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COMPOSITE TIMBER-CONCRETE ROAD BRIDGE STRUCTURE

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Abstract. *This work presents preliminary design of the road bridge made of laminated timber. The supporting system of the main bearing elements is made of the laminated timber in the system of arch with three joints; the bridge slab is designed as continuous slab, made of nine equal fields; each part is made as composite timber-concrete beam, where the road slab is made of concrete and the needle pieces are made of timber. Fundament is based on HW piles. All the elements are designed to EUROCODE.*

Key words: *the road bridge, composite construction, EUROCODE.*

1. Introduction

As in using new materials as in using traditional materials, modern civil engineering stands in front of constructors with new technologies and innovating methods during manufacturing and producing, considering optimal esthetic and rational demands.

Adequate and rational use of materials in constructions led to invention of composite beams. The most used composite beams are steel-concrete elements, but we can use other types of materials, like timber-concrete elements.

Timber, as well as steel, has respectable tense strength, so it can be combined with concrete. Compared to classical timber constructions, composite timber-concrete elements have higher stiffness, fireproof ness, stability and seismic resistance, and compared with composite steel-concrete elements, timber-concrete elements have less dead weight.

2. Bridge Layout

The supporting beam of the main bearing element is made in the system of arch with three joints. Whole construction is made of four arches in the distance of 167cm between them.

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The supporting bear is designed like rectangle, dimensions 0,4 x1,2m, with arch span 48,32m. It is made of first class laminated timber. Bridge wide is 8,0m, length is 72m. Buckling of supporting beams is stopped by composite needle pieces, dimensions 0,2 x 0,6m and by steel cross members, diameter 2cm.

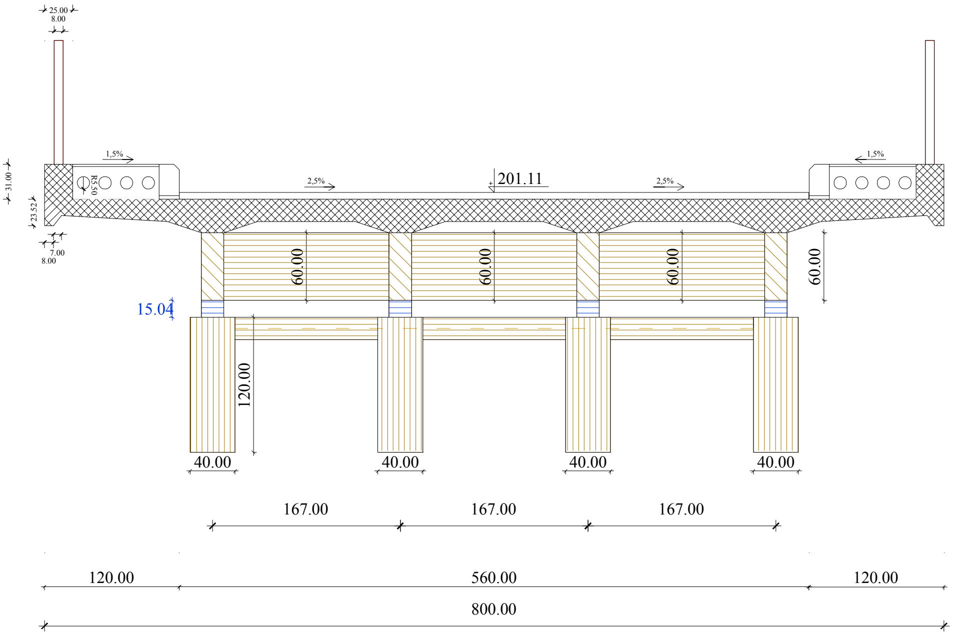

Fig. 1. Traverse road bridge section

Road slab as composite element is third bear of constructions and it is made of nine equal fields, length 8m; the each field is made like composite timber-concrete beam, where the road slab is made of concrete and the longitudinal pieces are made of timber.

