Durable Reinforced Concrete Power Transmission Poles Made of Nanomodified Concrete — the Future of Digital Distribution Networks

Improving the reliability and durability of reinforced concrete poles for overhead transmission lines is a direct way to reduce costs when constructing and operating energy facilities. Modern chemical additives can significantly affect the structure of concrete and improve its operational properties: strength, density, freeze-thaw, water and corrosion resistance. Identification and digital certification of power transmission poles with new properties is a guarantee of their sustained quality. The paper presents data on the industrial production of poles from nanomodified concrete. Also, the paper considers directions for further work on creating a unified series of 0.4 and 6-10 kV reinforced concrete power transmission poles characterized by high durability for digital distribution electrical networks.

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Fig. 1. 10 kV power transmission poles for overhead-underground transition

As of today, the length of overhead transmission lines with up to 20 kV voltage exceeds 2 million km in Russia. Traditionally these overhead lines are performed on vibrated concrete poles.

The development of technology, economy, new technologies and population needs requires upgrading distribution networks in regards to increasing their length and functionality (Figure 1). New types of conductors are used for increasing transmission capacity and application of additional fiber-optic links is required for establishing communication channels. Growing needs lead to load increase of power transmission poles and enhanced requirements for their load-carrying ability. Telecommunications networks requires the use of an increased reliability coefficient for power transmission poles (1.5 times more for ice loading). In addition, the poles of distribution networks are often constructed along highways. As a result, they are exposed to the aggressive influence of deicing products in the winter.

Thus, there is a need to increase such operational characteristics of vibrated reinforced concrete poles as load-carrying ability and crack, freeze-thaw, water and corrosion resistance

The solution of this task is achieved through the rational use of the internal reserves of the cement-containing system — application of new activating chemical additives.

A complex additive for concrete consisting of several components of different nature and specifically $SiO_2 \cdot nH_2O$ nanodispersions was developed at the Department of Engineering Chemistry and Natural Science of St. Petersburg State Transport University (PGUPS). Presented nanodispersions promotes the formation of hardly soluble compounds that are more resistant to the aggressive effects of salts and have a positive effect on the corrosion resistance of concrete.

Besides, the formation of an additional amount of hydrate joints with a needle-shaped structure is capable to provide micro reinforcing of concrete, its compaction, and as a result, increasing its strength, crack resistance and durability.

It is obtained that effective chemical activation of nanomodified concrete significantly heats the curing mass. It has a positive effect on hydration processes and allows engineers to significantly reduce the temperature in the curing chambers and to abandon their heating at all in the summer.

The developed complex additive was tested at the factories of "PO "Energozhelezobetonivest", LLC during the manufacture of SV95-3s reinforced concrete poles with B30 W6 F1200 design parameters of concrete. Standard plant products from a concrete mixture containing only polycarboxylate-based additives were taken as control samples. The developed complex additive is comparable in cost to the additive used in the plant. The additives dosage was kept at the same level. The poles were tested according to state standard 8829-94 (GOST 8829-94) for assessing their strength, hardness and crack resistance. Such physico-mechanical parameters of concrete as the compressive strength (after curing, at the age of 7 and 28 days), water and frost resistance were under control.

The test results of reinforced concrete poles showed that products with the developed chemical additive had lower values of such indicators as the number and average width of cracks and poles defl ection.

Samples of nanomodifi ed concrete with developed additive diff ered in high strength. The kinetics of concrete strength development when curing at a temperature of 60°C (reduced temperature relative to usual values) is presented in Figure 2.

The strength of nanomodifi ed concrete in compression at the age of 28 days exceeded the control values by 34%. It corresponds to class B40 (Figure 2).

Samples of nanomodifi ed concrete diff ered in increased water resistance (by 2 times more), corresponding to mark W12. Frost-resistance increased by 2.5 times. It conforms to mark F_1500.

Nano-modified concrete with B30 design class can be obtained by reducing cement consumption by 30%, while the water resistance increasing by 3 steps to mark W10, and frost-resistance double enhancing to mark F_1400.

The results indicate the eff ectiveness of developed ad-ditive for manufacturing concrete products such as poles, piles and pad and chimney foundations.

As of today, the use of nanomodifi ed concrete at the plants of "PO "Energozhelezobetonivest", LLC allows en-gineers to manufacture typical structures of increased du-rability while maintaining the existing cost.

Signifi cant savings at the construction stage of the facilities can be achieved by developing new designs of poles, piles and precast foundation with the use of mod-ern high-strength and durable concrete and high duty reinforcement. The list of topics recommended for imple-mentation within the framework of PJSC "Rosseti" R&D already includes "Development of unifi ed series of extra durable reinforced concrete poles for 0.4 and 6-10 kV overhead transmission lines using nanomodifi ed con-crete and electronic passport elements". The develop-ment of reinforced concrete poles with enhanced values of load-carrying ability will provide an increase of span length for overhead lines by 20–25% and an economic eff ect by reducing the number of intermediate poles and related costs of their construction and maintenance. Nanomodifi ed concrete application will ensure a lifetime of reinforced concrete poles over 50 years (in some cases a lifetime can reach even 100 years). This will signifi cantly reduce repairing costs.

New power transmission poles will be equipped with radio-frequency tags (microchips) containing a unique identifi cation number. This number provides access to

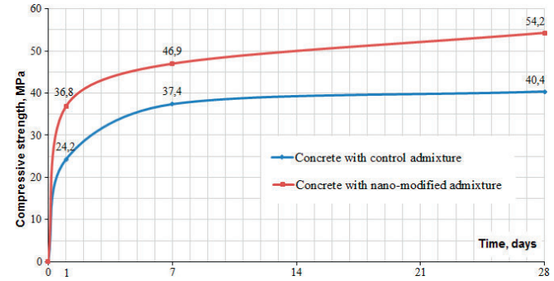

Fig. 2. Kinetics of concrete strength development

the electronic passport and, hence, to information on poles life cycle and technical documentation with detailed information on the released product and its characteristics. Electronic certification of reinforced concrete poles will allow engineers to produce products differentially and to supply them on energy facilities taking into account individual corrosion protection requirements. Products identification will allow the customer interested in quality to choose poles based on their properties. In addition, it will increase the responsibility of the manufacturer and supplier, ensure stable quality of the products used at the facilities, and exclude the supply of products mismatching the claimed characteristics. As a result, there will no problems during operation. Information on each product with reference to specific power transmission pole will be added to the electronic passport of overhead line.

CONCLUSIONS

1. A complex chemical additive for concrete has been developed. It includes nanosize dispersions, which make it possible to produce nanomodified concrete characterized by high strength, density, freeze-thaw, water and corrosion resistance. Such concrete provides increased reliability and durability of structural units.
2. The cost of reinforced concrete products made from extra durable concrete does not differ from the cost of standard structures. At the same time, the use of durable structures eliminates the need for repairs throughout the entire service life. This fact has the greatest importance for foundation structures — piles and pad and chimney foundations operating in rough soil conditions (there is no access to these structures during their operation).
3. Early order of existing standard designs using nanomodified concrete can significantly reduce operating costs in the future.
4. The development of a new unified series of reinforced concrete poles with increased reliability and durability for 0.4 and 6-10 kV overhead lines will decrease the cost of transmission lines construction by means of reducing the number of poles per kilometer. Also, operation costs will be reduced due to the absence of repairs. A digital electronic passport will allow engineers to transfer all information about the product to the IT system of electrical network for solving the problems of production and technical management, monitoring and equipment diagnostics. P

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