of ceramic mixture are treated with a high-voltage electric field, they are subjected to intense dehydrating which is on average of 24% more than dehydrating of articles being in natural solidification conditions, for the same time period. Electric treatment of concrete mix materials increases concrete strength and reduces the time for concrete setting, thus, reducing the process cycle duration.

Key words: Electric treatment of solidifying mix - Electric field - Concrete and cement mix - Strength - Mix plasticity

INTRODUCTION

Electric treatment (electrolytic process) with ionic liquid is a progressive direction of improvement of physical, mechanical and processing properties of reactive metals [1, 2]. In the sphere of building materials, the technologies of concrete construction using treatment of solidifying mix receive well deserved attention of scientists [3]. The issue of interaction of the non-conventional processing methods is aimed at improvement of its physical, mechanical and processing concrete mix on different stages of construction and properties [4].

Electric treatment of solidifying concrete mix increases concrete strength and reduces the time for concrete setting, thus, reducing the process cycle duration. It is ultimately a possibility to improve quality of concrete articles and structures [4].

A significant increase in volume of prefabricated monolithic and monolithic construction work as well as construction of low rise buildings and facilities, including those for individual customers, requires a large amount of concrete being the basic building material. Production of concrete uses more than 70% of total cement output in the country. Such amounts of material resources require application of efficient resource saving technologies and high performance equipment in order to reprocess and use them effectively. Furthermore, the problem of significant increase in quality of concrete due to the research of new non-conventional processing methods is aimed at improvement of its physical, mechanical and processing properties [5].

MATERIALS AND METHODS

Research on electric treatment of solidifying mix aimed at studying of electric field influence on concrete characteristics has been conducted in a laboratory environment and included the tasks of analyzing and reviewing of relevant scientific papers and performing some experiments which, thereafter, have become the subject of deeper research.
Electric treatment methods applied in the technology of concrete work are an advanced trend in construction (Fig. 1).

Electric field is used in all electric treatment methods. The electric treatment methods, depending on effects in interelectrode space are classified according to electric treatment technology and external electric field properties such as frequency, uniformity, etc. The following methods are distinguished: electrodialysis, electrophoresis, electric coagulation, dipolophoresis, electro-filtration, low power electrical charge, high-voltage pulse discharge, complex of electrical effects. The methods are stated in increasing intensity of the applied electric field ($E=0.5–10$ V/cm to $10^5$ V/cm).

**RESULTS**

Some methods are developed and practically used in order to eliminate corrosion of reinforced steel and prevent structural damage. Methods of cathode protection, electroextraction of chloride, electrochemical realkization are most extensively used. The use of electric current for reinforcement protection against corrosion by way of surface coating enables to improve the properties of reinforced concrete structures, increasing adhesion between concrete and reinforcement. When the electroosmotic pulse is applied, contaminating ions are removed from the concrete and crack closure and elimination are performed by electro-deposition. When the direct electric current of density up to $0.25$ mA/m² passes through newly placed concrete during 20 min., a very thin dense layer made of cement particles and cement interelectrode space are classified according to electric hydration products ($0.35$ g/cm³), protecting metal against corrosion, is formed on the surface of negative electrode (on the reinforcement). In this regard, the principles of ion motion in cement stone pores when applying an external electric field are of great importance.

Corrosive-resistant coating can be formed consequent on electrophoresis. Protective sediment can also be formed due to electroosmotic removal of superfine particles with the water, dipole orientation of the superfine particles and chemical interaction of a structured layer. For the process evaluation it is necessary to study the disperse composition of particles forming corrosion-resistant coating and define their statistically valid size. Field intensity and current distribution are also to be defined according to the electrode geometric characteristics. Difficulties in research of such parameters are discussed in the study [7].

Preventing of adherence between formwork forming surfaces and solidifying concrete during concrete placement on non-reinforced or light-reinforced structures and walls of complex shapes which are made of concrete mix without electrolyte additions and cleaning of set...
cement off the metal formwork (buildup thickness from 3–5 mm) are achieved by an 1-2V/cm electrical field passing through the concrete in its setting and hardening stage. Current passage through concrete mix on the forming surface (cathode) results in a gas-liquid layer which prevents adherence between the forming surface and solidifying concrete.

