CETRA 2016

4th International Conference on Road and Rail Infrastructure
23–25 May 2016, Šibenik, Croatia

Road and Rail Infrastructure IV

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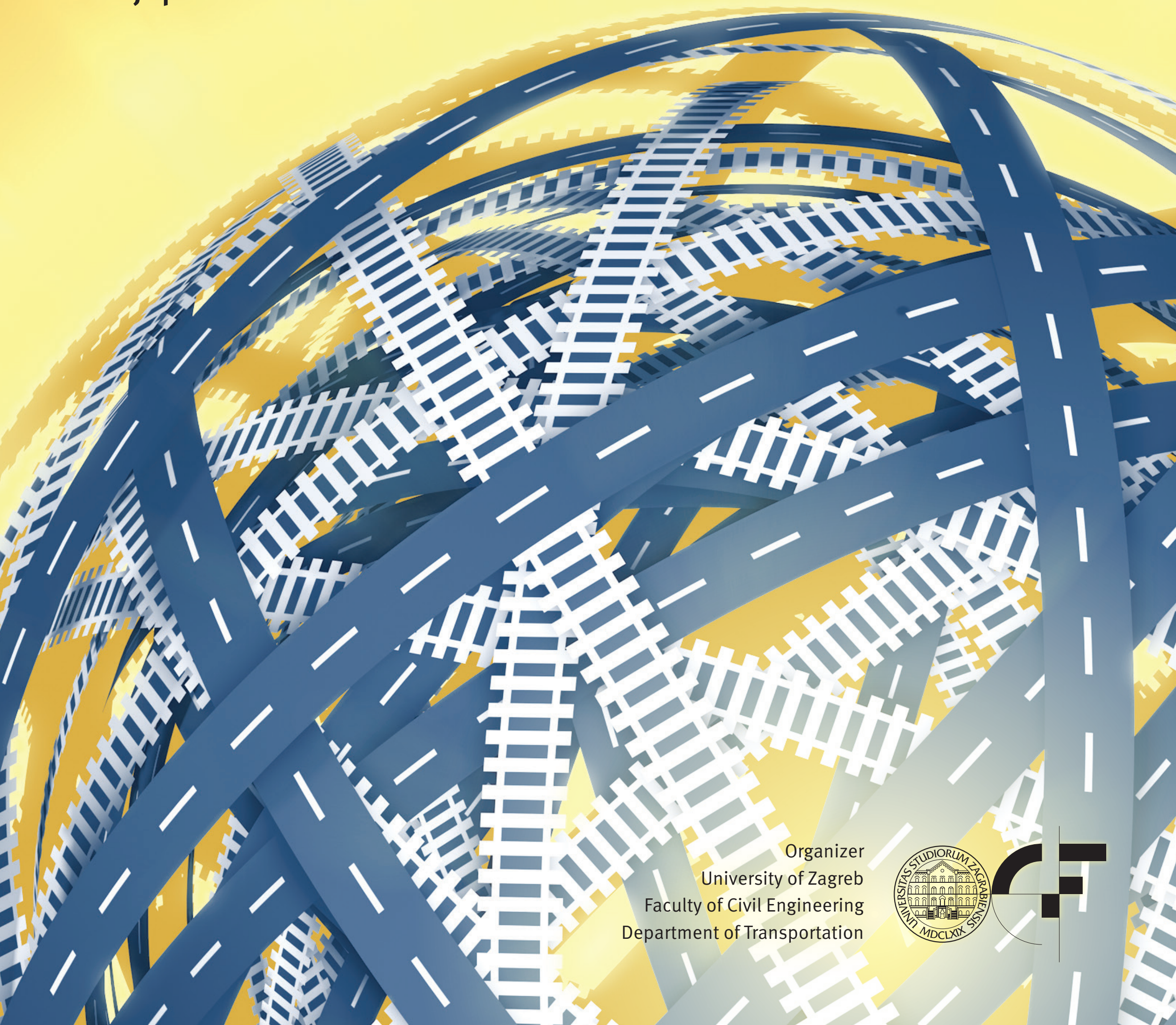

