Demountable Bridge Spans Made of Prefabricated Box Beams

Ponts démontables réalisés avec des poutres en caisson préfabriquées

Abmontierbare Brücken aus vorgespannten Kastenbalken

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SUMMARY
The results of tests on prefabricated prestressed reinforced concrete box beams are presented. Beams of this type can be used for the construction of demountable spans of road bridges. Some of the results obtained from the tests are compared with results yielded by the finite strips method.

RÉSUMÉ
L'article présente les résultats d'essais de poutres en caisson en béton armé, qui ont été préfabriquées et précontraintes. Des poutres de ce genre peuvent être utilisées dans la construction de ponts-routes démontables. Quelques résultats d'essais sont comparés avec les résultats dérivés de la méthode des bandes finies.

ZUSAMMENFASSUNG
Es werden Resultate von Versuchen mit vorgefertigten, vorgespannten Kastenbalken aus Stahlbeton vorgestellt. Balken dieser Art können in der Herstellung von abmontierbaren Strassenbrücken verwendet werden. Einige Versuchsresultate werden mit Resultaten der begrenzten Streifen-Methode verglichen.

1. INTRODUCTION

Demountable bridges are commonly used as metal constructions in by-pass objects, on forest tracks at felling areas, as well as for military purposes. They are usually made of rolled metal elements joined with screws, high tensile bearing-type bolts or pins. Concrete as a material for the building of demountable bridges is rarely used. However, due to their functional qualities the constructions of this type are more and more frequently employed. Concrete constructions are hardly used for building demountable bridges because of their considerable weight and inconvenience of joining them into a span. They are, however, superior to steel structures due to their longer service life, functional qualities and smaller labor demands.

Adaptation of typical prefabricated prestressed and reinforced concrete beams for demountable bridges building as well as some results of experimental and theoretical investigations corroborating their usability are presented in the paper.

2. DEMOUNTABLE SPANS

Prefabricated box girders are commonly used (also in Poland) to build small and middle-sized bridges. Prefabricated box-section elements are joined into a span by means of a wet poured reinforced plate [1]. Typical beams are 9-18 m long but their height varies. A typical prefabricated span for the theoretical length - 17.50 m is shown in Fig.1.