Road surface is made of asphalt AB11, with traverse and longitudinal drainage made by actual regulations.

Because of low soil capacity and huge forces in supports, especially because of huge horizontal force caused by minimal ratio between width and height of arches, the solution is fundament on HW piles, 1,5m in diameter, length 14m, made of concrete.

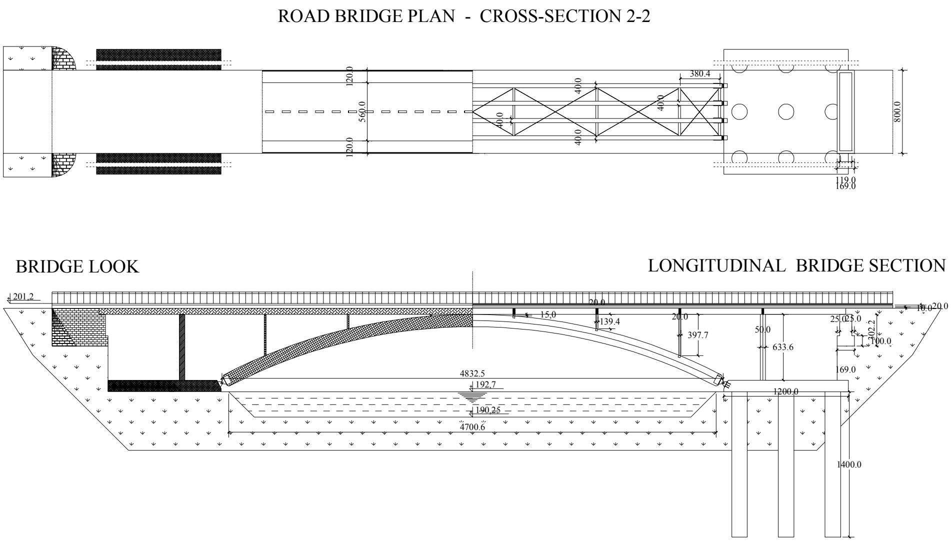

Fig. 2. Composite timber-concrete road bridge layout

3. Calculations and Loads

Stress calculations and loads are being conducted to European norms and the dimensions of supporting elements are also based on these. Stress calculation was conducted to ultimate state design and working load design, using partial coefficients for loads and materials. Stress calculation is made in Tower program, RadImpex 5,5; 3D bridge model is used.

Load analyses were conducted for permanent, temporary and incident load.

Permanent load is dead weight of construction (AC slab, arches, longitudinal and traverse beams of laminated timber, compounds in arches, steel and concrete columns).

Temporary load consist of:

- wind force (for the appropriate location)

$$F_w = q_{ref} \cdot c_e(z_e) \cdot c_d \cdot c_f \cdot A_{ref} \tag{1}$$

q_{ref} – reference mean wind velocity pressure

$c_e(z_e)$ – exposure coefficient

c_d – dynamic coefficient

c_f – force coefficient

A_{ref} – reference area

– snow load is $s_k = 1,0$ kN/m^2

– vertical load on fence is q = 1,0 kN/m^2

– main loading system, made of two partial systems:

– double axle concentrated loads – tandem system:

for the road track 1 – 300kN per axle, means 150 kN per wheel

for the road track 2 – 200kN per axle, means 100 kN per wheel

– distributed loads:
for the road track 1 – 9,0 kN/m^2
for the road track 1 – 2,5 kN/m^2