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Road and Rail Infrastructure IV

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PROPOSAL FOR THE WHEEL PROFILE OF THE NEW TRAM-TRAIN VEHICLE IN HUNGARY

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Abstract

The first integrated railway system in Hungary ("tram-train") is currently in planning phase, between Szeged and Hódmezővásárhely. The implementation of this system requires a special vehicle which has the ability to operate both on tramway infrastructures and also on conventional railways, and the necessary construction and reconstruction of tracks, as well. Some European manufacturers offer suitable vehicles, which requires a well-planned special wheel profile due to differences on the two types of infrastructure. Examples of mixed-mode wheel profiles are known in the case of existing Tram-Train systems, but for the present circumstances, domestic specialties, the proper shape of the wheel profile has to be developed, taking into account the domestic norms and standards.
The main goal of this article is to develop a proper wheel profile geometry for the new Hungarian Tram-Train vehicle, taking into account the current tram and conventional rail wheel profiles, as well as the track infrastructure (e.g. rail profiles, curves, turnouts). The applied tram and conventional rail wheel profiles are now different. Operating a rail wheel profile on the tram network is not possible due to the grooved rails, short radius curves and the special turnout solutions. The running of the tram wheel profile is not proper on the conventional rail network, principally on turnouts, and the higher speed is not favourable as well. Particular care should be taken to the permissible rail and wheel profile with wear, because the wheels have to be able to run on rails worn to the authorized limit.

Keywords: tram, tram-train, wheel profile, flange, turnout

1 Introduction

The introduction of the first Tram-train system in Hungary is in planning phase around the city of Szeged, a settlement in the southern part of Hungary. The reconstruction of tram line 1 (Szeged Main Railway Station – Szeged Plaza shopping mall, across the city area) was realized between 2009 and 2011. The current plan is to use this line as part of an integrated rail system, connecting to the nearby Szeged – Békéscsaba railway line, at the terminus of Szeged Plaza. For this project a new wheel profile has to be developed in order to be able to run on both types of infrastructure. Because of compatibility problems the change on conventional rail infrastructure it is not possible, however, the light rail infrastructure facilities are suggested to remain unchanged, according to its age and good condition. Fortunately the two types of railway has the same gauge, so it is not a problem.

2 Wheel profiles applied in Hungary

2.1 Railway wheel profiles

The wheel profiles used on the Hungarian railway network are partially according to the harmonized European standards (wheel profile UIC-ERRI S1002, defined by EN 13715), and some specific wheel profiles are also used (MÁV, K5 and MÁV K6). A common feature of the wheel profiles is the similarity for the rail head geometry, which means the appearance of radii of R320, R80 and R14 mm on the wheel tread (Fig. 1).

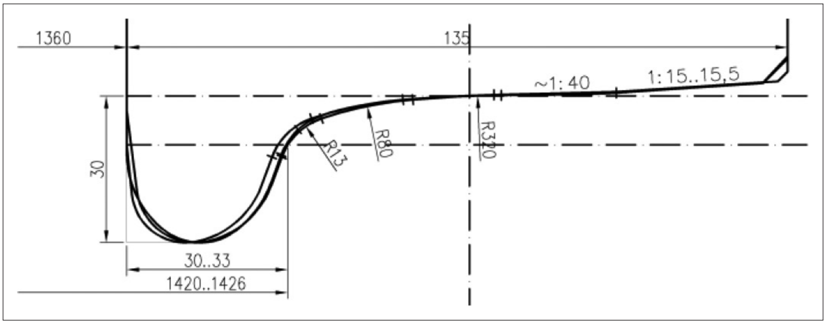

Figure 1 Railway wheel profiles used in Hungary

2.2 Tram wheel profiles

The standard wheel profile on the tram vehicles in Szeged is a conical profile, with a narrow rim-tyre and a narrow flange width (Fig. 2). The rounding radius at the gauge corner is 13 mm. Due to the passing on the turnouts with flat groove, the flange tip is flat on a 10 mm long section. The flange back has a 15° angle to the vertical. Nowadays a newer tram wheel profile is under propagation in Budapest and in Szeged as well, which has advanced tread shape. (dashed line in Fig. 2)

