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ANALYSIS OF CROSS-BEAM IN DMS-65 TYPE ASSEMBLED BRIDGE LOADED BY SELECTED WHEELED VEHICLES

Abstract: The aim of this article is to determine the possibility of driving Jelcz P662D.34 vehicles over the DMS-65 assembled bridge, standard equipment in the Polish Armed Forces. In the analyses the Finite Elements Method (FEM) was used for modelling the cross-beam as a monocoque construction with surface elements.

1. Introduction

The nature of contemporary military operations poses a major threat to armed forces. The way in which military conflicts are conducted makes it necessary to have suitable means of transport capable of driving on hard-surface roads and in difficult terrain, abounding in water obstacles. Another significant factor is the possibility of air - and sealifting those vehicles. The awareness of new challenges determines the need to modernize and adjust military equipment to the demands of a modern battlefield. To meet this challenge, the Polish Armed Forces have decided to purchase the Jelcz P662D.34 truck. It is a three-axle, 6x6 vehicle designed for specialist bodies, including fuel tanks with a pumping unit. It satisfies all the requirements of the right technical conditions for special vehicles and the vehicles used for special purposes in the Polish Army [1]. Owing to a wide range of applications, it may become the principal means of transport employed by army logistic units.

J. Rymsza's research team [2] determined the military load class for the majority of assembled military bridges deployed in Poland. For the DMS-65 steel road bridge in its basic configuration, depending on the theoretical length span and the type of load, the Military Load Class (MLC), in accordance with STANAG [3], ranges from 60 to 80. The work [2] also shows that because of the load-carrying capacity of the individual structural components of the deck, the acceptable wheeled vehicle single axle load is 114kN/axle for the bridge deck and 110kN/axle for the cross-beam of that bridge, whereas the acceptable tracked vehicle load corresponds to MLC 100 because of the load-carrying capacity of the bridge deck, and MLC 70 because of the load-carrying capacity of the cross-beam. This is why the ultimate load-carrying capacity of the structure of that assembled bridge is primarily dependent on the load-carrying capacities of its components, including the cross-beam.

For this reason, the aim of the article is to determine the possibility of Jelcz P662D.34 trucks driving over DMS-65 assembled bridges, which are deployed by the Polish Armed Forces.

2. Assumptions Made For Calculations

In order to determine the MLC for the Jelcz P662D.34 vehicle, an original application depicted in the work [4] was used, assuming that in this case the reliable span length was 30 m. In the course of the performed calculations, it was assumed that because of the size of transverse force, the Jelcz P662D.34 wheeled vehicle should be treated as a MLC 25 vehicle.

The research the authors of the article have conducted so far [5] shows that MLC 30 is the acceptable load for driving over the DMS-65 assembled bridge, therefore the load analysed now (i.e. the Jelcz P662D.34) should be within the range of the acceptable wheeled vehicle single axle load for the cross-beam. Analysing the axle spacing on the span lengths under consideration, it was assumed that a single cross-beam in the adopted load scheme can be loaded only with four concentrated forces, i.e. $2 \times P_2 + 2 \times P_3$, coming from the second and third axles for the considered wheeled vehicle.

In the analysed calculation scheme of the load of the Jelcz P662D.34 wheeled vehicle (Fig. 1) the following parameters were assumed: axle load P_1 = 78.48 kN, $P_2 = P_3$ = 88.29 kN, axle spacing L_1 = 4.40 m, L_2 = 1.40 m, vehicle width B = 2.40 m, and bridge deck contact width B_g = 0.30 m.

