10.26411/83-1734-2015-2-56-8-24

Temporary bays during reconstruction of destroyed railway bridges

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Abstract:
The subject of this article is provisional spans used in cases of ad hoc and temporary reconstruction of damaged or destroyed railway bridges. The general principles of temporary bridge reconstruction are given, as well as the purpose of using these spans and their classification. The following provisional spans were characterised in terms of construction and installation technology: lattice spans (folding and fixed), spans made of steel I-beams, load-relieving structures (bridge type and made of railway rails) and spans made of wooden beams. Attention was drawn to the need to try to use the existing structural elements of the damaged bridge as much as possible.

Keywords: railway bridges, temporary spans, temporary reconstruction.

1. GENERAL PRINCIPLES FOR TEMPORARY RECONSTRUCTION OF RAILWAY BRIDGES

The reconstruction of damaged railway engineering structures is a distinct field of bridge engineering.

It is of unique and special importance during natural disasters, warfare, and the subsequent recovery from these events. Bridges can be damaged or destroyed due to various reasons, including ice jams, vehicle collisions (including ships), hurricanes, support washouts, fires, and intentional destruction (Bień, 2010; Hydzik, 1986; Jaormniak & Rosset, 1986; Madaj & Wołowicki, 2013; Radomski, 2011; Surowiecki & Zamiar, 2005, 2012).

The need to quickly restore train traffic on a damaged or destroyed bridge necessitates the use of temporary reconstruction, which is much faster than permanent reconstruction (i.e., the construction of permanent bridges) (Białobrzeski, 1978; Cholewo & Sznurowski, 1970; Hydzik, 1986; Miklin & Sawicki, 1993; Sznurowski, 1989).

Two types of provisional reconstruction of damaged bridges are distinguished: ad hoc and temporary. The reconstruction method used depends on several factors, including the type of damage, the timing of the reconstruction, the expected service life, and the materials available for constructing collapsible bridges (Cholewo & Sznurowski, 1970; Miklin & Sawicki, 1993; Sznurowski, 1989).

Ad hoc reconstruction is typically carried out under wartime conditions with the aim of quickly restoring railway communication routes to ensure the continued operability and rapid continuation of military operations. The construction of such bridges proceeds without clearing the riverbed of fragments of the destroyed bridge and without regard to high water and ice flow conditions (Cholewo & Sznurowski, 1970; Miklin & Sawicki, 1993). Ad hoc reconstruction uses all possible and anticipated materials and work technologies. Temporary reconstruction is intended to resume and maintain train traffic for at least three years. In temporary reconstruction, concessionary technical conditions are allowed, and materials with reduced strength characteristics may be incorporated (Cholewo & Sznurowski, 1970; Miklin & Sawicki, 1993).

2. CHARACTERISTICS OF TEMPORARY BAYS

When designing a provisional (ad hoc or temporary) bridge reconstruction, attempt to use the existing structures of the destroyed bridge. If the damage to the bridges is so severe that they cannot be used without major repairs, temporary spans are employed. These types of spans have been previously documented by Białobrzeski (1978), Cholewo and Sznurowski (1970), and Miklin and Sawicki (1993). The contractor has access to several types of spans for the makeshift reconstruction of bridges, including:

- folding or fixed lattice structures,
- rolled steel I-beam bays,
- relief structures,
- wooden beam bays.

The selection of bay types is determined by the availability of materials, the height of supports, and the required theoretical span. Using the maximum technologically possible span reduces the number of supports required, as well as the amount of materials and labour intensity. Larger span lengths are necessary on navigable rivers (Cholewo & Sznurowski, 1970; Miklin & Sawicki, 1993; Sznurowski, 1989).

Provisional bays are structural systems that can be repeatedly assembled and disassembled into a well-defined shape that corresponds to the permanent structure, while maintaining a constant order of component assembly. The basic connector used in temporary spans is the bolt. Due to their design, many collapsible bridges can be classified as makeshift spans (Bialobrzeski, 1978). Collapsible spans represent the highest form of assembly system. Collapsible structures are defined as engineering static systems constructed from pre-prepared components that are reusable in different assembly systems (Bialobrzeski, 1978). They are characterised by the strength qualities of permanent structures and the following additional features (Białobrzeski, 1978; Miklin & Sawicki, 1993):

- fairly quick and uncomplicated assembly,
- ease of adaptation to local conditions,
- the possibility of creating more than one assembly scheme from the same basic elements,
- dismantlability without damage to connectors, joints and components,
- simplicity of operation,
- the ease with which the bridge components can be transported by mass transit.

The primary materials of the basic elements in collapsible bridges are: steel, aluminium alloys and plastics (Białobrzeski, 1978; Miklin & Sawicki, 1993; Surowiecki, 2021).

3. TEMPORARY FOLDING AND FIXED LATTICE BAYS

The general principle of steel structures for collapsible bridges is that the span consists of lightweight components, joined together by bolts. Collapsible span structures are classified according to their purpose as follows: (Białobrzeski, 1978; Miklin & Sawicki, 1993; Miklin, 1984):

- heavy rail folding bridges for large rivers,
- medium railway folding bridges for medium and small rivers,
- small railway bridges and flyovers for minor obstacles and access.

The structural solutions for collapsible bridges were determined based on the assembly arrangement of the basic elements, rather than a given static scheme. Folding spans can be designed using linear, plane, or spatial elements, as distinguished by Bialobrzeski (1978) and Miklin & Sawicki (1993) (see Fig. 1).

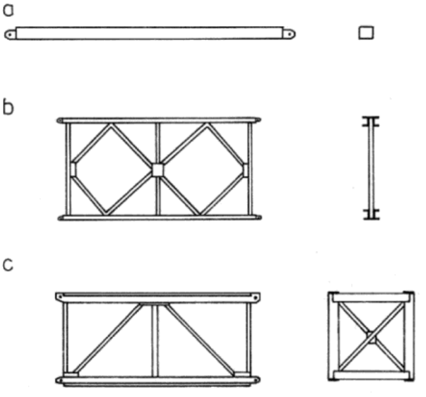

Fig. 1. Basic elements of a collapsible bridge (Białobrzeski, 1978; Miklin & Sawicki, 1993): a - linear element, b - planar element, c - spatial element

There are also spans of collapsible bridges with mixed structural arrangements, such as linear-flat and plane-space, etc. (Bialobrzeski, 1978).