Cleaning of formwork not filled with concrete is performed in a cyclic mode (polarity reversal) with the period of 2-10 min. After reversal of polarity, the formwork material starts to dissolve anodically and the adhesive bond between formwork and concrete starts to break. Channel formation in monolithic buildings with application of 2-110V electric current and periodic reversals of polarity enables to achieve high-quality channel surface due to formation of highly disperse gas-liquid layer between channeling tube and form panel during the period of concrete mix setting and hardening which prevents adherence between formwork and concrete. This method reduces labor intensity and duration at defect elimination after concrete placement [8].

**DISCUSSION**

There exists a number of elaborations of activating of concrete mix raw material components. Method of the pH variation of the concrete mix liquid phase during the mixing period gives a significant effect of liquid phase activation (with the pH 3 to 11). The use of membrane electrolyzers allows to obtain an alkaline medium with pH = 12.

Research in complex activation of concrete mix materials are often conducted. The combined effect of physical and chemical factors gives, under certain conditions, a net effect which is not, however, the sum of each separate effect. Activation of concrete mix materials (aggregate, mixing water and cement) increases, under certain conditions, the rate of cement hydration and, consequently, concrete strength. The effect of strength enhancement can be achieved by controlling the level of mixing water impurities and applying ultrasound, electromagnetic or electric field on them. Impurities in the water, activated by physical effects, influence the processes of cement hydration and set cement structure formation. They act as crystallization grains, create an alkaline medium, accelerate calcium silicate dissolving in the cement, reduce water surface tension, hence, decreasing water demand of cement paste and, finally, accelerate dissolving processes of the bonding agent by interacting with cement minerals.

Electric treatment of all mix materials has a significant influence on structure formation processes at early stages and the final stage of mix hardening. Concrete mix material components can be activated by external electric field, electric pulses with the magnitude of maximum 300V and frequency of 10–100 Hz and modulation of such pulses with the frequency of 60-100 kHz [9].

Nuclear magnetic resonance and parametrium monitoring of the structure elements has indicated the reduction of total porosity of electro-activated component samples from 17.5% to 16.5%. Increase in the rate of hydration and dispersion of new formations is proved by X-ray diffraction and differential thermal analysis and, indirectly, by increase in set cement compressive strength up to 35%.

Research on increase of concrete strength due to dealkalization control, cathode protection and chloride electrochemical removal has been often conducted [10]. The results of concrete mix electro-osmotic dehydrating have proved that the mix can be dehydrated before concrete setting in order to obtain the optimal water/cement ratio. This reduces total porosity, improves concrete freeze-thaw durability, its strength and corrosion resistance.

The author of the article has conducted an experimental research to define the effect of electric treatment on strength of solidifying cement paste. Solidifying paste was treated with a high-voltage electric field and a non-uniform electric field. Besides, an experiment was performed in semi-manufacturing conditions which objective was to decrease moisture index of ceramic paste articles due to electric treatment of the ceramic paste [11].

The experimental results proved that treatment with a high-voltage electric field promotes intense hydration of clinkers that has an impact on set cement strength [12]. However, non-uniform electric field treatment led to deterioration of hardening conditions due to active water transport in the samples that resulted in decreasing of the strength index.

Researchers have different opinions concerning the change of chemical reaction products when an electric field is directly applied on them. Some of them believe that formation of new phases is possible; the others do not confirm this fact. The answer can be obtained only through experimental research [13].

**CONCLUSIONS**

Treatment with a high-voltage electric field promotes hydration processes of clinkers that causes an intense
dehydrating of articles. Thus, concrete mix, when treated with an electric field at the stage of structure formation, obtains more regular structure orientation, monodisperse gas inclusions and more rigid adherence between filler and cement paste.

REFERENCES