RESEARCH OF THE FACTORS DETERMINING THE SAFETY OF TRAIN MOVEMENT UNDER BRAKING - INTEROPERABILITY

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Abstract: *Interoperability for newly adopted countries in the EU is key to trains safety. Calculating the braking force used by the Leaflet 544-1 of the UIC Leaflet [1] brake elements is important for safety when running trains in the braking mode.*

The researching of the facts shows that Regulation 58 [2] is harmonized with the contents of UIC Leaflet 544-1[1] and EU Regulation No 1302/2014 [3]. The test is to be used for the interoperability of the technical infrastructure in connection with Commission Regulation (EU) No 1299/2014 of 18 November 2014 [4] on technical specifications for interoperability with respect to the infrastructure subsystem of the railway system in the Union concerned.

When designing the rail lines used braking calculation, made by easy way remain based on the friction of the pads on the wheel surface, but it is not related to the examples in the UIC Leaflet 544-1 [1].

Keywords: Interoperability, Regulation No. №1302/2014, Railway track, rail system in the European Union

1.Introduction

Interoperability [3, 4] for newcomer's countries to the EU is crucial for train safety. The calculation of the braking force and the effectiveness of the braking action are important for the safety of train running when decelerating and braking. In areas where the use of braking force is required for a long time, the wheels and brakes are warmed up and the risk of fire is created. After these dangerous sections, detectors shall be installed to measure the temperature of the bearing boxes and brakes. If the temperature is higher than acceptable, the train is waiting for normalization at the nearest station.

The factor study shows that Regulation 58 [2] is in line with the requirements of UIC Leaflet 544-1 [1] and EC Regulation No 1302/2014 [3]. They comply with the requirements for the interoperability of technical infrastructure in connection with Commission Regulation (EU) No 1299/2014 [4] of 18 November 2014 on technical specifications for interoperability with respect to the rolling stock and infrastructure subsystems in all countries of the European Union [4].

When teaching the design of railway lines, the calculation of the braking force is made in a clear and easy to apply way based on the friction of the pads on the wheels, but it does not correspond to the ones set out in UIC Leaflet 544-1 [1] and European standards [5] and [6] on the method of calculating the braking force of different wagons, trains, separate autonomous vehicles and trains.

2. Preconditions and ways of solving the problem

The dimensioning of the railway line is the maximum longitudinal slope on which a train towed by one locomotive is moving at a constant estimated speed of the locomotive and hauling wagons of estimated weight [7]. This is the definition of railway line for the design elements of subsystems: infrastructure and rolling stock. The article raises the question of what happens when a train descends on a descent along or near this boundary slope. Obviously the train will need [1]:

- move in braking mode or partial braking,
- comply with the maximum speed limit in the section and
- observe the maximum stopping speed of an obstacle.

According to the UIC Leaflet [1] for determining brake performance, it is determined by the brake mass or by the deceleration of the train being delayed or stopped. The train's braking mass can be converted to a brake percentage of a separate vehicle or train. The train's braking effort is applied to: train stopping - service or emergency, reducing the speed to maintain a certain maximum speed in the section and stopping the train for a long stay at the station.

So far, the theoretical side of the problem is presented under idealized environments or standard conditions. For example, longitudinal slope in design, road condition within technical tolerances, vehicle operating condition, etc. In practice, a vehicle, train or autonomous vehicle can run in: poor condition of the vehicle as a result of insufficient braking force, altered friction coefficient, poor rail condition, poor environmental conditions, etc. For this purpose, the parameters of the railway are also investigated [7, 8]:

- hazardous sections of the railway network in accordance with the regulations,
- the condition of the railway as a result of not performing on-going maintenance but with parameters within the permissible maximum permitted speed, and
- repairs delayed or not carried out with a reduction of the maximum permitted speed in the section.

2.1. Current condition for determining the braking force

Currently, the design and construction of railway lines [8] is taught the determination of braking force by analogy with the determination of tractive power. The base is a railway wheel that is pressed by a one-sided pad Fig. 1

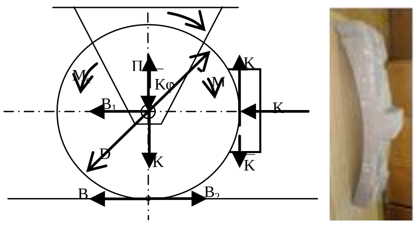

Fig.1 *Occurrence of mechanical brake force [7, 8]*

The calculation of the braking force for each particular wagon is determined according to the methodology set out in the UIC Leaflet [1]. This is done on the basis of a specific wagon, type of braking system, principle lever system for distributing the force for all axles Fig. 2.

