

ECONOMICAL INTEGRAL BRIDGE STRUCTURES BASED ON COMPOSITE DOWELS

Edward Petzek¹

Radu Băncilă²

УДК: 624.2/.8

DOI:10.14415/konferencijaGFS 2015.020

Summary: *The design and construction of sustainable and durable bridges with low maintenance costs is one of the European Road and Railway Administration tasks. The structures must be safe, economical and with good serviceability issues. All these needs can be found in integral abutment bridges. This solution, by eliminating the bearing and expansion joints, leads to low production and maintenance costs. Integral bridges have a good earthquake resistance. The main topics of the paper are the following: design of integral bridges and innovative composite dowels for the shear transmission.*

Keywords: *integral bridge, VFT®, prefabricated composite beam, composite dowel, Romanian motorway system.*

1. INTRODUCTION

Integral bridges are characterized by monolithic connection between the deck and the substructure (piers and abutments); they span from one abutment, over intermediate support to the other abutment, without any joint in the deck. Traditional bridges include bearings and expansion joints in order to accommodate the deck thermal and horizontal forces. Bearings and expansion joints are sensible elements; their deterioration can lead to interruption of the circulation on the bridge. The general concept of integral bridges is based on the theory that, due to the flexibility of the piles and the rigid connection between the superstructure and infrastructure, the stresses are transferred to the foundation soil (substructure). A complex soil-structure interaction takes place. Applying the integral concept can lead to:

- reduced material and construction costs of the bridge;
- minimized deterioration by chemicals;
- simplified construction;
- high durability with reduced maintenance
- increased seismic performance and resistance to blasts;
- comfort in circulation.

¹ Edward Petzek, Dr. Ing. Civil Engineering, Associated Professor, University Politehnica Timisoara Romania, Str. Tr. Lalescu 2A, 300222 Timisoara, Tel: 0040256404000. E-Mail: edward.petzek@upt.ro

² Radu Băncilă, Dr. Ing. Civil Engineering, Professor, University Politehnica Timisoara Romania, Str. Tr. Lalescu 2A, 300222 Timisoara, Tel: 0040256404000. E-Mail: radu.bancila@upt.ro

Furthermore, integral bridge solution can also be employed - with very good results - in retrofitting and rapid renewal of existing bridges.

Europe's road infrastructure is in a renewal process and at the same time, existing structures are being rehabilitated. The opening of the eastern bloc brought, alongside the political and social challenges, new targets for the Pan-European transportation system. In the early '90 European crossing corridors were elaborated. Three of these corridors cross Romania's territory: IV, VII and IX. The Romanian railway and highway infrastructure is presently involved in a large operation of renewal and modernization.

2. CONCEPT OF COMPOSITE DOWELS

In order to conceive competitive bridges and to shorten and simplify the site operation, a high degree prefabrication model was introduced. The system was used since 1998 at the beginning mainly in Germany, Poland and Austria and after that in all Europe Fig. 1 . [1]. This solution eliminates wind bracings during erection shortening the construction time. It is a cost-effective construction for composite bridges of medium spans with site-prepared traffic deck [2]. The pre-fabricated composite beams consist of a steel beam with a concrete flange, which serves as a compressive chord and formwork element for the site-mixed concrete deck (Fig. 1).

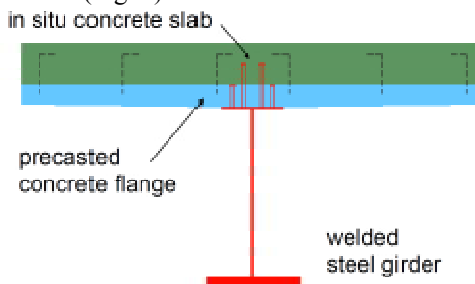


Fig. 1 VFT® - girder

A next step in the construction of efficient composite bridges is the elimination of the upper steel girder flange and of the shear connectors. The girder is cut in two, using a special geometry, which divides it into two simply symmetrical halves (Fig. 2), generating the composite dowel geometry at the same time. The composite dowels are formed by the steel dowel (or steel tooth), the concrete dowel (essential is the geometry of the steel dowel) and the reinforcement component of the dowel.