When it is necessary to cross an obstacle with longer spans, such as when reconstructing bridges over deep ravines in mountainous terrain, temporary reconstruction uses spans with a truss static system. This decision is based on the possibilities of obtaining in a lattice structure (Miklin & Sawicki, 1993):

- the most rational use of steel,
- the construction of higher, and therefore more rigid, load-bearing structures,
- uncomplicated assembly of the bay structure,
- the lowest possible impact of wind pressure.

Lattice spans can be either fixed or collapsible. Fixed lattice spans, which are intended for temporary reconstruction, are lightweight trusses with standardised spans made of profile steel. They are riveted together and adapted to be transported in their entirety on railway platforms [chosznu]. To maintain gauge during transport, these spans are built with a bottom run. The need to limit the dimensions of the spans is the reason behind this choice of design.

Fig. 2 shows examples of two such structures consisting of triangular gratings (L30 and L32 systems) (Białobrzeski, 1978; Miklin & Sawicki, 1993).

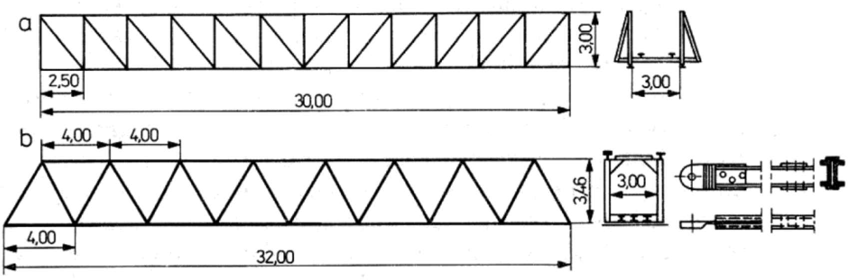

Fig. 2. Examples of lattice spans of collapsible bridges (Białobrzeski, 1978; Miklin & Sawicki, 1993): a - L30 system, b - L32 system

Several other systems are worth mentioning, such as the Austrian Roth-Wagner (R-W) (shown in Fig. 3), the German R70 (Fig. 4), and the English ESTB (Fig. 5) (Białobrzeski, 1978; Miklin & Sawicki, 1993). These structures are characterized by a wide variety of possible spans and the possibility of graded spans.

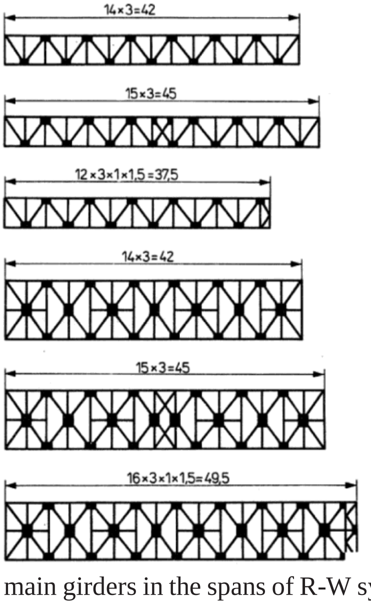

Fig. 3. Diagrams of the main girders in the spans of R-W system folding bridges (Bialobrzeski, 1978; Miklin & Sawicki, 1993)

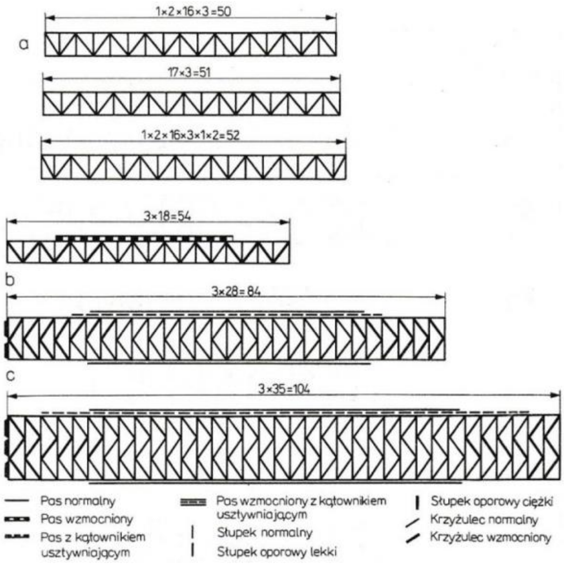

Fig. 4. Diagrams of the main girders in the spans of folding bridges of the R70 system (Białobrzeski, 1978; Miklin & Sawicki, 1993): a - single-storey girders, b - two-storey girders, c - three-storey girders.

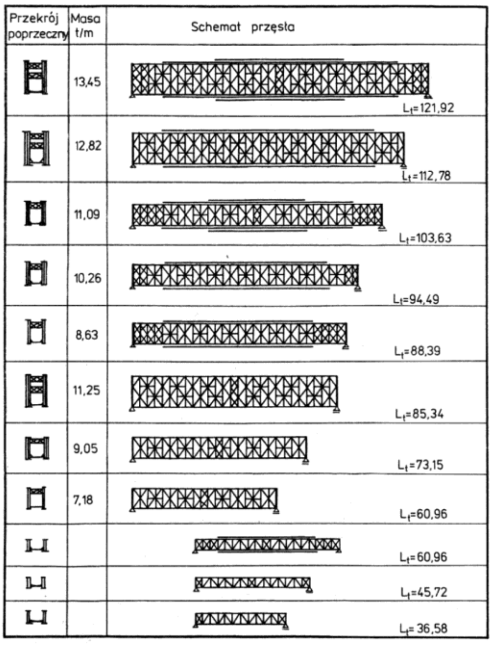

Fig. 5. Diagrams of the main girders in the spans of the ESTB system of collapsible bridges (Białobrzeski, 1978; Miklin & Sawicki, 1993)

4. BAYS COMPOSED OF STEEL I-SECTIONS

Spans made of rolled steel I-beams have several advantages, including ease and speed of assembly, convenience of transport to the bridge reconstruction site, and the possibility of obtaining significant theoretical spans (up to 29 m). However, the disadvantage of these spans is their relatively high weight (Białobrzeski, 1978; Cholewo & Sznurowski, 1970; Miklin & Sawicki, 1993).