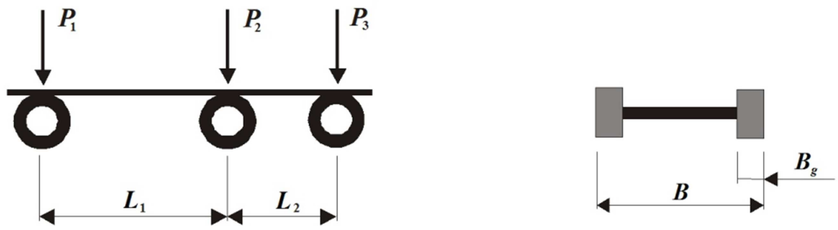

Fig. 1. The calculation scheme for the Jelcz P662D.34-type vehicle

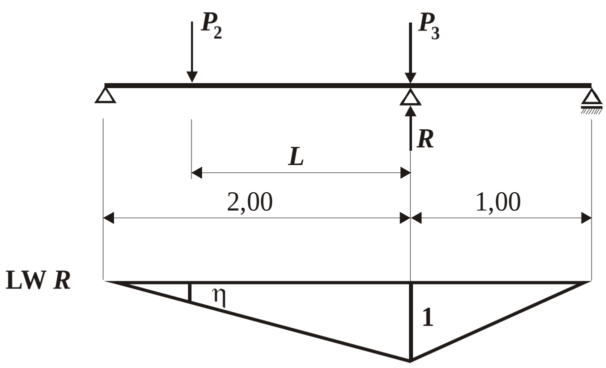

Fig. 2. The influence line of bearing reaction R corresponding to the load transferred onto the cross-beam from the two axles of the Jelcz P6622D.34 wheeled vehicle

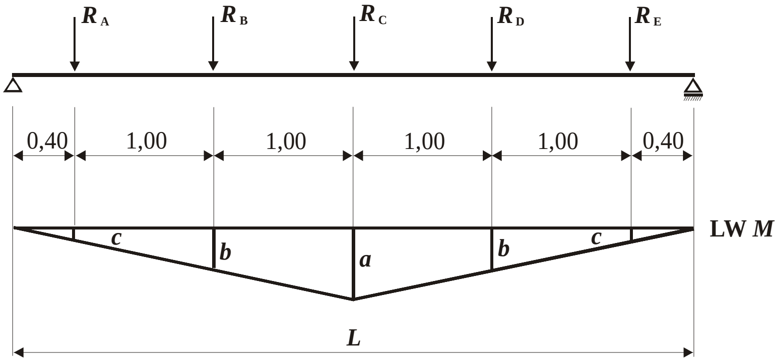

Fig. 3. The influence line of bending moment M in the middle of the cross-beam from the load transferred by bridge decks

Fig. 2 shows the influence line of bearing reaction *R* from the load transferred onto the cross-beam from the two axles of the Jelcz P6622D.34 wheeled vehicle (L = 1.4 m), whereas Fig. 3 the right influence line of bending moment *M* in the middle of the cross-beam from the load transferred by bridge decks.

Analysing the technical specifications of the Jelcz P6622D.34 wheeled vehicle adopted for calculations, it seems that the strength condition for the vehicle under consideration is fulfilled, because $P_2 = P_3$ = 88.29 kN/axle ≤ 110kN/axle. However, given the spacing between the second and the third axles (Fig. 1 and 2), it is necessary to increase the design load on the cross-beam up to 114.78 kN/axle, which exceeds the value determined by J. Rymsza as the boundary one [2].

The work [5] analyses two variants of cross-beam loading: W1 (symmetric) and W2 (asymmetric), coming from MLC 30 and MLC 70 wheeled vehicles transferred by both two and four bridge decks. Computational analyses show that greater stresses will occur in the cross-beam from the load transferred by four bridge decks, thus it was this load scheme that was adopted for further analyses in this article.

In addition, it was assumed that the loads from bridge decks are spot transferred onto the cross-beam, i.e. not in the actual locations of mandrels in the upper belt of the cross-beam, but directly above the reinforcement of the web, where there are stiffening ribs (Fig. 3).

The cross-beam in the DMS-65 assembled bridge is connected with main girders, constituting with the pillars and the diaphragms of the walls of main girders the so-called half-frame, which causes the elastic fastening of the ends of cross-beams traditionally treated as freely supported beams [2]. This is why J. Marszałek et al [2] suggested that for the calculations of the exact values of internal values in this kind of structures the scheme of the half-frame loaded at the height of the belts compressed with thrust force should be adopted. This justifies the adoption of the simplified calculation model of the cross-beam as a freely supported beam, additionally loaded with the moment at the support M_p at the ends, generating in reality the unloading of the cross-beam in the middle of its length [2].

It is commonly known that the value of the unloading moment M_p depends on axial force occurring in the compressed belt. In the most unfavourable arrangement for the cross-beam, i.e. in the direct vicinity of extreme supports, this value is relatively small (and in the case of entry spans it does not occur at all), and should not always be taken into account in the static and strength calculations of the cross-beam. Adopting for the purpose of calculations the static scheme of the cross-beam without taking account of the unloading moment M_p contributes to the determination of the most unfavourable load arrangement in strength analyses in the middle section of the cross-beam, and this is what was done in the computational analyses. Table 1 presents the values of the forces adopted in computer calculations.