Fig. 2 Separating cut line

In this way the VFT-WIB (Walzträger im Beton), elegant and efficient solution is obtained (Fig. 3)

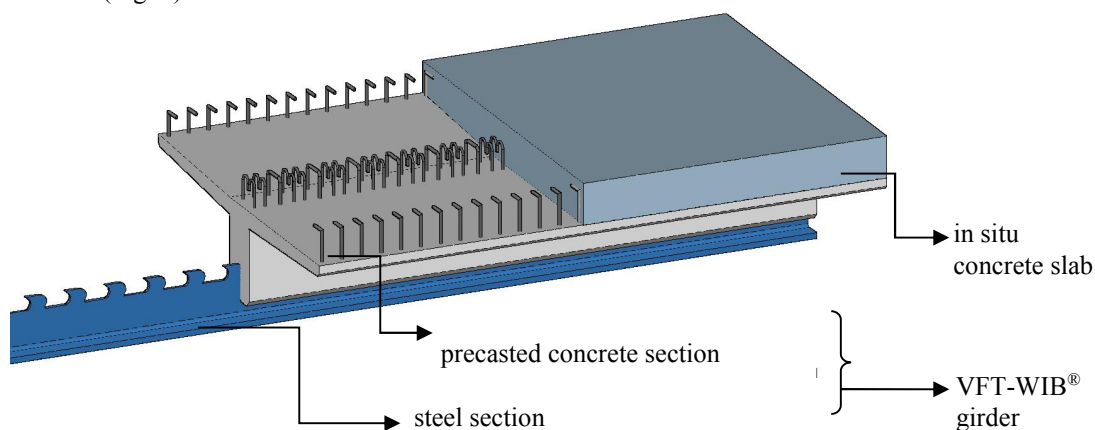


Fig. 3 VFT-WIB® girder

In Fig. 4 the evolution and the advantages of the new proposed solution are given. In Fig. 4a the classical solution for composite sections is presented. In Fig. 4b the stress distribution for the VFT solution is shown. Fig. 4c presents the VFT-WIB concept, and in Fig. 4d the next step (solution with external reinforcement) is described.

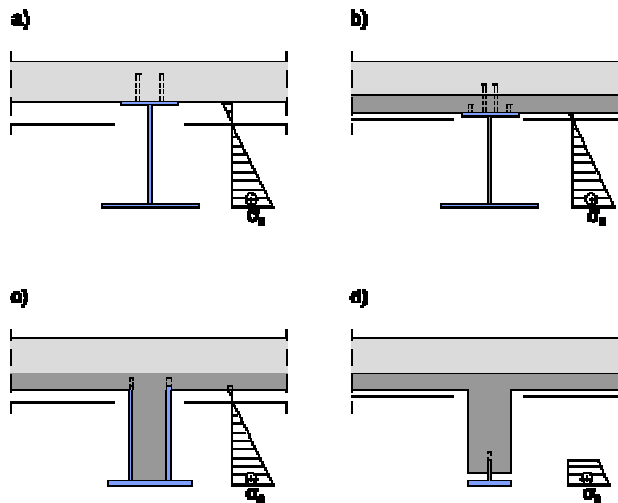


Fig. 4 Stress-distribution for different composite-sections

3. ROMANIAN INTEGRAL BRIDGES WITH COMPOSITE DOWELS

On the Orăștie – Sibiu motorway section (situated in the South of Transylvania), and the first lot of 24 km, all structures were designed as bridges with integral abutments (except a viaduct with a total length of 240 m, which is a semi-integral structure). Finally 7 motorway bridges, 7 motorway overpasses for national, county or agriculture roads and 13 box bridges resulted [4].

For the motorway underpasses, structures with small spans, box bridges – reinforced concrete frame-type structures – with one or two spans were chosen Fig 5. The foundations are continuous and the frame walls were casted “in-situ”. On these vertical walls, precast elements acting as formworks were placed, reducing the time and effort on site. The precast elements include connecting reinforcement to ensure the connection of the in-situ concrete slab.