Spans can be made of rolled normal-alloy steel beams and wide-flange steel beams, as well as welded beams. These beams are the main girders of the span. A distinction is made between two groups of spans constructed from these beams (Miklin & Sawicki, 1993):

- bays made on site or in workshops,
- demountable spans, for standard spans.

Depending on the way in which the individual steel beams are joined together to form the whole of the temporary bays and the type of connectors used, bays of rolled beams can be treated as:
(a) temporary - with wooden braces, bolted together (Fig. 6);
(b) semi-permanent – demountable, bolted together, with steel bracing;
I fixed, riveted joints (Cholewo & Sznurowski, 1970; Miklin & Sawicki, 1993).

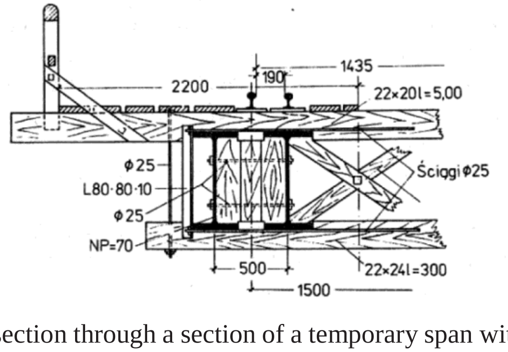

Fig. 6. Cross-section through a section of a temporary span with steel girders (each girder composed of two I-beams), with timber braces, bolted together (Cholewo & Sznurowski, 1970; Miklin & Sawicki, 1993)
Horizontal wooden beam 22x24l =300 (so called sub-beam) is the element that connects the main girders to the pavement by means of Φ25 mm bolts

The main girders in the spans for temporary railway bridges, depending on their span, are made of 2 to 4 I-sections under each railway track. Thus, a span of rolled normal- or wide-footed beams consists of the following main parts (Fig. 6) (Cholewo & Sznurowski, 1970; Miklin & Sawicki, 1993):

- normal-alloy and wide-alloy steel sections,
- longitudinal and transverse bracing,
- railway superstructure (track composed of rails and fenders attached to 22x20l = 500 transverse beams called bridges).

Some of the parameters for the essential structural elements used in the ad hoc and temporary reconstruction of damaged railway bridges include:

- length of I-beams $L \leq 30.0$ m;
- most commonly used I-beam heights H = 500÷1000 mm,
- axial spacing of main girders x0 = 1500 mm.

To ensure the rail tracks work evenly when loaded with rolling stock, appropriate bay bracing is used to stiffen the free-standing girders under the rail tracks. This includes both transverse and longitudinal bracing.

The design of the transverse bracing is illustrated in Fig. 6:

- the (I) beams in the main girders (under the rail tracks) are connected to each other by two horizontal bolts 19÷25 mm in diameter,
- the space between the I-beams is filled with timber bundles so that there is a gap of approximately 0.15 m between the beam flanges;
- between the steel beam bundles (forming the main girders) in cross-sections braced by Φ25 mm horizontal steel ties, vertical timber bracing – cross-bracing – is assembled, the purpose of which is to spread the main girders.

At the supports, the main girders must be fixed to the eyes and secured against lateral movement by hooks, screws or steel plates over 15mm thick. These plates should be fixed to the jambs with screws. Tall I-beams are stiffened at the supports by means of short braces, supported by one end on the upper flange of the beam and the other end recessed into the support cap (Cholewo & Sznurowski, 1970; Miklin & Sawicki, 1993).

The railway superstructure on a temporary reconstructed bridge span made of beams in the form of rolled steel sections, is composed of basic elements (Cholewo & Sznurowski, 1970; Miklin & Sawicki, 1993):

- timber bridge girders fixed to the main girders with hook bolts,
- rails laid on bridges, fixed to them with screws or rail hooks.

The bridges' roadway can be constructed economically using sleepers and girders in the following order: for every two sleepers (typical sleepers are 2.40÷2.50 m long), one 5.0 m long girder. The bridges' cross-section has larger dimensions than the sleepers, so to compensate for the height difference, the bridges are indented (to a dimension of 10 mm) in the main girders' zone and connected to the girders by bolts (refer to Fig. 6). The girders are indented to a dimension of 10 mm and support the I-beams from below. The sleepers are fixed to the I-beams with hook bolts. The maximum distance between the axes of the girders and sleepers is 0.65 m.

Fig. 7, 11 show typical solutions for temporary spans whose main girders are constructed from one (Fig. 7), two (Fig. 8, 9), three (Fig. 10) and four rolled steel section (Fig. 11) (Cholewo & Sznurowski, 1970; Miklin & Sawicki, 1993).

