APPLICATION OF COMPOSITE MATERIALS IN MOSCOW MEGAPOLIS BRIDGE CONSTRUCTION

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ABSTRACT

In this paper, current problems associated with bridge construction in the Moscow city megapolis are described. Methods of solving these problems with the use of composite materials are then proposed. Several realized and planned bridge projects, including small pedestrian bridges, collapsible bridges, pedestrian decks, motor-car bridges and other cases are presented. It is shown that FRP is cost effective in these applications.

KEYWORDS
FRP, bridge, megapolis, standards.

INTRODUCTION

The current state of Moscow infrastructure is unsatisfactory due to rapid aging and degradation. It is important for the economic progress of the city that these problems be addressed in the most economical way at the shortest possible time. The traditional methods of repair may not be quite efficient as they often take long, are bulky and produce a lot of waste.

World experience of the use of composite materials in bridge construction has been positive. In Russia, its application has begun with the direct assistance of ApATeCh since 1998. The short history of this process includes the following stages:

1998 – Proposal of ApATeCh to Russian Railways Ministry (RRM) for pedestrian bridges
2001 – Temporary technical specifications for RRM (Institute of Bridges and ApATeCh)
2002 – Fragment of pedestrian stair flight
2003-04 – Two technical certificates of ROSSTROY (State Building Department of Russia)
2003-04 – First composite bridge in Russia (Chertanovo)
2004 – First Russian composite bridge with stair flights
2005 – Temporary technical specifications for Moscow (TTS)
2005-06 – Mobile pedestrian bridge for Moscow
2005-07 Park bridges for Moscow
2007-… issue concerning GFRP in construction regulations of Moscow (MGSN)

Under the order of ministry of Railways of the Russian Federation (RRM) ApATeCh developed temporary technical specifications, regulated the main stages of building pedestrian bridges from composite materials. Furthermore, in 2002, ApATeCh installed a set of pedestrian stairs from pultruded fiberglass with a width of 4 m and length of 4.5 m to be used for long-term field tests in Saint-Petersburg. The stair flight has been in use till the present time without any complaints from railway authorities.
A pedestrian bridge which was the first of its kind in Russia was constructed from GFRP. It was designed based on existing standards for bridges from traditional materials in combination with Technical Specification for GFRP pultrusion by ApATeCh and temporary technical specifications of RRM for the application of composite materials in pedestrian bridges. The bridge shown in Figure 1 was built in cooperation with Fiberline of Denmark and installed in November 2004. Assembly time was very short – a mere 12 hours. Weight of the bridge was about 10 tones, its width 3m, span lengths were 2*13m and 1*15m. Comparing to normal practice, the maintenance costs reduced more than a 100 times.

In 2004 it was necessary to build a bridge over the highly loaded railway line (four tracks). A problem there was that the area which could be used for building site and storing of constructional materials was limited. The use of composite materials for bridge construction allowed erection of the structure which has a weight of 55 tones (Figure 2) in one month from the start-up till approvals were obtained. Assembling did not impose much need for storage area. The two-span structure with the width of 5m and span length of 17 m was assembled using mobile cranes in 4.5 hours.

The construction of aforementioned structures relied on extensive experimental studies by Ushakov et al. (2005). Particular tests were performed to determine:

- parameters of strength and durability of the material of pultrusion profiles
- static strength and durability of main components of bridge structure (Figure 7a)
- static strength, vibratory characteristics and creep of the material (Figure 7b)
- static strength, creep and vibratory characteristics of fall-scale structure (Figure 7c)
Obtained experimental data and experience of design and construction of pedestrian bridges from composite materials allowed ApATeCh to obtain the required certificates of ROSSTROY of Russia (State Building Department of Russia) for the application of composite materials in building and bridge construction in 2004 and to develop technical specifications in 2005 upon request of Moscow government. Technical requirements included the following:

− requirements on the material and structure;
− tolerance of structure and elements;
− requirements for structural analysis, elements and joints
− regulations of acceptance;
− regulations of transportation and storage;
− regulations of assembling and erection of pedestrian bridges from GFRP;
− safety requirements.

The first project, designed in accordance with technical specifications, was a mobile bridge with stairs, constructed upon the request of Moscow government.

The bridge was designed for quick installation above the highly loaded Moscow highways (Figure 4a). Basic requirements of the construction were:

− Minimum time of assembling and minimum site area required for erection;
− Installation on the light temporary supports;
− Transportation by non-special transport;
− Storage in the open air.

