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STRENGTH IN RAIL FASTENING IN THE BALLASTLESS TRACK SYSTEM IN THE TRANSITIONAL AREA BETWEEN EARTH WALL AND BRIDGES

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Key words: *Track, bridge, transition plate, superstructure, rail fastening*

Abstract: *The report presents the emerging deformations and displacements in the supporting structure of the bridge at its ends in the transition area with the earth's foundation. Additional tensile and compressive forces were calculated in the rail fastening in the slab track in the joint zone. Structural measures are proposed to reduce the effort in the fixings. This applies to the ends of the bridge in place of the joints between the bridge superstructure and resist or joints along the bridge facility or between two top structures. As a result of the deformations of the top structures at their ends a tense state is created at the points of attachment of the rails - tensile and compressive.*

1. INTRODUCTION

The construction of the superstructure of the track on the bridges must be the same as that of the adjacent between the stations. This is of particular importance in the implementation of slab track structures for the superstructure of the track, which together with the overhead bridge construction must form a unified system.

For safety movement of rolling stock, significantly influenced the transitional areas to the bridges. When crossing the railway from the earth structure to the bridge structure, measures are taken for a smooth transition between them due to the different deformation qualities. This happens so because stiffness in the way of approach of subgrade significantly - lower than a bridge. In this transition (Fig.1), the monolith slab track is particularly "sensitive" in this area. Even after the consolidation phase of the earth base due to the different stiffnesses, different actions were taken in the transition areas.

The transition from a slab track (from a non-ballast railway) on a ground base to a slab track on a bridge is made by transition plates and an improved base of the non-ballast rail track in the zone to the back edge of the puncheon (Fig.2).

The transition plate is a transient construction of the road at the end of the bridge or such a construction between two "simple beams" over a pillar of removing the "harmful" loads of the monolithic sub-base.

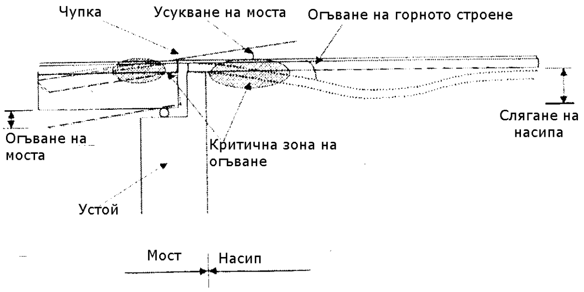

Fig.1. Deformations in the transition area

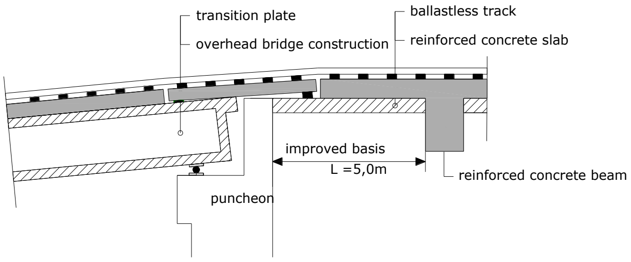

Fig.2. Transition plate

2. TRANSITION PLATES FOR RAILWAY BRIDGES WITH A SLAB TRACK BASE

2.1. General

Slab track formed by the supporting structure of the bridge a single system. It follows that the deformations and displacements of the supporting structure of the bridge are transmitted to the track and must necessarily be taken into account when designing the bridge.

This applies to the bridge ends at the fugues between the bridge structure and the bridge or the joints along the bridge structure or between two top structures. As a result of the deformations of the overhead bridge construction at their edges a tense state is created in the points of the rail fastening - tensile and compressive. (Fig.3).

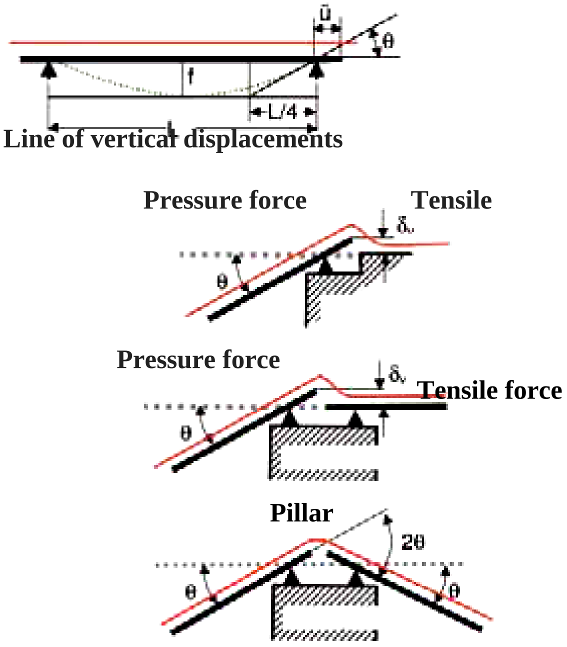

Fig.3. Efforts in the rail fastenings

As a result of the minimal displacement in the fugues at the bridge ends can cause very high effort in the intermediate rail fastenings, as a result of which the rails can be separated from the hard base underneath. This can lead to:

-overloading of intermediate and joints fastening rails;

- disturbing the position of the track along the axle and level;

To prevent 'harmful' load slab track can be applied track base plate (Fig.2).