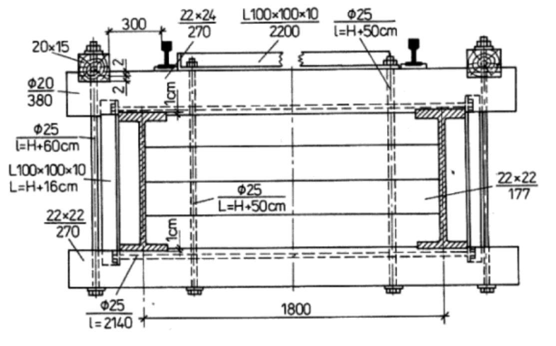

Fig. 7. Cross-section through a temporary span with steel girders constructed from single wide-flange I-beams (Cholewo & Sznurowski, 1970; Miklin & Sawicki, 1993)

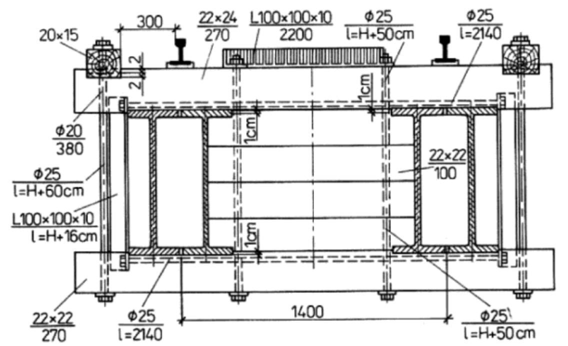

Fig. 8. Cross-section through a temporary span with steel girders constructed from two wide-flange I-beams (Cholewo & Sznurowski, 1970; Miklin & Sawicki, 1993)

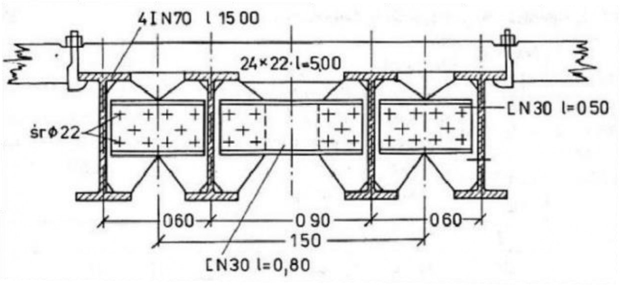

Fig. 9. Cross-section through a temporary span with steel girders constructed from two I-beams and with steel cross-bracing (Cholewo & Sznurowski, 1970; Miklin & Sawicki, 1993)

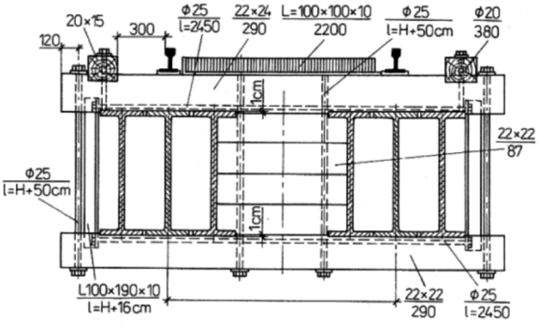

Fig. 10. Cross-section through a temporary span with steel girders constructed from three wide-flange I-beams (Cholewo & Sznurowski, 1970; Miklin & Sawicki, 1993)

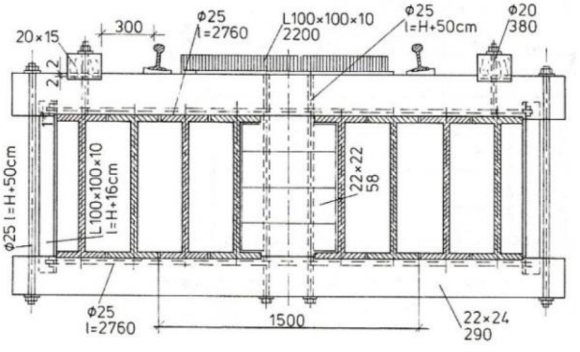

Fig. 11. Cross-section through a temporary span with steel girders constructed from four wide-flange I-beams (Cholewo & Sznurowski, 1970; Miklin & Sawicki, 1993)

Fig. 9 shows that the transverse bracings of rolled girders (I-beams) can be made of rolled steel sections with channel cross-sections, known as channels. The channels are bolted to stiffening plates that are permanently welded to the walls of the girders. Such spans are demountable, inventoried, and can be transported as individual beams along with their connecting elements.

5. RELIEVING STRUCTURES

5.1 General remarks

When carrying out works related to the construction, strengthening or main repair of spans or supports of railway engineering structures on operational lines, it is essential to maintain the continuity of train traffic. This can be achieved in two ways (Białobrzeski, 1978; Cholewo & Sznurowski, 1970; Miklin & Sawicki, 1993):

- by building a temporary diversion bridge; or,
- through the use of a so-called relief structure in the active track.

The first method enables more convenient execution of the planned works, but necessitates the construction of embankments, laying tracks on the embankments, and building a new temporary bridge. This method is only employed when no other more cost-effective solution is feasible.

The second way, i.e., a stress-relieving structure, is less expensive and its implementation is fairly quick. It consists in installing a special structure in the track in service, which takes the weight of the passing rolling stock and allows for the repair, replacement, rebuilding, or reconstruction of elements of the engineering structure. Temporary structures built along the existing track axis can support the damaged facility without interrupting train traffic.

Relieving structures, according to Miklin and Sawicki (1993), can be divided into two groups: bridge-type and rail-rail structures (grouped into so-called rail bundles). Both groups are discussed below.

5.2 Bridge-type strain relief structures

Structures of this type alleviate pressure on sections of railway track that are no longer than 6.0 m (as shown in Fig. 12) (Cholewo & Sznurowski, 1970; Miklin & Sawicki, 1993). This is the maximum span that can be exceeded by girders consisting of four steel I-beams with an NP450 profile. For structures with a beam static scheme, it is assumed, depending on the type of supports, that the speed of movement is limited to 30 km/hr for fixed supports, 15 km/hr for pile supports, and 5 km/hr for sleeper cage supports.