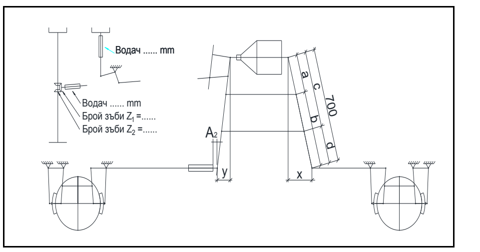

Fig. 2 *Schematic diagram for the calculation of mechanical braking force for a two-axle wagon with a load of 20 t per axle with full / empty mechanical switch [1]*

The determination of the braking force as required by the UIC is applied in our railways. A major part of this is the determination of the brake mass [9, 10]. It is determined before the train goes into service and is a basic technical characteristic of the wagon braking system, individual vehicles, train crews and trains. The brake mass determines the effectiveness of the action of the braking force and serves to determine the braking distance or the permissible operating speed. Its value corresponds to the braking mode assigned to each wagon. According to Ordinance 58 [2, 9], the braking distances correspond to the pre-signaled braking distances and for standard railway lines are 1500, 1200, 1000 and 700 m. The stopping distance shall not be allowed to exceed the pre-signaling stopping distance for a given burnout.

2.2 Possible causes and solutions

The reasons for the condition of the hazardous sections of the railway network are: the different construction time and the normative documents in force at that time, the condition of the rolling stock and the use of traction in different historical periods. Of course, the timely implementation of the repair activities, the necessary reconstructions, and now the need for the interoperability of the railway system with the EU railway network are also important.

The hazardous sections of the railway network are inspected for: element length, element slope and combination of adjacent elements. The length of the hazardous elements is related to the warning braking distances discussed above. The slope of the elements for longitudinal descents under Regulation 58 is greater than 15 ‰ [2]. They must be specially marked. When the slope of the railway between the warning and the entrance traffic lights is downwards to a station with a slope of 14 ‰ and above, the traffic manager on duty agrees to receive the train only if there is a free acceptance track, the route is prepared for him and the maneuver is terminated [2].

According to Regulation (EU) N1302 / 2014 [3], in calculating the thermal load capacity, the maximum slope of the line, the length and the service speed for which the braking system is designed in relation to the heat load capacity shall be determined by calculating at state of "maximum brake load". The service brake is used to maintain a constant train speed. The standard slope case is to maintain a speed of 80 km/h on a steep slope with a constant slope of 21 ‰ within 46 km [1]. According to Regulation 58 [2], "continuous downstream" is a section of railway with a longitudinal slope exceeding 14 ‰ descent of a length equal to or greater than the pre-signaled brake distance.

Regulation 58 [2] defines the "Big Down" signboard, which is a square, diagonally divided, with the left lower half black and the right white with inclination figures (Annex No 48) [2]. It is placed at the beginning of long descents greater than 15 ‰.

3. Solution the investigated problem

There are two solutions to the dangerous sections of a train when the train is running.

Removal of hazardous sections. The section of a new route is reconstructed or a tunnel is made. The dangerous slope no longer exists. Example of operational program decisions in the Sofia-Plovdiv section Fig. 3 large tunnels and bridges are designed and constructed, maximum slopes are reduced and interoperability with EU railways is ensured. The downside is the price, which is hundreds of millions of BGN.

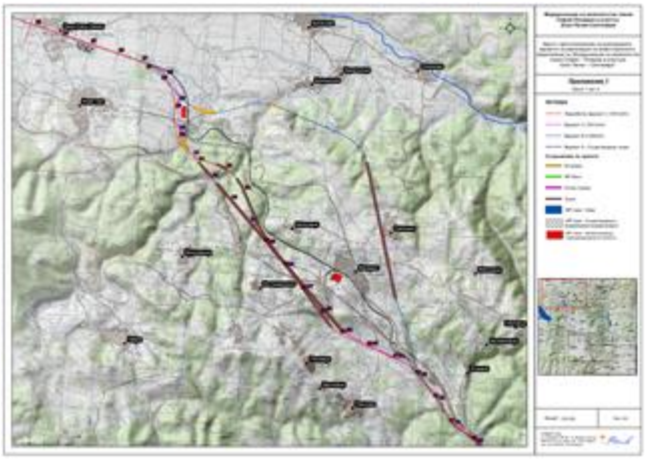

Fig. 3 *Variant solutions that eliminate hazardous sections [11]*

Improving operational performance or operation of the track with the big dangerous slopes. A checkpoint is being built after the dangerous section. Check point Fig. 4, which measures the temperature of the bearing box, wheel and pad.

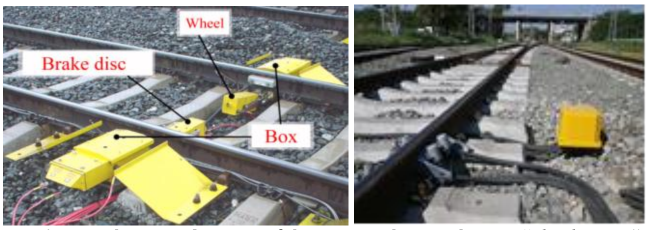

Fig. 4. *Schematic diagram of the universal control point "check point" and a counter axle [12]*

In Bulgaria universal checkpoint checkpoints are used Fig. 5. They measure the temperature of the axle, the wheel and the pad, the axle load, the location of the load on the axles, the gauge, the check for the dug-in bandages Fig. 6, etc.