Tab. 1. The values of concentrated forces in [kN] constituting the load adopted in the calculations from the Jelcz P662D.34 vehicle

Load	R_a	R_b	R_c	R_d	R_e	Total
Symmetric W1	3.81	52.62	1.92	52.62	3.81	114.78
AsymmetricW2	48.78	8.61	43.04	14.35	0	114.78

The bridge cross-beam was modelled as a monocoque construction. In the digitizing process, Coons' meshing method with quadrangular 4-knot surface elements was used. The dimensions of the created computer model of the cross-beam were adopted on the basis of the manual *DMS-65 Assembled Road Bridge. Construction and Operation* [6].

In the analyses the calculation scheme of the cross-beam was adopted in which it was assumed that its attachment to the truss post of the main girder, with two bushes and screws, causes its partial fastening, i.e. it enables its movement only in the longitudinal direction of the web [5].

Because of the adopted model of the attachment of the component and after taking account of the occurrence of lower wind braces in the span, the adopted numerical model of the cross-beam acted as expected.

3. Results of numerical analyses

Figure 4 presents the map of normal stress patterns with respect to the longitudinal axis of the cross-beam coming from the Jelcz P662D.34 wheeled vehicle from the load set both symmetrically W1 and asymmetrically W2.

Tables 2 and 3 and Figures 6 and 7 collate the results of the calculations of normal and reduced stresses in the middle of the cross-beam from the two adopted calculation schemes, i.e. the load with the Jelcz P662D.34 wheeled vehicle and a standard MLC 30 wheeled vehicle [5].

a)

b)

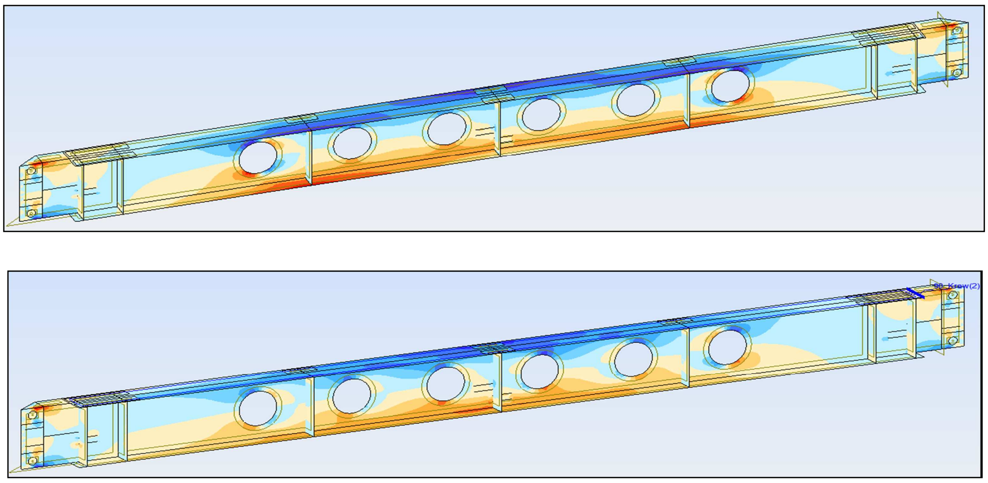

Fig. 4. The map of normal stress patterns in the cross-beam coming from the Jelcz P662D.34 wheeled vehicle with a) symmetric load W1, b) asymmetric load W2