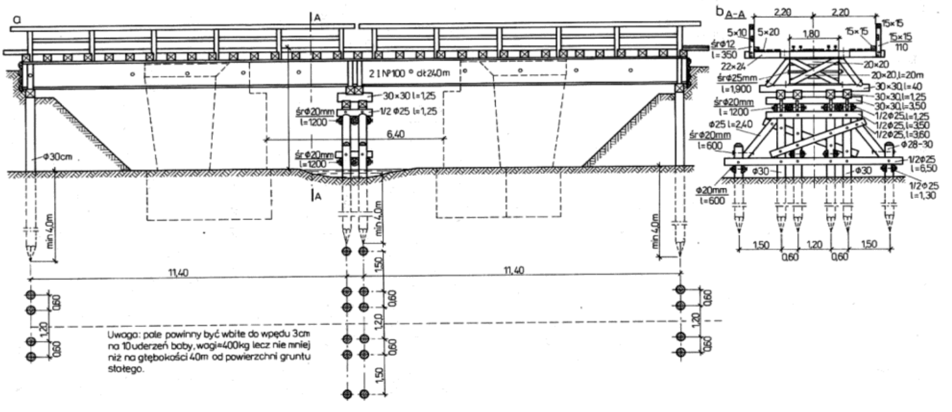

Fig. 12. Bridge-type stress-relieving structure of I-beams. Relieved track section 6.40 m long in the light of the abutments (indicated by the dashed line) (Cholewo & Sznurowski, 1970; Miklin & Sawicki, 1993); a - longitudinal view and location of foundation piles, b - cross-section A-A

Fig. 13, 14, and 15 show typical solutions for relieving structures used by the Polish State Railways (Pl.: PKP): twin girders, KO-21/73 type box girders, and KO-30/75 type twin girder system box girders (Miklin & Sawicki, 1993; Rybak, 1982). The use of these structures allows for theoretical spans of up to 30.0 m and train speeds limited to 60 km/h. The Catalogue of Typical Supporting Structures of Railway Bridges (Central Office, 1997; Miklin & Sawicki, 1993) provides designs for temporary supports for KO-type relieving structures with theoretical spans of 21.0 m and 30.0 m. These designs include bank supports made of concrete and steel elements, steel folding yokes, and a steel cap specifically designed for KO spans. Fig.s 16, 17, and 18 (Miklin & Sawicki, 1993) show schemes of these supports for the KO-type relief structure.

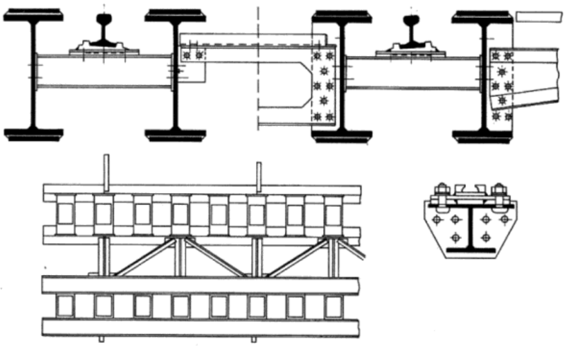

Fig. 13. Bridge-type relief structure; main girders composed of twin beams (Miklin & Sawicki, 1993; Rybak, 1982)

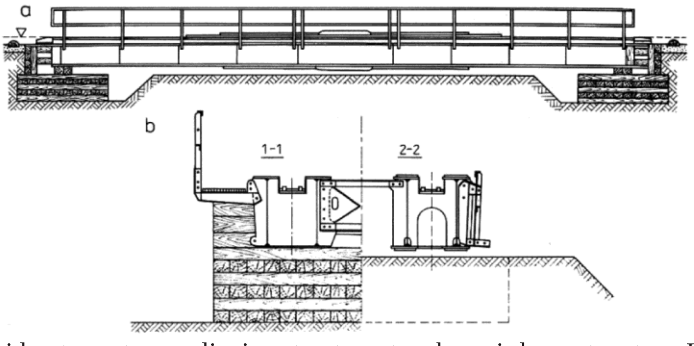

Fig. 14. Bridge-type stress-relieving structure; two box girder system type KO-21/73 (‘Central Office’, 1997; Miklin & Sawicki, 1993): a - longitudinal view, b - cross-section, 1-1 cross-section at support with folded pavement, 2-2 cross-section in the span with folded pavement

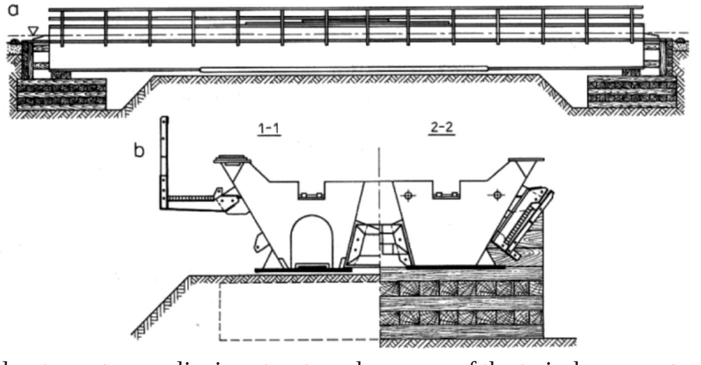

Fig. 15. Bridge-type stress-relieving structure; box span of the twin-beam system, type KO-30/75 (Miklin & Sawicki, 1993): a - longitudinal view, b - cross-section,
1-1 cross-section in the span with folded pavement, 2-2 cross-section at the support with folded pavement

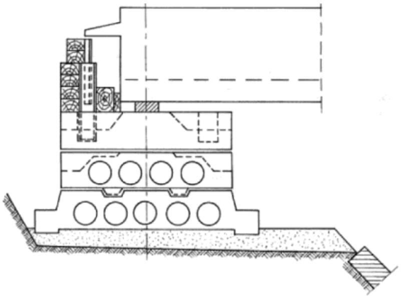

Fig. 16. Concrete element bank support (type KO-Pb) ('Central Office', 1997; Miklin & Sawicki, 1993)

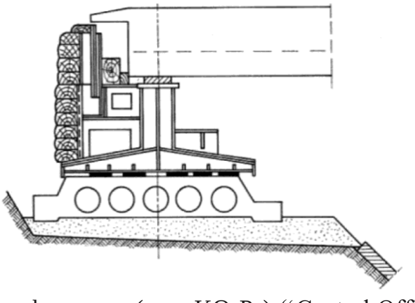

Fig. 17. Steel element bank support (type KO-Ps) ('Central Office', 1997; Miklin & Sawicki, 1993)