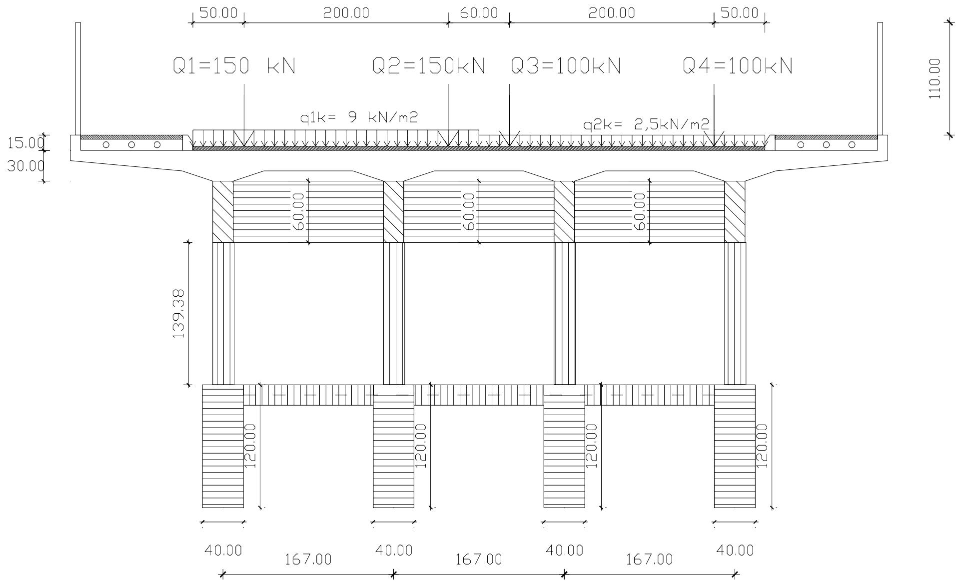

Fig. 3. Road bridge cross-section 3-3

For finding the most unfavorable dynamic loads, two models are used:

1) model 1, wheels presented as moving concentrated forces, pedestrians load presented as moving distributed load in front of and in the back of wheels.

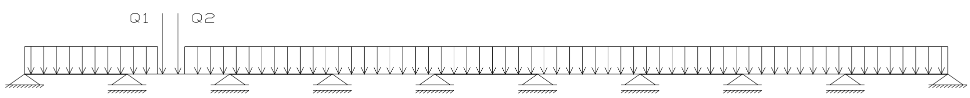

Fig. 4. Dynamic load, model 1

2) model 2, wheels presented as concentrated forces, pedestrians load presented as distributed loads placed on the fields with the most unfavorable bending moments, defined by influence lines.

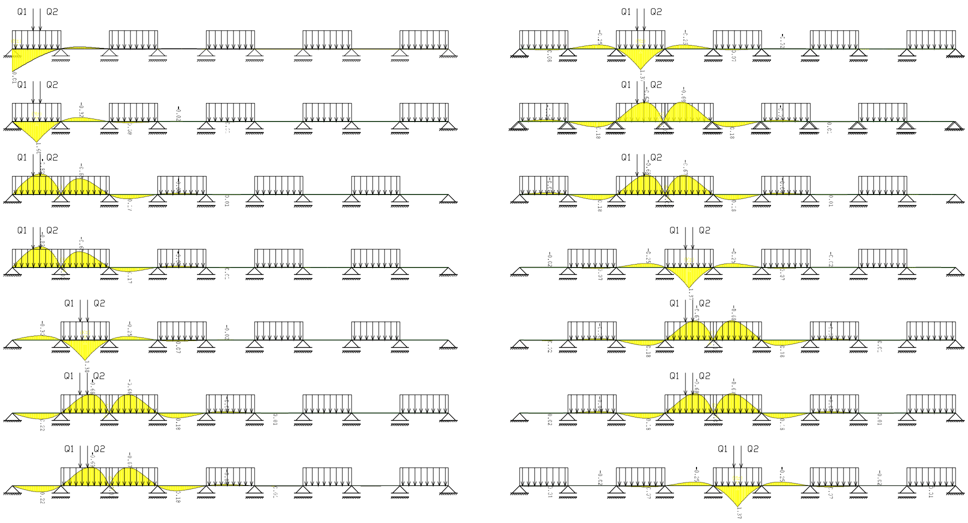

Fig. 5. Dynamic load, model 2

– Braking forces and acceleration forces

$$Q_{LK} = 0.6 \cdot A_{Q1} \cdot (2Q_{1K}) + 0.10 \cdot A_{Q1} \cdot Q_{1K} \cdot W_E \cdot L \tag{2}$$

– Dynamic loads on pedestrian sidewalk

For the pedestrian and bicycle sidewalks on road bridge only distributed load of 5,0 kN/m^2 is taken.