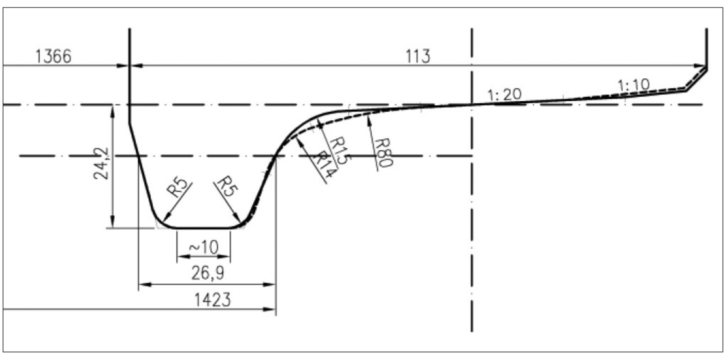

Figure 2 Tram wheel profiles used in Hungary

2.3 Comparison of wheel profile geometries

The two types of the wheel profile has many differences as seen in Table 1. This means difference in geometric and in size.

Table 1 Differences between the two types of wheel profile.

Properties	Conventional railway	Tramway
Wheel back-to-back	1360 mm	1366 mm
Rim tyre width	wide (135 mm)	narrow (124 mm)
Wheel tread	compound (varying radii)	conical (1:20)
Flange width	wide (30..33 mm)	narrow (26,9 mm)
Flange height	high (28,30,32 mm)	low (24,2 mm)
Flange tip	rounded	flat (~10 mm wide)
Flange back	vertical	oblique (15,1°to vert.)

3 Geometric examinations on wheel-rail contact

Because of the difference between the wheel profiles as described in Section 2.3., the run of the different wheel profiles on the other infrastructure can have problems. The suitability of the railway wheel profile on the tram infrastructure and the tram wheel profile on the conventional railway track have to be examined.

3.1 Conventional railway open track

In Hungary UIC54 and MÁV48 (this is a specific Hungarian profile) rail profiles are widely used on the railway network, with 1/20 rail inclination. On the reconstructed TEN-T railway network 1/40 rail inclination is also used since the year of 2000.
The tram wheel profile can properly run on the conventional rail lines, because it has smaller flange dimensions (width and height) than the rail wheel profile. In addition the same superstructure is used on tram lines in suburban areas, with ballasted track. Therefore, this type of track has the lowest affect to the specification of the new Tram-train wheel profile geometry, if the dimensions of the designed profile have the size between the two types of wheel profile dimensions.

3.2 Conventional railway turnouts

The railway turnouts have two essential points related to the wheel run: the front of the tongue rail and the common crossing (frog). In the case of the tongue rail, the q_R distance related to the shape of the flange is dominant to avoid derailment at the front of the tongue rail. This value is significantly less in the case of tram wheel, and does not reach the railway standards.

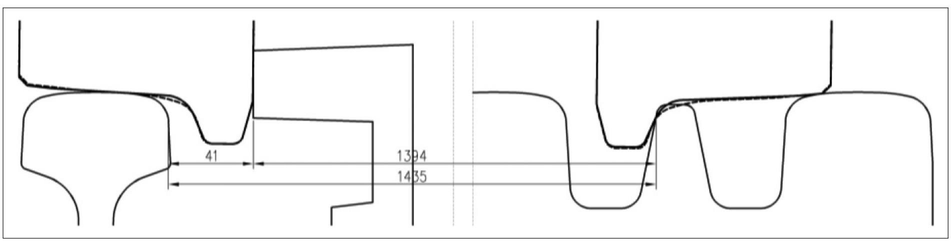

Figure 3 Tram wheel profile in railway track turnout

At the common crossing (See Fig. 3), the dominant size is the wheel back-to-back distance. With a large back-to-back distance the check rail cannot avoid the nose of the crossing from the collision. The tram wheel has not the proper size. During the bypass on the common crossing, some lack of support can be formed. To avoid this, a wing rail can be used, but on steep crossing angles and with narrow rim-tyre width (like the Szeged tram wheel profile has) this method has not enough effect. In summary, the run of the tram wheel profiles are not supported on the railway turnouts due to its size.