It is a small bridged reinforced concrete or steel bridging structure which is supported on a movable bearing on the side of the bearing and fixed on the side of the overhead bridge construction.

With the transition plate the fugues between the end and the bridge bridging at the end of the bridge is secured and ensures a smooth passage transition. As a result, damage to the deformation of the superstructure of the track construction is prevented.

2.2. Advantages of the transition plate for the track at the end of the bridge

Significant horizontal movement of the movable parts of the bridge can lead to unacceptably increase the distance between the points of support rails at fugues. When applying transition plates, the longitudinal displacement is reduced by half, due to its distribution in the two fugues of the transition plate. The described advantages of the transition plates make them applicable in the practice of bridge construction, especially in long multi-opening railway bridges with overhead bridge construction of the type "simple beam".

2.3. Reducing the boundary loads on the railway track

Even small vertical movements and displacements δ (Fig.3) at the end of the overhead bridge construction can result in considerable effort in the intermediate rail fastenings located adjacent to the fugue. This is especially true of the ballastles track, which is hard with respect to these deformations. In the case of ballast superstructure in the intermediate rail fastenings, the abutment of which allows small vertical movements to occur in the crushed stone, therefore significant reactions at the points of abutment of the rails do not occur.

These reactive forces at the locations of the intermediate fixings can reach dangerous values and disturb the position of the track in the fugues zone.The vertical moving is of great importance δ (Fig.3).

As a result of the positioning of the transition plate, the vertical displacement occurring at the expense of the two pivotal angles becomes zero. As a result, the reactive forces at the rail abutment points in the fugues zone decrease significantly.

2.4. Elements modules in monolith slab track - stiffness grip

In the case of slab track, the contribution of the bearing layers is an insignificant part of the elasticity. In designing, extremely flexible intermediate layers as elastic components should be considered. The effect of the elastic intermediate layers on the stiffness of the clamping point (spring constant) C1 is determined by the force in the reference point divided by the deformation under the rail z:

$$(1) \quad C_1 = \frac{S}{z}$$

Compared to the ballast in the balastlless track the bed module C is used. The connection between the module of the bed and the stiffness of the support points is given by the expression:

$$(2) \quad C = \frac{S}{F.z} = \frac{C_1}{F}$$

2.5. Track stiffness cS

(3) $c_s = \sqrt[4]{64.E.I.b^3.C^3}$

where:
b=F/a – the fictitious width of the resiliently supported longitudinal beam [mm];
F – half of the supporting abutment area of the sleepers[mm²];
a – the distance between the axes of the sleepers [mm];
E – the modulus of elasticity [N/mm²];
I – the inertia moment of the rail [mm4];

2.6. Admissible force values at the adjacent track attachment points

In order not to not displaced the position of the slab track, the allowable values of the forces in the adjacent rail joints must be regulated.

2.6.1. Admissible lifting (tensile) forces in intermediate rail fastening of rails

In the DB Netz AG has the following admissible lifting forces:

- Admissible lifting forces Fz, add.=12kN for standard rail fastening type of rail;
- Admissible lifting forces Fz, add.=27kN for for certain rail fastening type of rail;

2.6.2. Admissible compressive forces in the intermediate rail fastening type of rail

Under the forces applied to the rail fastening, the elastic deflection of the pressure pad under pressure must not exceed the limit S = 2,5mm in order to ensure the lifetime of the elastic pad.

Hence, it is necessary to prove the pressure force in the rail fastening under frequent loads and at a lower dynamic coefficient of elasticity Cdyn + 20° = 30kN / mm of the fixings, at a higher temperature of + 20 ° C.

FD,add.= S. Cdyn+20° = 2,5.30 = 75kN
where:
FD – the compressive force in the rail fastenings;

2.7. Forces in intermediate rail fastening to deformation fugues using and without transition plates

An example is given in which the most unfavorable case is shown when the tangential angle θ2 appears only on one side of the fugue (Fig.3).