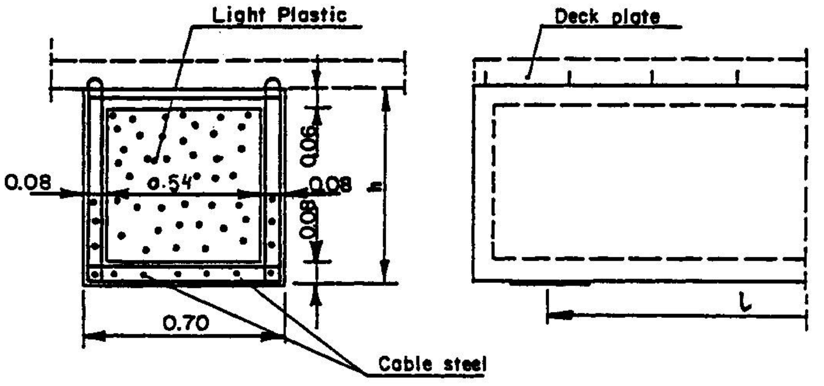

Fig.1 A typical prefabricated box span l = 17.50 m

Box girders filled with a light material are of simple shape and small weight which does not exceed 80 kN for a beam 18 m long. These characteristics make the girders especially suitable for demountable bridges of small and average spans. Cross-sections of demountable box bridges of partially changed reinforcement are shown in Fig.2. Since shackles are closed, the top surface of the beam is smooth, only assembly slings protrude slightly. In the cross-section shown in Fig.2a, a curb with rails made of angle or channel bars, fastened by means of a rifle anchor is concreted of the lateral box element (right or left). Other elements of the railing are fastened with screws. Box beams placed side by side form the bridge deck on which, after sealing contacts between the beams with fibreboard, an asphalt carpet 0.03-0.05 m thick is laid, thus covering assembly slings of the beams. Operation life being terminated, the asphalt-concrete bridge flooring is removed and all the other elements are demounted and transported to another place. A demountable bridge of a smaller load capacity with separated box girders is shown in Fig.2b. Prefabricated reinforced slabs of the plate deck (1.40 x 2.00 x 0.10 m) of full section or with vertical holes (to reduce weight and drain off rain-water) form the road. Different cross-sections of prefabricated beams are shown in Fig.3 [1], [4]. The main box-section (or I-section) girder is split vertically into two channel-section elements in order to reduce the weight of the box elements. The channel-section elements are joined into beams on the spot by means of high tensile bearing-type bolts or demountable bar cables. The main channel elements are made as reinforced elements from B-30 concrete and Q_r = 360 MPa steel. Undesirable initial prestressing strains of elements do not occur due to the use of reinforced concrete. Methods of joining the elements into a span shown in Fig.3 are similar to those presented in Fig.2 except the method shown in Fig.3b, where the section is prestressed by means of demountable bar cables.