3.3 Tram open track

On the tram network, mainly on paved superstructures, grooved rails are used. In Szeged the 59R2 rail profile is widely used on straight and curved sections equally, which has 42 mm groove width. In small radius curves (R‹40m) a "Ph37a" profile is used with extended (58 mm) groove width. Because of the narrow groove the train wheel profile with a wide flange does not have a possibility to run without touching the sidewall of the groove. This effect is serious in small radius curves, where cross-run of the bogie can be experienced.

3.4 Tram turnouts

On the Szeged tram network flat groove turnouts are applied, in which the maximum running speed is 15 km/h in both direction. In the monoblack common crossing the wheelset is running on the flange tip of the profile (called synchronous flat grove crossing), so the support of the wheel is continuous in the whole crossing area. But due to the high contact pressure between the rail and a narrow flange tip, wear can quickly occur in the bottom of the groove. The rounded flange tip used on conventional railways is not suitable to run in flat groove crossing due to the higher contact pressure. Moreover, in the Hungarian grooved turnouts a 36 mm narrow grooved 60R2 rail profile is applied, in which the train wheel profile cannot fit due to the wide flange, so a double flangeback guidance can occur (see Fig. 4.)

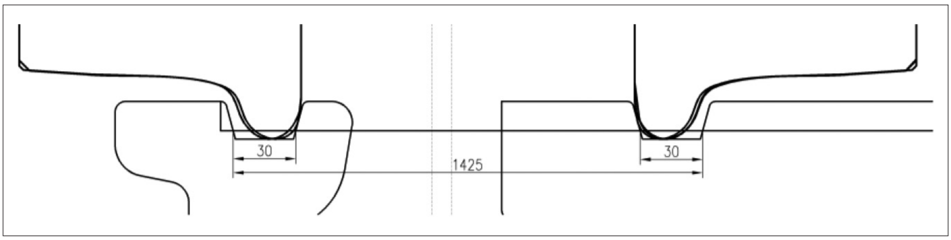

Figure 4 Railway wheel profile on tram flat-groove turnout

4 Proposal for the geometry of the Tram-train wheel profile

As seen in Section 3., none of the currently used wheel profiles are suitable for running on both types of infrastructure. It is necessary to develop a modified wheel profile, which is as much as possible comply with the current regulations. The difference from the standards can be allowed if it is not compromise safety.

The rim tyre width has to meet the railway standards (135 mm), which is required to run on railway crossings. This size is not problem for the tram infrastructure, because although tram wheel profiles under the current regulations only 124 mm wide, the old nostalgic vehicles' wider tyre (130 mm) has taken into account during the Szeged tram line reconstruction. Given the disparities in the wheel back distances of 6 mm it means only a 132 mm tire width, which fit into the acceptable range defined by the standard.

The wheel back-to-back distance has to comply with the railway standards (1360 mm), otherwise the crossing section of the turnouts cannot work, the check rails cannot perform their duties, as set out in Section 3.2. shown above.