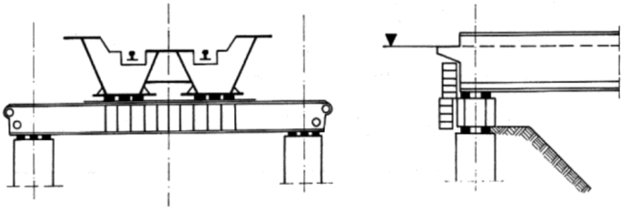

Fig. 18. Steel abutment founded on large diameter piles (type KO-Os) ('Central Office', 1997; Miklin & Sawicki, 1993): left - cross-section through the span at the support; right - longitudinal view of a section of the span

When using supports for KO-type relieving structures, it is recommended to follow these principles (Miklin & Sawicki, 1993):

- the axial distance of the main girders is 1.50 m;
- the width of the bay is assumed to be a maximum of 2.50 m at the level of its lower edge,
- the track runs on a straight section,

- the axes of track, span and supports coincide,
- the axial distance of the tracks on multitrack lines for concrete and steel supports shall be a minimum of 3.50 m; and for steel yokes a minimum of 4.0 m (variable with a 0.25 m modulus),
- the use of buttresses and pile caps does not need to be justified on the basis of analytical procedures, other than to ensure sufficient bearing capacity of the ground,
- the use of a cap on a support must be preceded by the design of large diameter piles or a well design, individually for each subsoil condition,
- the determination of the permissible speed of trains on a temporary bridge should be made on a case-by-case basis for each of the substructures built.

Concrete and steel supports of the KO type are used instead of the so-called 'sleeper cages'. To assemble these structures, place the spans on previously constructed supports in the active track. It is crucial to choose spans that allow for excavation of the track bed and planned bridge work. The construction of the bridge-type stress-relieving structure depends on the availability of train traffic interruptions on the line. On lines with a significant volume of train traffic (single-track or multi-track), closures usually last between 3-8 hours.

The installation of bridge-type stress-relieving structures should be carried out based on a specially developed project. The technology for the installation of these structures involves preparatory works, including the construction of the structure's supports, during short track closures for train traffic.

The essential work of building the superstructure is carried out during the track closure, in the following sequence (Miklin & Sawicki, 1993):

1. dismantling of the existing track (a grate made up of rails attached to sleepers),
2. removal of ballast,
3. carrying out earthworks ("digging up" the trackbed),
4. completion of the construction of the supports according to the agreed design (the construction of the supports is already carried out in the process of preparatory works),
5. the installation of pile caps (the piles form the foundation of the supports) or the setting of sleeper "cages",
6. removal of the existing supporting structure,
7. incorporation of a relief structure,
8. track installation.

Fig. 19 shows the support of a bridge-type relieving structure (Miklin & Sawicki, 1993). The support consists of: timber yoke and sleeper cages as abutments, a fixed pillar (already in place), intermediate support (pillar) adapted for load-bearing structures with different span heights.

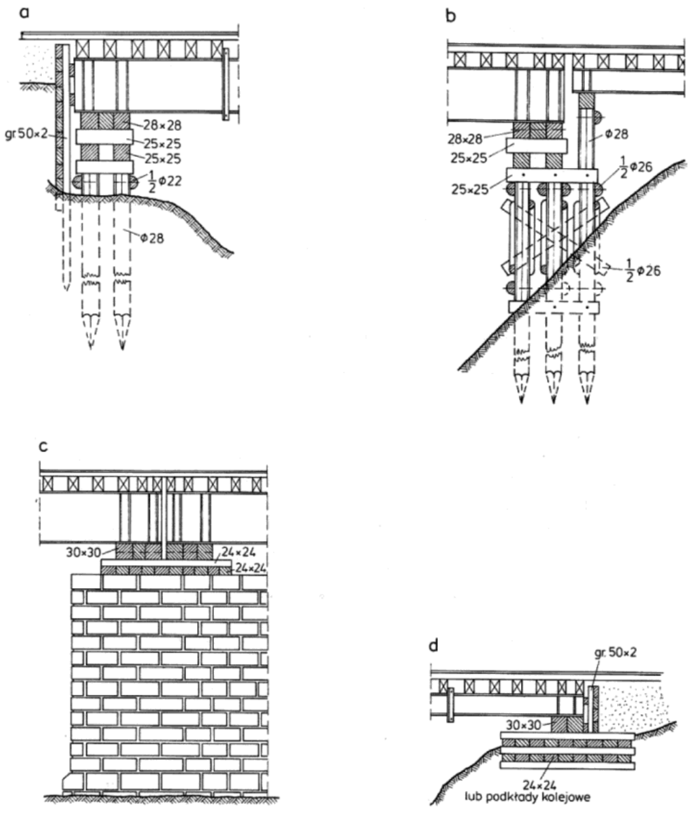

Fig. 19. Methods of supporting bridge-type relieving structures (Miklin & Sawicki, 1993): a - abutment made of a wooden yoke, b - intermediate support (pillar) for load-bearing structures with different span heights, c - support of the load-bearing structure on a fixed pillar, d - abutment as a cage made of railway sleepers

The relief structure must be under constant professional supervision due to its makeshift nature (Cholewo & Sznurowski, 1970; Miklin & Sawicki, 1993).

If it is difficult to drive the support piles in the axis of the active track, the support for the relieving structure can be made via a transverse beam, as shown in Fig. 20

(Miklin & Sawicki, 1993). The course of action is then as follows:

- piles (which are part of the support) are driven on both sides of the track,
- a transverse beam (consisting of rolled I sections, for example) is supported on the piles,
- the transverse beam supports the ends of the spans with main girders consisting of, for example, two I-sections (Fig. 20).

To protect the spans from lateral displacement at the supports (perpendicular to the longitudinal axis of the bridge), the span is braced with vertical angles and a transverse beam.