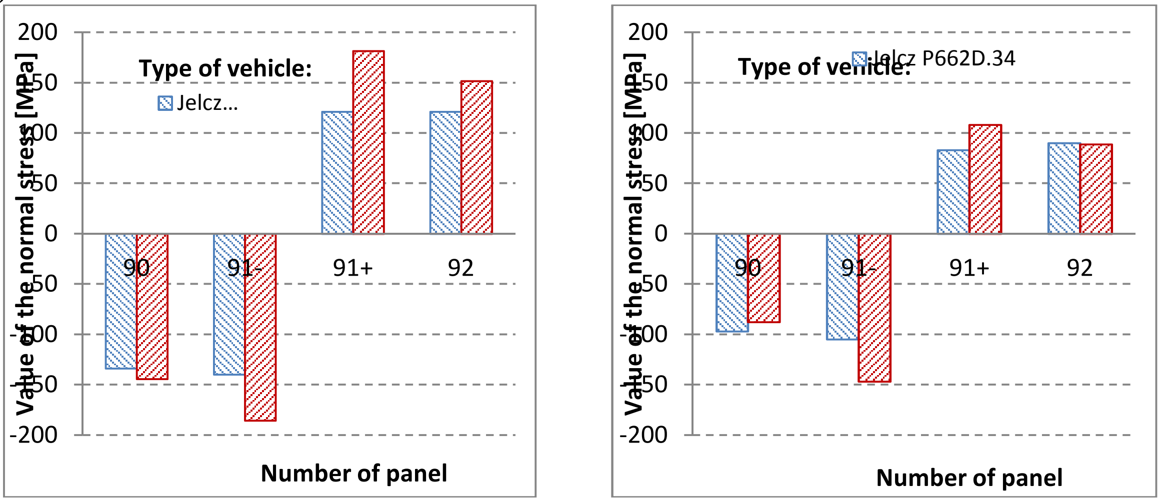

Fig. 5. Normal stresses from: a) symmetric load W1, b) asymmetric load W2

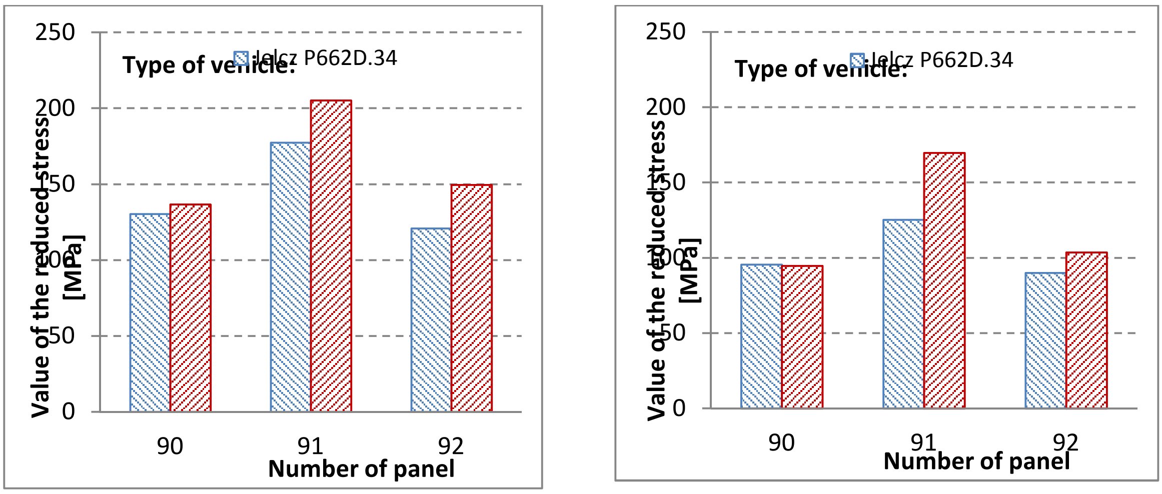

Fig. 6. Reduced stresses from: a) symmetric load W1, b) asymmetric load W2

Tab. 2. The results of numerical calculations – normal stresses

Item	Panel number	Symmetric load		Asymmetric load	
		Jelcz P662D.34	MLC 30	Jelcz P662D.34	MLC 30
1.	90 (upper belt)	-133.81	-144.36	-96.99	-87.63
2.	91- (web)	-139.89	-185.54	-104.95	-146.65
3.	91+ (web)	121.42	181.48	83.07	108.12
4.	92 (lower belt)	121.4	151.75	90.21	88.78

Tab. 3. The results of numerical calculations – reduced stresses

Item	Panel number	Symmetric load		Asymmetric load	
		Jelcz P662D.34	MLC 30	Jelcz P662D.34	MLC 30
1.	90 (upper belt)	130.28	136.68	95.38	94.55
2.	91 (web)	177.28	205.08	125.24	169.58
3.	92 (lower belt)	120.82	149.38	89.85	103.62

The analysis of stress patterns in the examined cross-beam confirmed that, like in the work [5], the greatest normal and reduced stresses occur not in the belts of the cross-beam, but primarily in the vicinity of assembly holes located in its web (Fig. 6 and 7).

The conducted analyses show that the Jelcz P662D.34 wheeled vehicle, whose load was classed as MLC 25 because of the effort of main girders, generates the effort of the DMS-65 assembled bridge cross-beam at lower level than the load with a MLC 30 vehicle, which may be allowed for driving on such a span.

4. Conclusion

Given the analyses performed by J. Rymsza's research team [2] finding, among other things, that the acceptable wheeled vehicle single axle load is 110 kN/axle for the DMS-65 assembled bridge cross-beam, it can certainly be concluded that the analysed Jelcz P662D.34 wheeled vehicle can safely drive over the span of that bridge.

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