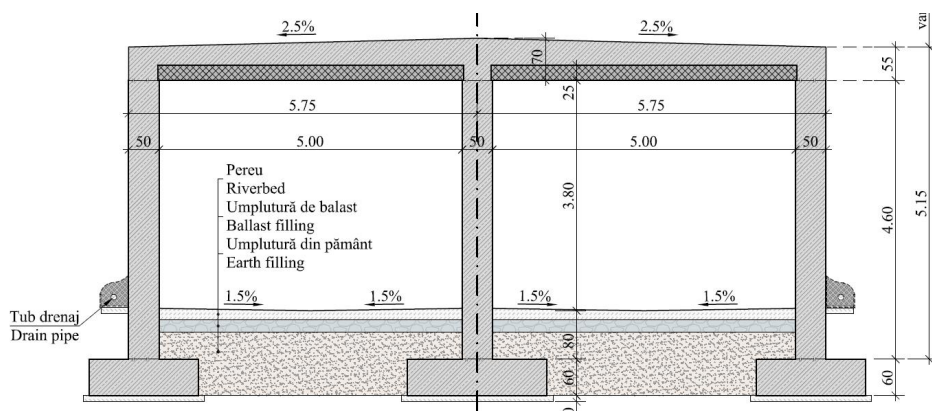


Fig. 5 Box bridge cross section

In another case the integral solution was adopted for two skew $\approx 70^\circ$ overpasses. The girders are 39 m long and assure a clearance in the orthogonal direction of 35 m (Fig. 6). A frame static system was adopted in this case as well (Fig. 7).



Fig 6 Overpass on the national road – site photo

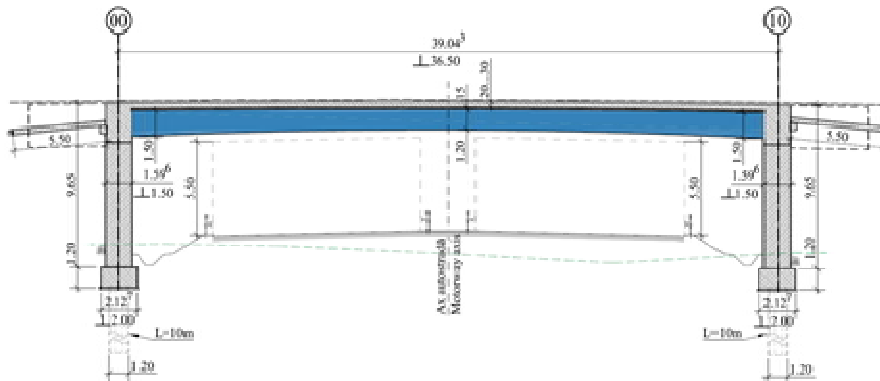


Fig. 7 Longitudinal view of the overpass



Fig. 8 Steel girders on the site, ready for erection.

In another case this solution was adopted for a bridge in the South of our country on a local highway deserving a rural community (Fig. 9). The major advantages are reduced costs and simplicity in on site operations. The structure is an integral bridge, with three spans of 21,10 m. Three steel girder HEM 600 from steel S 460 ML where used and after cutting following a special geometry, six girders where obtained.

4. CONCLUSIONS

Composite structures [5] are highly competitive solutions – over a wide range of spans. Beside the classical solution, the new ones with efficient design and construction improve and consolidate the market position of the steel construction and steel producing industry [6]. Composite dowels realize a high load bearing capacity and ductile connection between steel members and concrete part.