The bridge consists of 6 blocks that are easily connected to each other (4 of 6 m and 2 of 9 m) and 2 whole-composite stair flights. The first installation of mobile bridge (Figures 4b and 4) was performed on the 3rd of
December, 2006 in Moscow above Garden Ring in the region of Smolenskaya metro station near the Russian Foreign Ministry. Time of traffic suspension was 3 hours. Assembling of the span took 20 minutes.

Figure 5 presents the deck from composite materials on the metal framework of bridge above federative automobile to Saint-Petersburg way near Moscow. The main problem during the construction of the bridge was limited assembling time and necessity of realization of works in winter under low temperature. Initial project specified concrete casting of the deck in field conditions, construction of intermediate support and two times suspending traffic on the automobile route. Replacement of reinforced concrete deck by composite materials allowed fulfilling the installation of the span for one raise without construction of intermediate support and to avoid concrete works. Time of traffic disturbance on the route was 1 hour. Table 1 contains calculation of technical and economical gains of building the deck from composite materials instead of reinforced concrete. Parameters of construction included: length of the span =56 m, width = 4 m. Main technical and economical effect: decreasing of the weight of elements of the bridge by 63% and decreasing of the cost of installation of bridge by 12%.

<table>
<thead>
<tr>
<th>Name of elements and works</th>
<th>Initial project of pedestrian bridge</th>
<th>Variant of bridge with a GFRP deck</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Weight, tones</td>
<td>Cost, thousand rubles</td>
</tr>
<tr>
<td>Assembling of the span (including assembling, transportation, mounting) excluding the cost of metal</td>
<td>84,01</td>
<td>6 918</td>
</tr>
<tr>
<td>Reinforced concrete deck (including waterproofing and tiling)</td>
<td>110,22</td>
<td>482</td>
</tr>
<tr>
<td>Installation of reinforced concrete deck (including waterproofing and tiling) excluding cost of reinforced concrete deck</td>
<td>110,22</td>
<td>4 363</td>
</tr>
<tr>
<td>Deck from GFRP</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Installation of the deck from composite materials</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Total</td>
<td>194,23</td>
<td>14 121</td>
</tr>
</tbody>
</table>
Besides the aforementioned truss bridges, in 2005-2006, a cable-stayed bridge, several girder bridges and railing barriers were designed and constructed (Figure 6). All bridges are installed in parks or recreation areas, where construction is difficult.

There are several prospective bridges shown in Figures 7 and 8. These structures have been designed but not constructed as yet due to different reasons. There is a mobile standard pedestrian arch bridge with a span of 15 m as shown in Figure 7a. It is meant to be installed on small rivers of Moscow, basically in recreation areas. Bridges are produced fully in the factory and installed on site with minimum disturbance to the area. Additional advantage of this construction is the possibility of erecting the bridge in wintertime.

A bridge combined with commercial outlets (Figure 7b) not only serves the city as a bridge, but also solves the problem of financing the construction. Investors who purchase the outlets would in fact pay off the construction cost. In this scenario, the use of traditional methods and materials is not quite as workable because of the maintenance issues that have to be sorted out amongst a large number of owners. A low maintenance structure made of composites would be a lot more efficient in the long run.
Another proposed project as shown in Figure 8 allows increasing the traffic capacity of existing automobile roads. Superstructure of the bridge is steel; the deck is from composite materials. The structural advantages are that the support area is small and that the whole bridge can be installed as one piece with minimum disruption to the traffic.

The realized and prospective projects have been brought about in Moscow region due to the many advantages of composite materials such as:

- reducing of time and cost of assembling;
- minimum area required for the building site and supports;
- low costs of transportation and storage;
- minimum time of traffic disturbance;
- possibility of building in winter;
- improving serviceability and reliability of structural elements and reducing of operational costs;
- Prolonging lifetime and increasing the traffic capacity of existing bridges.

Based on the information obtained during the design, analysis and construction of the aforementioned structures, an additional section has been added to the Moscow City Construction Code (MGSN) with the title: Use of GFRP in Pedestrian bridges and tunnels. This process (which has taken around 10 years from the time of first construction of this kind in Moscow to the time of having the method implemented in the standards) has opened avenues for mass production.

REFERENCES