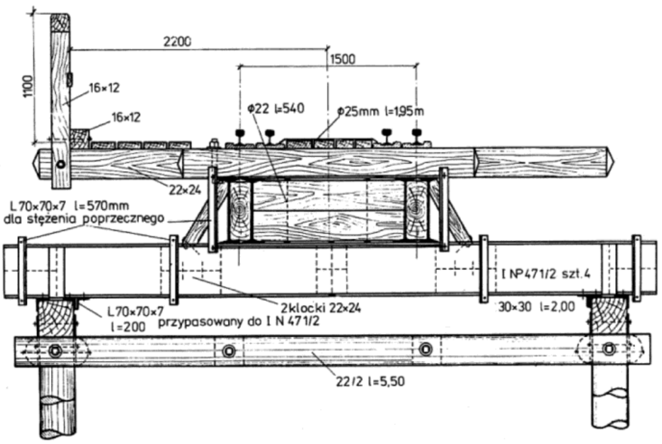

Fig. 20. Cross-section through a provisional span (bridge-type stress-relieving structure). The span is supported on the pillar via a transverse beam (Miklin & Sawicki, 1993)

5.3 Rail relief structures

Rail bundles are essential components of temporary spans and can be used to overcome obstacles with spans of up to 5.0 m under the railway track. The rail bundle structure consists of bundles of three or five rails laid symmetrically on sleepers on both sides of the rolling rails of the track. The rail bundles are attached to the sleepers from above using ties, also known as hamsters, and fasteners (Fig.s 21 and 22) (Miklin & Sawicki, 1993). The hamsters connecting the rails, forming a bundle, are made of 26 mm diameter steel bars attached to 200x100x14 unequal angles (fig. 22). Alternative solutions for these structures are discussed in textbooks such as Cholewo & Sznurowski (1970) and Miklin & Sawicki (1993).

The length of the relieving structure L_0 depends on the length of the obstacle (excavation) L_p. For $L_p = 2.0÷3.0$ m, L_0 is 15.0 m, and for $L_p = 4.0÷5.0$ m, L_0 is 18.0 m. The rails used for the relieving structures should not have more than 10 mm of vertical head wear, taking into account lateral wear according to Technical Conditions Id-1 (D-1) (PKP Polskie Linie, 2015). Rail joints in the track along the length of the track strand to be relieved must be eliminated by replacing the rails. The maximum distance between sleepers along the length of the rail bundles should not exceed 0.65 m. Before installing the relieving structures, ensure that the ballast in the track is properly compacted along the length of the rail bundles. Steel stirrups suspend the sleepers from the rail bundles. Fig. 21 illustrates the protection (strutting) of the vertical walls of the excavation against landslides. The struts and formwork of the excavation must be designed and constructed to prevent any potential landslide of the ballast aggregate (stone ballast) from under the rail sleepers, which are built in as support sleepers on the edges of the obstacle.

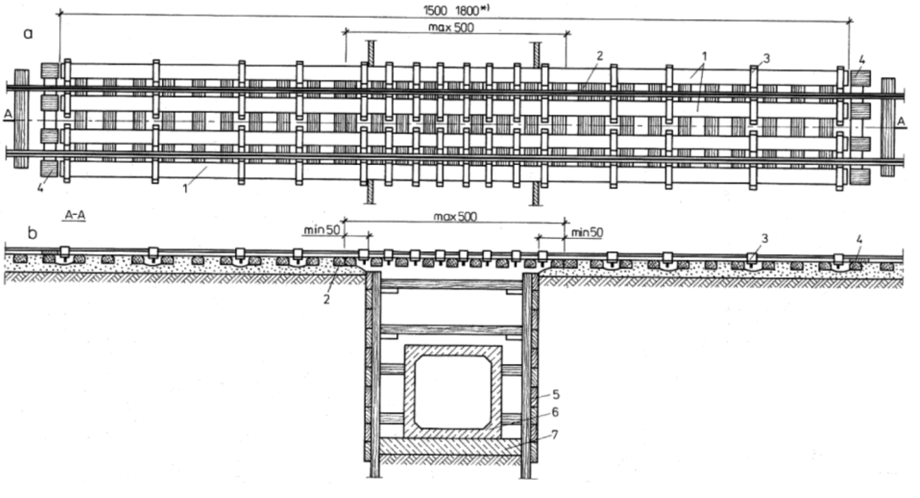

Fig. 21. Scheme of a rail relief structure for a concrete culvert reconstruction (Miklin & Sawicki, 1993): a - top view, b - cross-section through the reconstructed culvert, 1 - rail bundles, 2 - support sleepers in the obstruction zone, 3 - steel ties (chinstraps), 4 - timber blocks at the ends of the relieving structure, 5 - excavation formwork, 6 - reconstructed culvert structure, 7 - culvert foundation

Fig. 22 illustrates a cross-section of the main girders of a stress-relieving structure made as bundles of rails suspended by steel ties, according to the Swiss system design. This design is commonly used in the construction of railway bridges by the Polish State Railways (Pl.: PKP) due to its convenience, fast installation, stability, and ability to ensure traffic safety (Miklin & Sawicki, 1993).

To ensure sufficient capacity on railway routes where work is carried out under relief structures made of rail ties, the Polish State Railways have established permissible train speeds on sections of laid track relief, according to Miklin and Sawicki (1993):

1. for a theoretical obstacle span L_p = 5.0 m with five-rail bundles (old-use 49E1 rails) v = 15 km/hr,
2. for a theoretical obstacle span L_p = 4.0 m with five-rail bundles (old-use 49E1 rails) v = 20 km/hr,
3. for the theoretical obstacle span L_p = 3.0 m with old-use 49E1 rail bundles:
   - five-rail v = 30 km/h,
   - three-rail v = 20 km/h,
4. for a theoretical obstacle span of L_p = 2.0 m and smaller from a three-rail bundle containing 49E1 old-age rails, v = 30 km/hr.