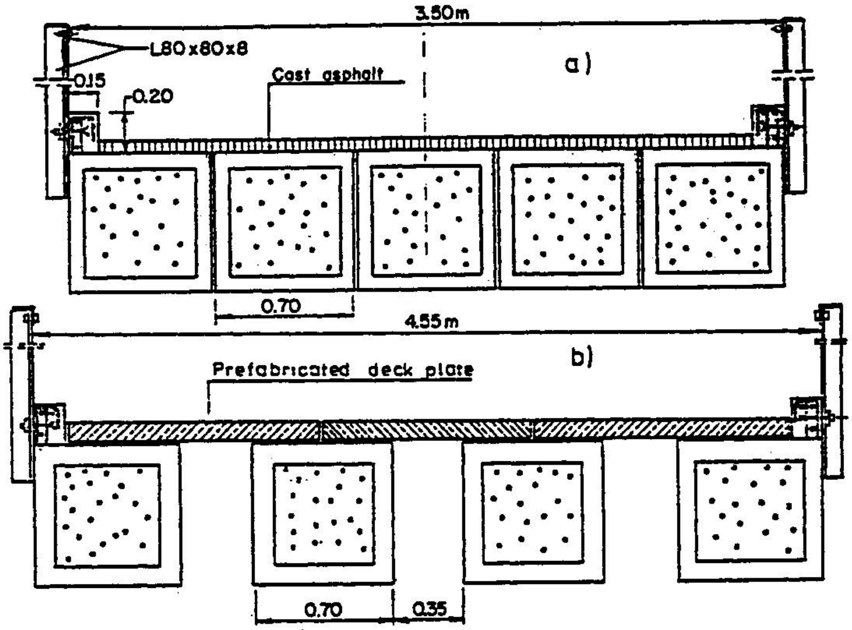

Fig. 2 The cross-sections of demountable reinforced box span

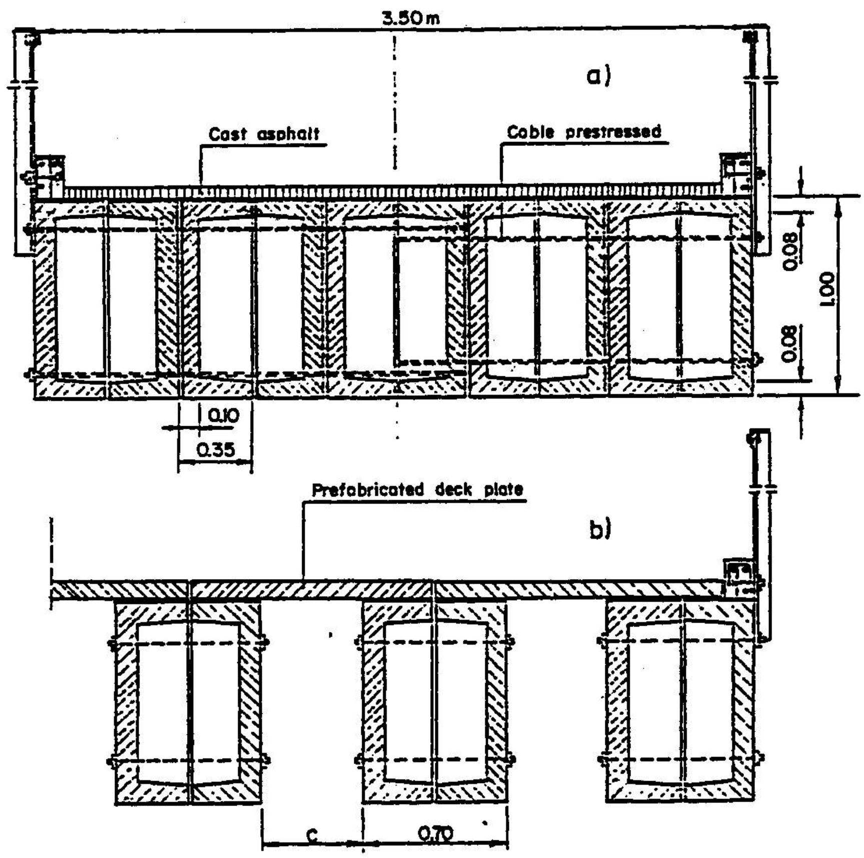

Fig.3 The cross-sections of demountable prefabricated box span

3. EXPERIMENTAL AND THEORETICAL INVESTIGATIONS

The presented designs of prefabricated demountable bridges are characterized by the application of main box-section girders. The box-section has high flexural and torsional rigidity which is especially important in demountable bridges where there is no transverse mating between main girders and the load is often carried along the edges of beams, thus causing bending and considerable torsion of the section. The experimental and theoretical investigations were carried out to determine the work and load capacity of box beams. A calculation program based on the finite strips method and checked during the analysis of steel bridges was applied to the theoretical analysis [2], [3]. Loads were estimated after Polish loading standards according to which wheel loads placed along the longitudinal bridge axis at every 1.60 m, were 60 kN. The schemes of loading realized during the experiments are presented in Fig.4. The results of the analysis for a closed-type box beam with the top deck of different thickness are presented in Fig.5. The theoretical analysis corroborated the high load capacity of the beams. Then, experimental investigations of a prestressed beam, selected from current production, were carried out. The detailed description and results of the experiments are published in [4].