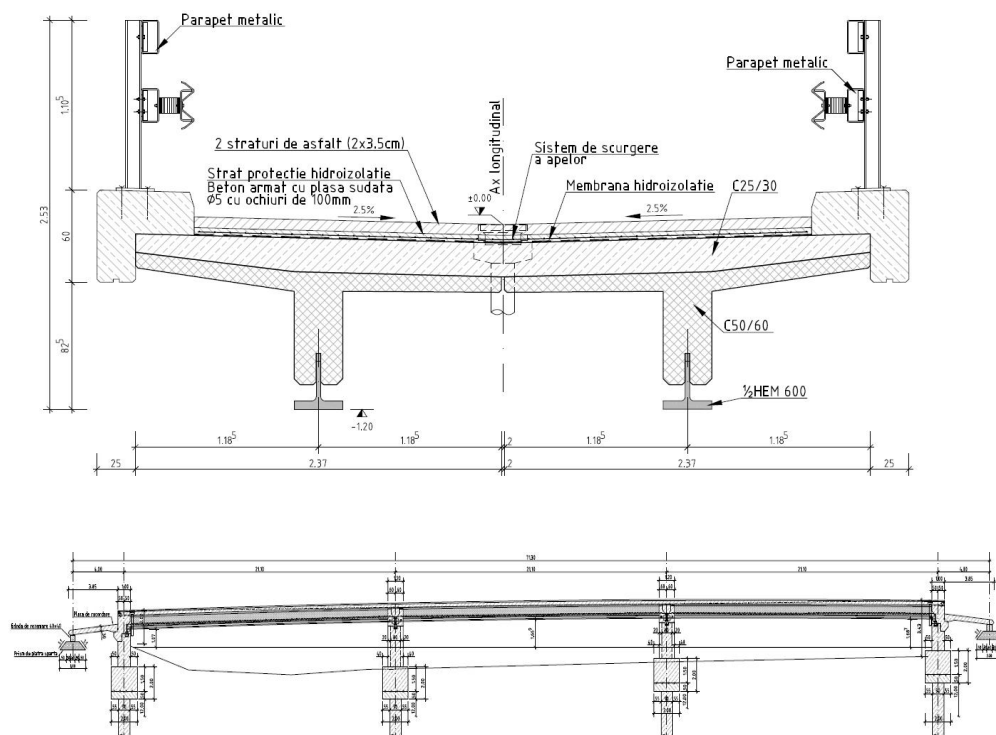


Fig. 9 –VFT-WIB bridge

REFERENCES

- [1] Schmitt, V., Seidl, G.: Verbundfertigteil-Bauweise im Brückenbau, Stahlbau 70 (2001), Heft 8, pag. 546-553.
- [2] Petzek E., Băncilă R.,: Bridges with embedded girders (in Romanian), Orizonturi Universitare, Timișoara, 2006.
- [3] Seidl, G., Braun, A., :VFT-WIB Brücke bei Vigaun – Verbundbrücke mit externer Bewehrung”, Stahlbau 78 (2009), Heft 2, pag. 86.
- [4] E. Petzek, R. B Băncilă,: Economical Bridge Solutions based on innovative composite dowels and integrated abutments, Springer Verlag, 2014, ISBN 978-3-658-06416-7.
- [5] EN-1994-1 EUROCODE 4: Design of composite steel and concrete structures, August 2005.
- [6] E. Petzek, R. B Băncilă, The eight international conference Bridges in the Danube Basin, Proceedings, Springer Verlag, 2013, ISBN 978-3-658-03715-4.

EKONOMSKI INTEGRALNE MOSTOVSKJE KONSTRUKCIJE NA BAZI KOMPOZITNIH SPOJNICA

***Sažetak:**Projektovanje i izgradnja održivih i trajnih mostova malih troškova održavanja je jedan od zadataka Evropske administracije za puteve i železnicu. Konstrukcije moraju biti bezbedne, ekonomične i lako održive. Sve ove osobine se mogu naći u integralnim mostovima. Ovo rešenje, eliminacijom oslonaca i dilatacionih spojnica, vodi do jeftinije proizvodnje i manjih troškova održavanja. Otpornost na zemljotrese integralnih mostova je dobra. Glavne teme rada su sledeće: projektovanje integralnih mostova i inovativna spojna sredstva za prenos napona smicanja.*

***Ključne reči:**integralni most, VFT®, montažna spregnuta greda, spregnuti moždanici, sistem rumunskih puteva.*