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Bridge Solutions Based on Composite Dowels Executed in Romania

Edward Petzek[a]*, Elena Meteş[b], Luiza Toduţi[b], Radu Băncilă[a]

[a]*Prof.Dr.Ing., Politehnica University of Timşoara and SSF-RO Ltd. Spl. T. Vladimirescu 12/6, Timişoara, 300.195, Romania*
[b]*Drd.Ing. Politehnica University of Timşoara and SSF-RO Ltd. Spl. T. Vladimirescu 12/6, Timişoara, 300.195, Romania*

Abstract

The design and construction of sustainable and durable bridges with low maintenance costs is one of the European Road and Railway Administration tasks. The main topics of the paper are the following: design of efficient, economical bridges with reduced maintenance during the life service, integral bridges – frame structures based on innovative composite dowels for the shear transmission, construction of bridges in Romania.

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1. Introduction

In the background of Europe's transportation system renewal process, Romania is also passing through a development period of its transportation infrastructure. This is an opportunity for a country to develop efficient, economical and also modern projects, targeting towards obtaining sustainable systems in the end. Most of the new investments in the transportation system are assigned by tender projects in form of „*design & build*" and this way joint ventures between execution companies and structural engineering offices are given the possibility to build whole road sectors in an economic advantageous manner. This assignment method permits the newly developed, innovative and economical solutions to be used in Romania too.

The present tendency in bridges consists in simplifying the structure as much as possible and beyond, designing of modular systems based on prefabricated elements, which moves important work steps from the site to weather protected areas guarantying a better quality of the constructive elements.

* Corresponding author. Tel.: +40-256-20 10 21; fax: +40-256-20 10 21.
E-mail address: epetzek@ssf.ro

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The bridges are vital structures for the transport infrastructure; it is a fact that, in the last decades, composite bridges became a well-liked solution in many European countries as a cost-effective and aesthetic alternative to concrete bridges. Their competitiveness depends on several circumstances such as site conditions, local costs of material and staff and the contractor's experience.

An important step in the construction of efficient bridges was done in our country beginning with 2011 through reusing of integral structures. At these types of structures the abutments and the piers are monolithically connected to the superstructure and in this case a clear distinction between the superstructure and the infrastructure of the bridge is not possible. The integral bridges have a very long tradition; arch-like bridges have been erected for over 2000 years. Practically nowadays the frame structures are the so called "old arch bridges".

The first lot of motorway Orăştie - Sibiu, which is part of the IVth pan-European corridor located near to the town Orăştie and the Mureş River and its confluents, with a total length of 24,110 km, where 27 bridges were included, represent the first example in this sense. On this section all structures are being designed and executed as bridges with integral abutments, except the viaduct from km 1+240, with a total length of 240 m, which is a semi-integral structure. As a consequence, only two pieces of expansion joint equipment and eight bearings were used for the whole motorway lot [1]. This motorway lot can be considered a European premiere, having only integral or semi-integral bridge structures.

It is clear that the frame bridges need special attention in the design due to the interaction between the structure and the soil conditions. But nowadays the designers can correctly evaluate the behavior of complex structures making use of present design methods and modern dedicated software. The integral bridges, frame structures with single or multi spans, present some well-known advantages which are at the same time important for beneficiaries and also for the contractors, like:

- Slender structures and material savings by means of the frame effect which reduces the maximum bending moments in the middle of the span in comparison with the simple supported ones, avoiding high stressed structural elements, reducing great deformations.
- System reserves through redundant structural behavior.
- The lifting forces are compensated by the monolithic connection between the superstructure and the substructure.
- The stress concentrations at the bearings area are eliminated.
- The presence of the backfill assures a better dissipation of the horizontal forces.
- Simple and rapid erection due to the modularity of the system.
- The risks induced by the great execution precision needed for the disposal of the equipment like expansion joints or bearings are eliminated.
- Low maintenance costs through elimination of the consumables (expansion joints and bearings). Greater driving comfort without expansion joints. Less noise, a fact which is very important in the urban area.
- Durability and robustness of the structure.

Another step in the construction of efficient bridges was the development of prefabricated composite or concrete girders with rigid external steel reinforcement using the innovative composite dowels for the effective transmission of shear forces between concrete and steel. This is the so called new construction method VFT-WIB®.

The designed bridge beams cross sections, which are already applied in our country, are presented in Figure 1.

There are two main types of cross-sections, namely a composite one (type I, see Fig. 1), respectively a concrete one with external rigid reinforcement (type II, see Fig. 1). In regards of their load carrying behavior the type I cross-sections are comparable to a classical composite cross-section due to the fact that the dowels' line is positioned near the neutral axis. Regarding type II cross-sections, where the distance between the dowels line and the neutral axis is greater, the steel section is almost subjected to tension and doesn't participate in the transmission of bending and shear forces between the two different materials (concrete and steel), thus the steel part can be considered as an external rigid reinforcement.