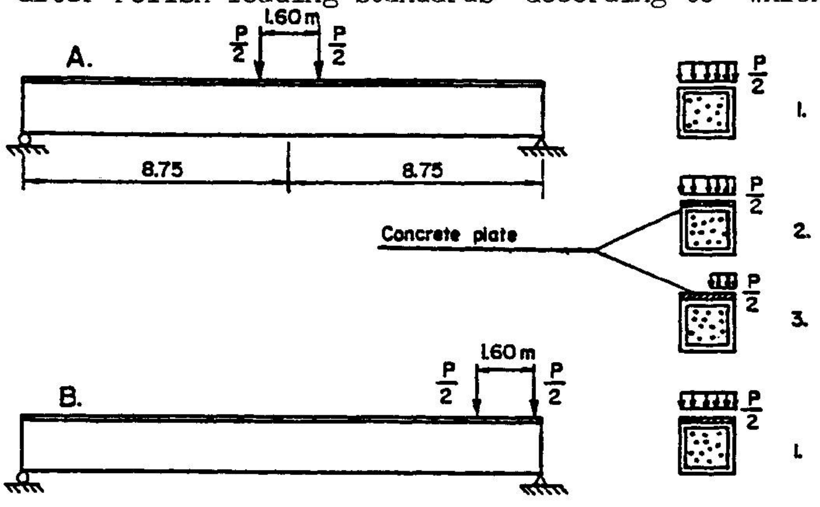

Fig.4 Schemes of loading during the tests

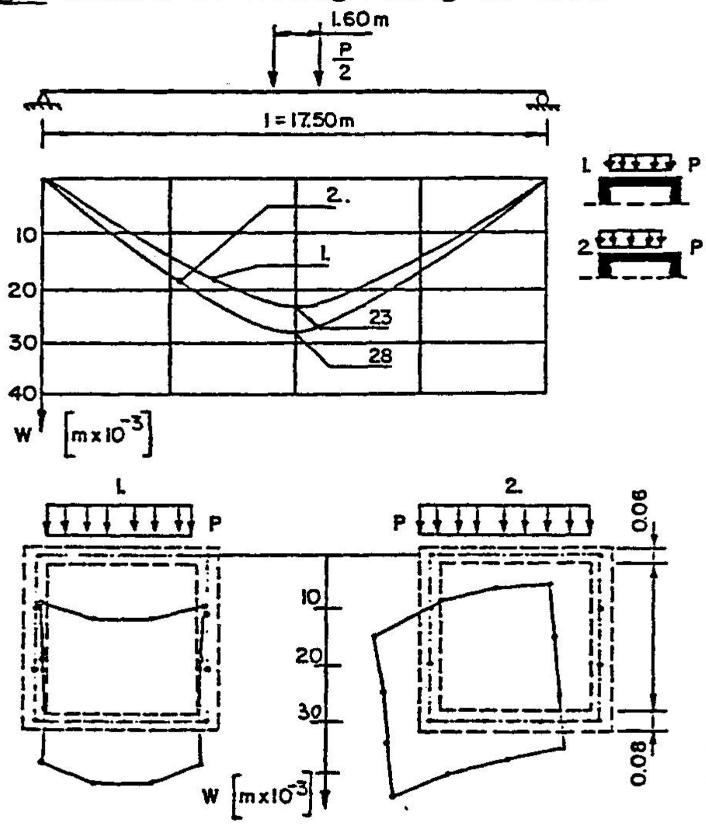

Fig.5 The results of the analysis for a closed-type box beam

The analysis aimed at:
- determining the actual load capacity and effort of the beams under increasing and cyclic loadings,
- estimating the effect of loading on permanent displacements of the beam,
- evaluating the work of the beams under torsional load (load causing torsion).