2.7.1.Tensile forces in the intermediate rails fastening

The tensile forces in the rail fasteners adjacent to the fugues at the edge of the bridge are reached in the given calculation example, in case no transitional plates are used, dangerously high values. They considerably exceed the permissible:

max Fz = 26,6kN > Fz,adm. = 12kN

Additionally, the tensile forces arising from wheel loads that can be reached, including the dynamic coefficient $(f_y = 1{,}5)$ and centrifugal force $(f_b = 1{,}2)$ in accordance with Ril 804.5405, the following wheel load:

$F_z = 1{,}2.1{,}5.4{,}1 = 7{,}4kN$

With this tensile force exceeds the permissible value in the rail fastening systems by local load:

max Fz = 26,6+7,4 = 34kN > Fz,add. = 27kN

If the acceptable exceedance of the permissible limit values is the solution adopted with this space with spacers other than those standard for a particular type of ballastless track construction, the rational use of heavy road repairs will be complicated.

When using transient slabs, the tensile forces at the points of the rail supports immediately adjacent to the fugues considerably decrease. The decrease from Fz = 26,6 kN to 4,3 kN means a tensile force reduction of 84%. The same is due to the fact that the vertical displacement is compensated by the insertion of a transition plate.

By incorporating the additional tensile forces, due to the wheel load, the permissible limit values for the standard type rail fastening for a particular type of slab track base using the transition plates remain within the tolerances.

The maximum tensile force:

max Ftens. = 4,3+7,4 = 11,7kN ≈ Fz,add. = 12kN

This means that along the length of the railway track at the end of the bridge, a standard type of rails fastening can be used for the particular type of monolith slab track base, which is important for the maintenance of these sections.

2.7.1. Compression forces in the intermediate fastening rails

When the transition plates are not applied to the rails fastening at the end of the bridge, the force value is min Fn = -43,0 kN.

Here, also, the additional forces exerted by the wheel load have to be taken into account.

For a frequent combination of impacts with a load combination coefficient ψ = 0,8 according to DIN Fb 101, Table G2, with dynamic coefficient and centrifugal force in accordance with Ril standard 804.5405, the wheel load forces may have a value:

min FD = -0,8*1,2*1,5*42,85 = -61,7kN

This indicates that the values of all the forces are greater than the tolerances:

min FD,compression = - 43,9+61,7 = 105,6 > FDadd. = - 75kN

When using a transition plate, the determination of the compressive forces at the rail fastening points shall be carried out with the dynamic coefficient Cd, determined at a temperature of 20 ° C. In these calculations Cdn.=60kN/mm. According to the requirements of Ril 804.5405, the maximum compression force must be determined at Cdin. = 30kN / mm, determined at 20 ° C.

Two times less than "Cdn" means that the maximum forces in the applied example will constitute half of the force values in the rails fastening at the end of the superstructure of the track using a transition plate smaller of the limit values of FDadd. = - 75kN.

3. CONCLUSION

It is possible to compare the results of the forces in the intermediate rail fastening of the rails with and without a transition plate.

With the example shown, a significant reduction of the reactive forces in the rail fastenings is demonstrated in conjunction with the fugues at the bridge end in the case of the use of a transition plate, wherein:

- The limit values of the forces in the intermediate rail fastenings of the rails shall not be exceeded;
- The application of transition plates allows the use of a standard type of intermediate rail fastening for a specific type of monolith slab track base at the edges of the bridge bridge construction. This is important for the bridge structure;

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УСИЛИЯ В РЕЛСОВИТЕ СКРЕПЛЕНИЯ ПРИ БЕЗБАЛАСТОВА КОНСТРУКЦИЯ ЖЕЛЕЗЕН ПЪТ В ПРЕХОДНАТА ОБЛАСТ МЕЖДУ ЗЕМНО ПЛАТНО И МОСТОВЕ

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Ключови думи: *Железен път, мост, преходна плоча, горно строене, скрепление*

Резюме: *Конструкцията на горното строене на железния път върху мостово съоръжение трябва да бъде еднаква с тази на прилежащите междугария. Това е от особенно значение при изпълнение на безбаластови конструкции за горното строене на железния път, която заедно с връхната мостова конструкция трябва да образуват единна система. За безопасността при движение на подвижния жп състав, съществено влияние оказва коравината в преходните участъци от земно платно към връхната мостова конструкция.*

При преминаване на железния път от конструкцията на земното платно към мостовото съоръжение са предприемани мерки за плавен преход между тях, поради различните деформационни качества. Това се получава затова, защото коравината на пътя на подхода на земно платно е значително по – ниска, отколкото на мостово съоръжение.