Fig.5 *Operating checkpoint near to Zimnitsa*

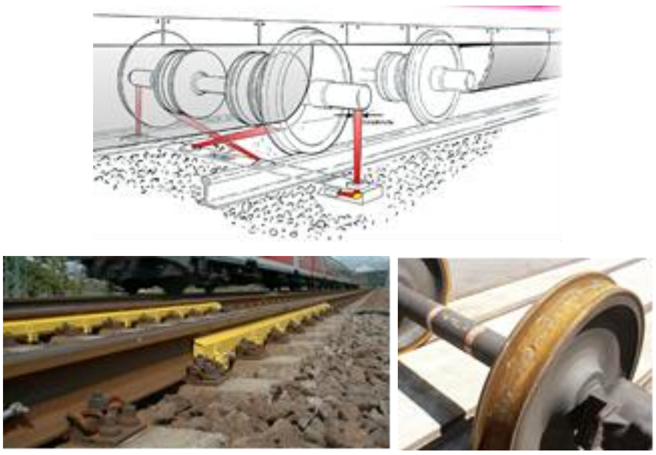

Fig.6 *Detector for entrenched wheels [12]*

4. Results and discussion

The results of the project are not yet final because it is still in the process of exploration and implementation. In addition to the factors mentioned above, solutions in the subsystem of railway rolling stock and operation of the railway line may also be sought in the subsystem of railway infrastructure. For example, measurement of the temperature of blocks, wheels and bearing boxes in nearby stations, control of the specified elements for the presence of cracks in Fig. 7, including internal prophylactic measurements with ultrasonic flaw detectors, etc.

Fig. 7 Measurement with an ultrasonic flaw detector

5. Conclusion

The study [10] and the analysis of the hazardous sections of the NRIC network lead to the conclusion that at least 25 sites of the network should be placed so on, checkpoints for checks and brakes. The criteria for the selection of hazardous sections in Bulgaria were compared in accordance with Ordinance 58 and in the EU.

6. Literature.

1. UIC Leaflet 544-1: Brakes - breaking performance

2. Ordinance 58 of 2.08.2006 on the rules for the technical operation, movement of trains and signaling in railway transport, issued by the Minister of Transport, promulgated SG, issue 73 of 5.09.2006, amended, issue 88 from 2007, as amended. and suppl., issue 43 of 2009, issue 68 of 2014, and issue 97 of 23.11.2018, effective from 24.02.2019.

3. Commission Regulation (EU) N1302/2014 COMMISSION REGULATION (EU) No 1302/2014 of 18 November 2014 concerning a technical specification for interoperability relating to the ‘rolling stock — locomotives and passenger rolling stock’ subsystem of the rail system in the European Union, Official Journal of the European Union, L 356/228-393 http://data.europa.eu/eli/reg/2014/1302/oj

4. Commission Regulation (EU) No 1299/2014 of 18 November 2014 on the technical specifications for interoperability relating to the ‘infrastructure’ subsystem of the rail system in the European Union Text with EEA relevance http://data.europa.eu/eli/reg/2014/1299/oj

5. DIN EN 14531-1:2005: Railway applications - Methods for calculation of stopping distances, slowing distances and immobilization braking - Part 1: General algorithms, May 2005,

6. DIN EN 14531-6:2009: Railway applications - Methods for calculation of stopping and slowing distances and immobilization braking - Part 6: Step by step calculations for train set or single vehicles

7. Nikolov V., Todorov S., Roads and Railways, textbook, UACEG, ISBN 978-954-12-0205-0, 2011 г., 471 стр.

8. Dencheva Z., K. Kutzarova-Dimitrova, Railway engineering, textbook for University of architecture, civil engineering and geodesy, ISBN978-954-724-116-9, 2018, p. 139

9. Kutzarova K., Researching of the factors determinant safety movement of the train in braking regime – impact of braking force on the superstructure of the railway with regard to the interoperability and the experience of the railway section Gorna Oriahovitsa, 4-th international scientific conference – winter session Industry 4.0 11-14.12.2019 Borovets, ISSN 2535-0153 (Print), ISSN 2535-0161 (Online)

10. Todorov S., K. Kutzarova, Determination of braking force and assessment of dangerous sections of the railway network of the Republic of Bulgaria, XXIV international science conference „Transport 2019“, VTU „T. Kableshkov“, Magazine „Mechanics, Transport, Communication”, ISSN 1312-3823 (print), ISSN 2367-6620 (online), бр. 3, 2019, стр. VIII-19- VIII-24

11. Citizens want revision of Sofia Plovdiv railway line, Граждани искат преразглеждане на жп линията София Пловдив, https://obshtestven.wordpress.com/2019/02/13/grajdani-iskat-prerazglejdane-jp-linia-sofia-plovdiv/

12. Schöbel A., Wayside train observation at Austrian federal railways, International science practice conference УАСГ2009, 29–31 October 2009, Annual of UACG, volume XI, Transportation engineering