Incident loads consist of:

– the vehicles on pedestrians and bicycle sidewalks

It is not neccesary to include this type of load, because of curbe height of 25cm.

– suddenly applied load on curbes

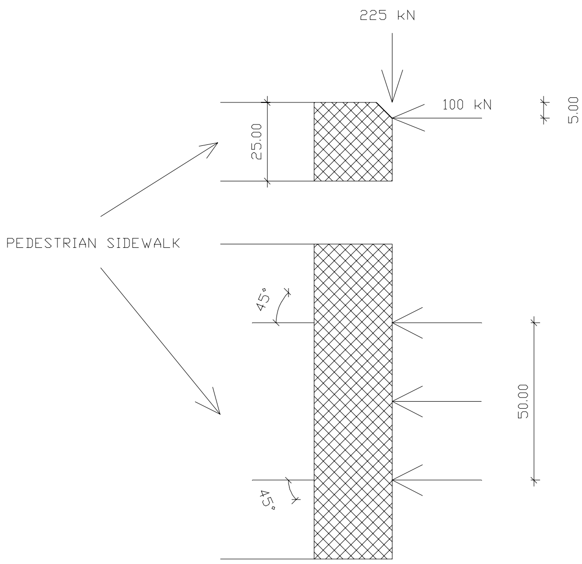

Fig. 6. Suddenly applied load on curbes

– suddenly applied load on safety barriers

It is not necessary to include this type of loads, because safety barrier is missing.

– suddenly applied load on construction elements

It is not necessary to include this type of loads, because of road surface placement.

Load combination I

a) permanent and temporary load

1. dead weight + main loading system
2. dead weight + wind load
3. dead weight + snow load
4. dead weight + wind load + snow load
5. horizontal wind load on unloaded bridge
6. horizontal wind load on loaded bridge

Load combination II

b) permanent, temporary and incident load

7. dead weight + incident load
8. dead weight + main loading system + incident load

Load combination III

c) permanent, temporary and seismic load

9. dead weight + seismic load
10. dead weight + seismic load + main loading system

For the composite bear timber-concrete element full analyse for limit state design and working load design was performed; based on ideal model of composite concrete slab element with timber pieces, which were linked by mechanical union nuts. Analyse has shown that geometry and used materials can satisfied EUROCODE NORMS.

Base element can be taken as prefabricated element, but also can be built IN CITY on building area. That is innovating system where you can easily put those elements into bridge construction.

4. Conclusion

This preliminary design of the road bridge is one presentation in modern conception of beam construction made from unexpected combination of materials as timber, steel and concrete.

As a prime material, timber is dominating in construction because of warm, esthetic, physical and economic advantages. In this type of constructions, where the arches are above the road slab, timber construction is partially protected from weather. Adequate protection for the weather exposed elements provides high level of durability for this type of construction.

Working with light materials, fast building and low price with full safety are the most important premises for that kind of constructions.

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SPREGNUTI DRUMSKI MOST OD LEPLJENO-LAMELIRANOG DRVETA

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Ovim radom je predstavljeno idejno rešenje drumskog mosta od lepljeno-lameliranog drveta. Glavni nosač konstrukcije mosta čine lukovi na tri zgloba, a kolovozna ploča je projektovana kao kontinualni nosač, gde je svako polje izrađeno kao spregnuta konstrukcija drvo-beton, gde beton čini kolovoznu ploču, a drvo poprečne nosače. Fundiranje je izvedeno na HW šipovima. Svi elementi su dimenzionisani prema EUROCODE normativima.