The above travel speeds are applicable for providing non-settling theoretical support points for the rail bundles. In excavations that are strutted, tight vertical wall formwork is required.

When protecting the track from sub-track works without digging up the track, such as making tunnel crossings or pipe jacking, a speed limit of 30 km/h should be observed for trains.

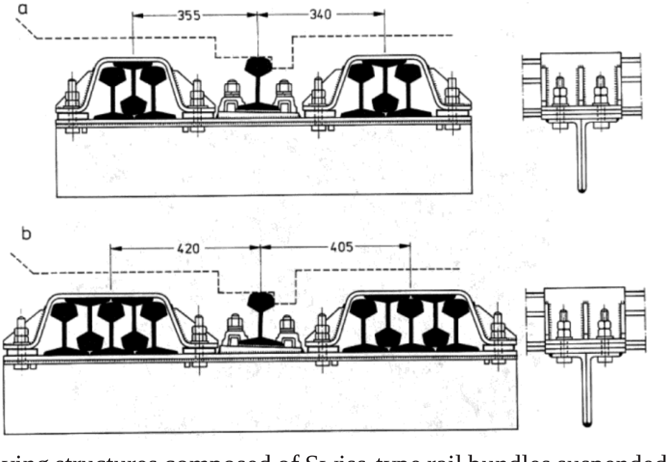

Fig. 22. Relieving structures composed of Swiss-type rail bundles suspended by stirrups (Miklin & Sawicki, 1993): a - three-rail bundle structure for obstacle span Lp ≤ 3.0 m; b - five-rail bundle structure for obstacle span Lp > 3.0 m

In summary, rail bundle relieving structures are suitable for work on live tracks as they can be installed without interrupting train operations. These structures have the advantage of a low construction height. It is important to continuously maintain the ballast structure once it is installed in the track. The maintenance of the structure involves tightening the bolts and compacting the ballast (stone aggregate) under the support sleepers located at the edges of the obstacle (see Fig. 21).

To prevent snagging – in the case of rail vehicle faults – it is recommended to secure the ends of each rail bundle with wooden blocks, as demonstrated in Fig. 23 (Miklin & Sawicki, 1993).

Fig. 23. View of the protection of the ends of the rail bundles from being hit by a protruding element in the event of faults in rolling stock (Miklin & Sawicki, 1993)

6. WOODEN BEAM BAYS

Timber spans are also used for the temporary reconstruction of railway bridges. Main girders are composed of multiple beams, as shown in Fig. 24 (Białobrzeski, 1978; Cholewo & Sznurowski, 1970; Miklin & Sawicki, 1993). These beams can be used for bridge spans with a maximum length of 8.0 m. However, they require a large amount of timber and have a low structural height. If sufficient steel I-beams are available, it is recommended to avoid using timber temporary spans.

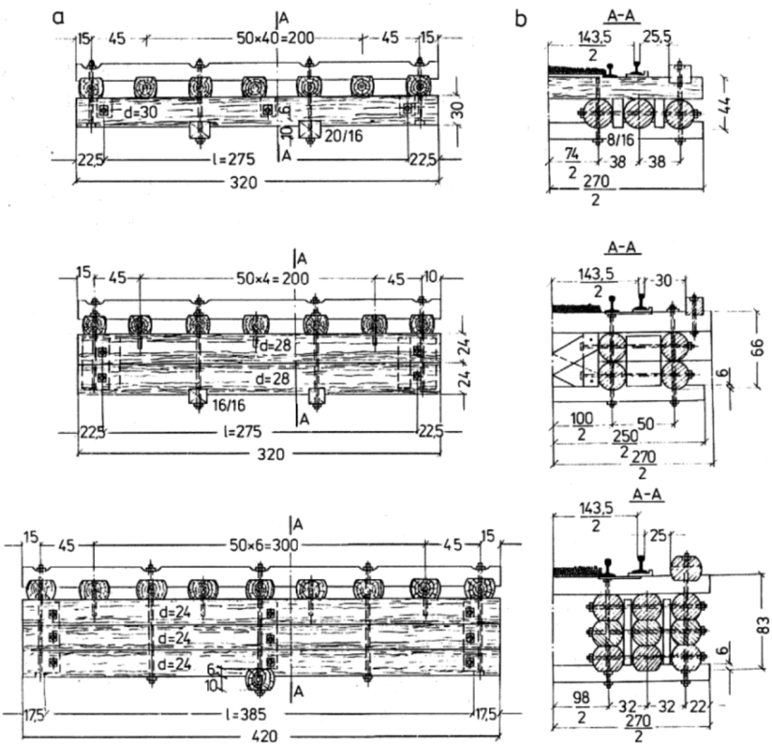

Fig. 24. Wooden spans of temporary bridges with main girders composed of so-called multiple beams (Cholewo & Sznurowski, 1970; Miklin & Sawicki, 1993): a - longitudinal view, b - cross sections through a main girder composed of three, four and nine beams

CONCLUSION

This text discusses the types and characteristics of various spans commonly used in the temporary reconstruction of railway bridges, as well as an outline of their installation technology. The choice of a specific span type is primarily based on the available materials, support height, and theoretical span requirements.

When constructing high supports, it is recommended to reduce their number by using longer spans. This approach can help to save on labour and materials. Additionally, longer spans should be used on navigable rivers, regardless of the height of the supports.

When designing a temporary bridge reconstruction, it is recommended to utilize the existing structural elements of the damaged bridge. If the damage is too extensive to use these elements without significant repairs, one of the temporary span types presented in this article should be employed.

It is advisable to use relief structures during the construction of temporary bridges on active railway lines. When reconstructing or rebuilding small structures such as culverts or partially damaged bridge elements like abutments, relief structures consisting of rail bundles in the active track may suffice.

Temporary spans made from rail bundles have the significant advantage of low structural height of the girders.

The principles of statics, maintaining the safety of train movements, and saving materials and labour apply in all cases of reconstruction.

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