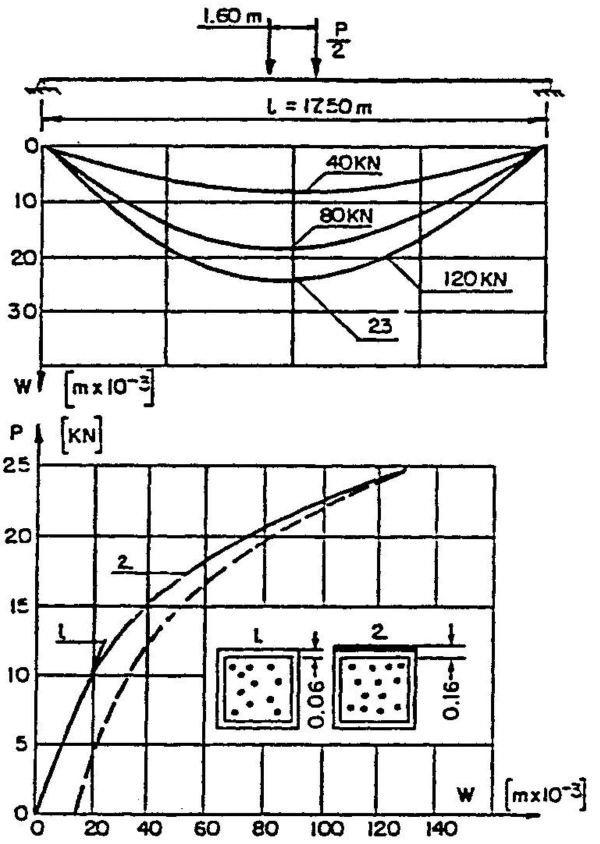

Fig.6 The exemplary distribution of dis placements for A-1 scheme of load

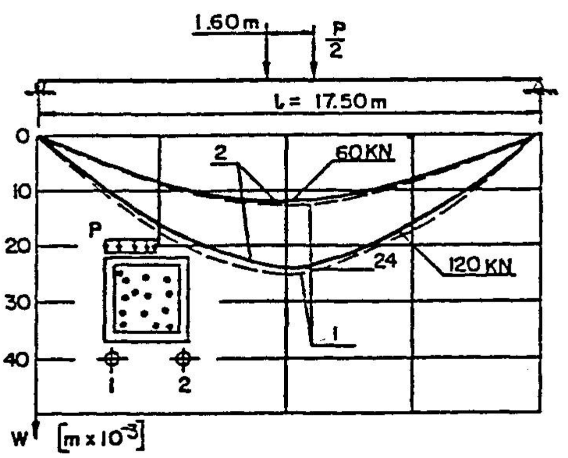

Fig.7 The relation between deflections and loads under maximal loading

The investigations were carried out on a test stand where necessary loads were imposed by dilating the beam and the supporting structure with hydraulic lifts. The force was measured by means of elastic dynamometers.
The investigations were carried out in the following way: after setting up the beam on the stand, the tests were carried out according to A-1 scheme. At this stage the maximal loading was 120 kN. Then, a reinforced concrete slab joined with a beam 0.08 m thick was concreted to the box beam, thus thickening its top plate. A-1 scheme was repeated and then A-2 and B-1 (P_{max} = 180 kN) schemes were applied. The beam was subjected to recurrent loading of the amplitude of 20-120 kN and 2000 cycles and then it was destructed (A-1 scheme being applied). The exemplary distributions of deflections of the beam along its length for A-1 scheme before and after the imposition of recurrent loading as well as the relationship between displacements in the middle of the span and loads of successive schemes are presented in Fig.6. A-3 scheme was applied to examine the work of the beam under off-centre loading (when the edge of the beam is loaded by a vehicle). The relationships between displacements of vertical deflections of the central section of the beam and imposed loads as well as deformations of the cross-section under maximal loading (120 kN) are shown in Fig.7. It is worth noting that there is a linear dependence of strains and loading and that the measured maximal strains are smaller than the theoretical ones. Changes of strains in the concrete reinforcement of the beam are presented in Fig.8 as a function of increasing loading up to the breaking (failure) load. Strains in the strings increase linearly up to the load of 120 kN which corresponds to the scrach ing moment. The scratching load being exceeded, the inclinaction angle of the P/ decreases while the strains still increase linearly.

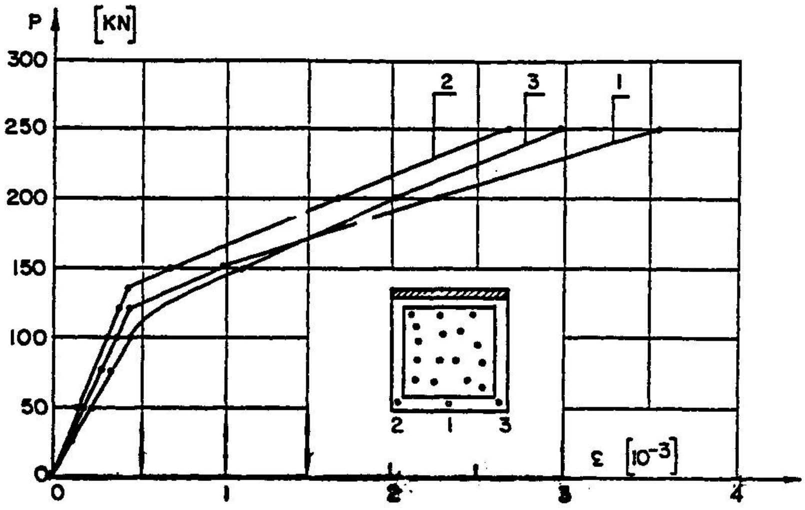

Fig.8 Changes of strains in the concrete reinforcement of the box beam

4. CONCLUSIONS

The investigations of the box beam showed that the prefabricated box-section girders may be applied for demountable bridge buildings. The application of these elements is especially advantageous because of their small dead weight and high torsional and flexural rigidities. These properties facilitates site assembly and transport of the elements and cut down the time of building the objects.

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