The wheel tread profile is suggested to match the UIC ERRI S1002 profiles, which is widely used in Hungarian railcars and EMUs, gained a good experience with them, so there is no reason to change. This profile is not significantly different from the tread section of the modern wheel profiles nowadays started to use on tram vehicles in Hungary as well. The flange width of the S1002 profile may vary as described in [7], so the suitable flange width is 31,5 mm according to 1423 mm flange face width in tram regulations.
The difficulty to develop a proper wheel profile is originating from the flange width. This size has an upper limit from the aspect of tram infrastructure, because of the groove width given by the available network. The flange width consists of three main sections: flange face size q_R, width of flange tip (flat section) and projection of the oblique flange back section. All three factors has am expedient minimum value, which are administered with the flange width, however, not collectively exceed the tram wheel regulations. The minimum value of the flange face size q_R is 6.5 mm, that the design value should exceed, so wear spare is available, thus the minimum value of q_R = 8 mm was determined. The now used tram wheel profile has a flange tip width of 10 mm, this (or almost this) size is necessary to bypass on the flat bottom turnout crossings. In the case of the flangeback section, steeper angle can reduce this, however, this angle shall not exceed the sidewall angle of the used grooved rails (slope = 1 : 6, angle = 9.5 °).
The height of flange need to be preferably aligned to the tram standards. However, according to the wheel profile S1002 variants can be found in the standard, the q_R value can only be greater than the minimum required value of 8 mm if the flange height value has the minimum of 26 mm, otherwise the flange face has to be shortened. The new flange height is 1.8 mm greater than the current tram wheel standard of 24.2 mm. The groove is deep enough to run this higher profile, but the run on the flat groove turnout can be problematic.
Due to adverse experiences on flat groove turnouts some minor changes are suggested to be achieved. The essence of this suggestion is that with deepening of flat grooves a favourable wheel-rail contact can be realized. In this case the support of the wheel can be divided between the flange tip and the running surface, reducing the high contact pressure on the flange tip. The groove depth has to be exactly the same size than the flange height to realize this effect. Now the groove is 18 mm deep, the proposed value is 26 mm, according to the new Tram-train wheel profile. In this case the current tram wheel profiles have to be partially modified.

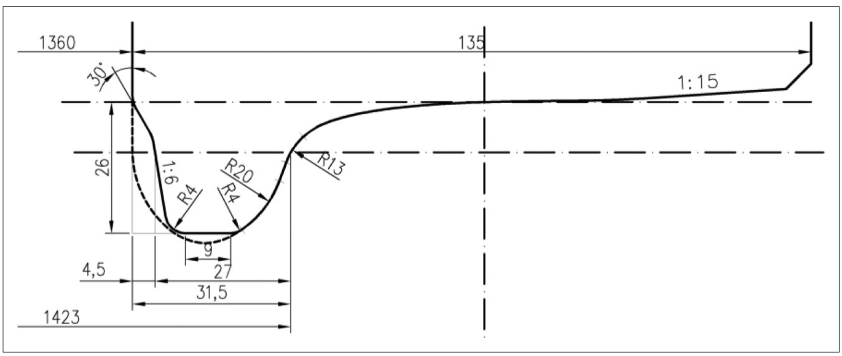

Figure 5 Proposed Tram-train wheel profile compared to the UIC-ERRI S1002 rail wheel profile

5 Conclusion

In this article the geometrical development of a tram-train wheel profile was presented. The wheel profile is able to operate on both of the railway and tram infrastructure comes from the EN 13175 standard, defined as UIC ERRI S1002. This widely used profile ensures that there will

be appropriate running on the railway track. The flange shape and dimensions, however, do not agree the regulations valid for the railway network, because of the problems at some point of the tram network such as grooved rails and turnout crossings. Thus, the flange dimensions of the designed new wheel profile are modified, to be closer to the tram wheel profiles, but they do not fully agree with that.
This solution is a compromise between the two types of wheel profile so it cannot fully meet any of the standards. Therefore, specific authorization is required, but this is the price of the introduction of integrated transport system.
The designed wheel profile works on the railway network in the same way as a standard rail wheel profile, due to the relevant dimensions comply with that. The running surface profile determining the dynamic behaviour and the equivalent conicity is identical to a standard wheel profile UIC ERRI S1002. The q_R value essential for the derailment safety meets the standard requirements but lower than the corresponding standard wheel profile value. The main dimensions needed to proper passing in railway turnouts, like the rim tyre width and the wheel back-to-back distance are also the same as the rail standards.
The proposed wheel profile can work also fine on the urban rail network. The S1002 tread profile has not disadvantages on the tram rails as the tram operators get some new positive experiences with modified running surface tram wheel. The flange tip width is a little bit smaller than the present values, but the proposal to change the turnout crossing geometry can avoid the system from that high contact pressure. The flange width nominal value is the same as the present tram wheel profile, so the flange can fit in the groove in any case the present profiles do.
Because of the nature of pilot project and special circumstances after 1 year operation field measurements have to be made to gather experiences. Depending on examination results possible minor changes on the developed wheel profile can be executed.

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