

12th International Conference "Organization and Traffic Safety Management in large cities",
SPbOTSIC-2016, 28-30 September 2016, St. Petersburg, Russia

Evaluation of the Effectiveness of the Method for Calculation of Composite Materials in the Construction of the Bridges in Terms of Their Safety and Reliability

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Abstract

The article reveals the problem of applying composites to bridgework abutments. The advantages of composites over traditional materials are described. The examples of existing structures made of composites are presented. The article reports the problem related to the composite bridgework abutments construction. The goal of undertaken study is set. Testing of composite samples potentially suitable for bridgework abutments construction is reported.

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Peer-review under responsibility of the organizing committee of the 12th International Conference "Organization and Traffic Safety Management in large cities"

Keywords: traffic structures reliability; bridgework on motorways; bridgework abutments; calculation procedure; structures lifecycle; composites; testing

1. Main text

Traffic safety depends not only on motorways condition but on the relevant structures as well. Guaranteed reliability of traffic structures is the cornerstone of traffic safety. The responsibility for building a traffic structure is

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extremely high. As a rule, they are erected over obstacles bearing risks for humans. There is a problem as to the reliability of artificial structures on motorways during their lifecycle. This becomes even more important with urban structures for population density in cities is times higher.

In this country column bents had been built since 1960s with use of reinforced concrete shell piles with diameter 0.8...1.0 m, bridge link stretch up to 8 m, wall thickness 10–12 cm. Later sections having length up to 12 m and diameter 1.6 m appeared. Shell piles links were connected with bolts with use of flange joints. The lower part of shells was filled with concrete to the level of 3 m to provide bearing capacity, and the upper part was filled with non-wettable sand to the level of possible fluctuation of water horizon to exclude any possibility of rupture by freezing water. The advantages are as follows: no need for grillage erection and material consumption decrease [Salamakhin (2014)]. However, oftentimes such abutments being operated for a little time show vertical cracks. This is caused by imperfection of a structure, as shell armoring is not designed for side impacts on shell walls; concrete strength for such structure is not sufficient. Thus, the study subject is bridgework abutments.

In recent times, reinforced concrete and metal traditionally used in construction have been being actively replaced with composites. The very idea of a composite (compositional, combined) is rather wide-ranging and relates to all materials consisting of two and more components, e.g. reinforced concrete, glass, glued wood, etc. However, currently this word is more often understood as certain innovative materials which just a while ago have been used in rather narrow industries such as space or aviation. As these materials contain several components with different properties, they combine properties of all constituents though not in full. This advantage favorably sets composites apart from traditional construction materials. It gives the possibility of improving existing structures, create new ones and produce hybrid systems enhancing reliability of famous structural solutions for the combination of various properties. The properties associated with composite structure purpose are formed in the course of structure manufacturing, which gives actually endless prospects through the possibility of structure and composition modification.

Besides, one of the main directions of USSR economic development as long ago as in 1986–1990 and for the period till 2000 was the structural improvement of applied construction structures and materials with use of plastics, resins, polymers, and other non-metal materials. More than two decades later, we still call them innovative ones [Bondarenko and Shagin (1987)]. It means that on the one hand the study context is still broad, on the other hand it is required to make up for lost time and expand the range of produced goods and structures and composite structures in this country.

Composites are characterized by a series of peculiarities. The constituents and mutual disposition scheme are to be determined in advance. The appearance and quantitative composition of components are selected with consideration of required properties of a designed item. The resulted material appearing homogeneous in macroscale is non-homogeneous in microscale; the constituents have different properties and in joint points there is a boundary — a layer between phases [Shevchenko (2010)] also influencing the resulted item operation characteristics.

Components differ in geometric sizes. A non-continuous component split in the composition is called armoring element or filler. The component continuously filling the whole volume is called matrix which may be represented by metals, alloys, organic and non-organic polymers and other substances. An armoring element is usually represented by evenly spread fine particles (to 2–4% of the whole substance volume), or fibers of materials of various nature mainly high-strength ones. In fiber composites, the share of high-strength fibers may reach 75%. In the course of fiber composites production the tendency is to evenly spread armoring fibers to provide uniform resistance to impact loads across an entire section. Essentially, in fiber composites an armoring element is envisaged in one direction, therefore such composites vividly demonstrate anisotropy of properties [Arzamassov (2008)]. That is to say that such materials have different resistance to loads depending on the impact direction and fibers disposition.

Mechanical properties of fiber composites are very good for construction use. Among the main characteristics are high strength of armoring fibers, bonding strength on the interphase boundary and matrices rigidity. These very characteristics determine the mechanics of operation and fracture of such materials. Thus, in the course of design it is required to form an optimal structure of the material itself. As for the interphase boundary, the imperative requirement to this part of the material is resistance to stresses and impacts considering their assignment in a construction structure.

The bases for composite materials used in different industries are represented by various fiberglass plastics; basalt fiber reinforced polymers and carbon fiber-reinforced plastics are less spread for a higher cost [Oreshkin (2014)].

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