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MODELING THE TURNOUT SWITCH FOR CALCULATION THE OVERTURNING FORCE

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Abstract. *In the paper the calculation models for determination the switch force of turnaut tongue in all stages of its work are given. The three phases of switching are analized:*
- Initial phase,
- Second phase when the peak of the tongue touches the main rail,
- Final phase when the tongues are locked to the main rails.
This calculation for turnout type UIC 60-1200-1:18.5 is carried out, and an the model in the factory the results would be checked.

1. INTRODUCTION

Introducing high speed in Jugoslav railways couse increasing demands for turnout. The turnout type UIC60-1200-1:18,5 for placement in the high speed line Subotica - Beograd - Niš - Dimitrovgrad is adopted. This turnout has the movable nose frog that provides an uninterrupted, smooth ride on the selected track. The swing nose frog is moved simulteneously with the switch.

In our previous paper [1] modelling the movable frog in order to calculate its switching force was presented. In this paper the similar model is made for the switch tongue. If the turnout is in the automatic block-signal teritory, the value of the tongue switch force is of great importance because on the one hand it is restricted, and on the other hand it is not possible to record its fault. By measuring in situ or by calculation using the model, the values of tongue switch force can be estimated.

The switch of turout type UIC60-1200-1:18,5 is shown in Fig. 1.

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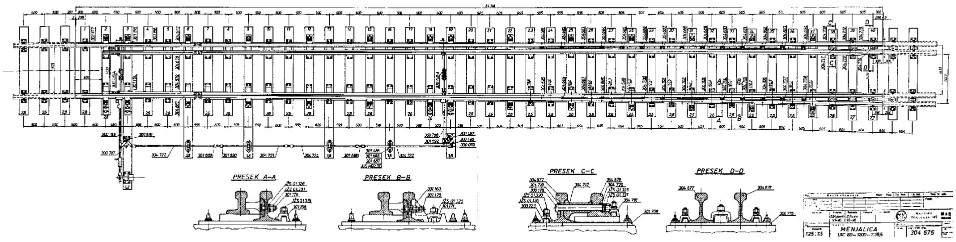

Fig. 1

The switch is consisting of two main rails, two tongues, sliping plates, setting device and locking device. The tongues are made from special profile Zul60, whose carateristic cross sections are on the Fig. 2.

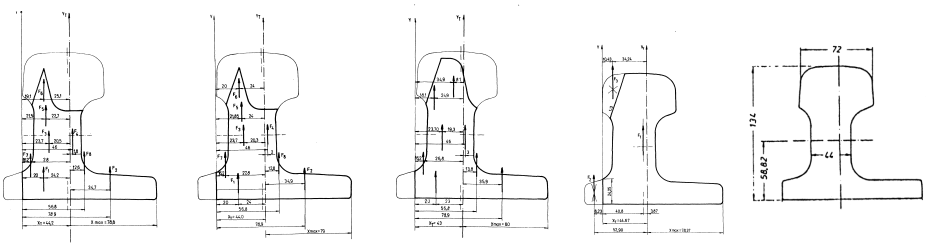

Fig. 2.

The connection betwen the tongues and the main rails is perform by means of root spools and the holding a distance betwen them is achieved by means of supporting spools.

The overturning and the locking of the tongues are made by means of bars and two locking devices. First locking device (Fig. 3a) is placed betwen the second and the thirol sleeper and the second one (Fig. 3b) is placed betwen the 18th sleeper and the 19th sleeper (from the beginning of the turnant).

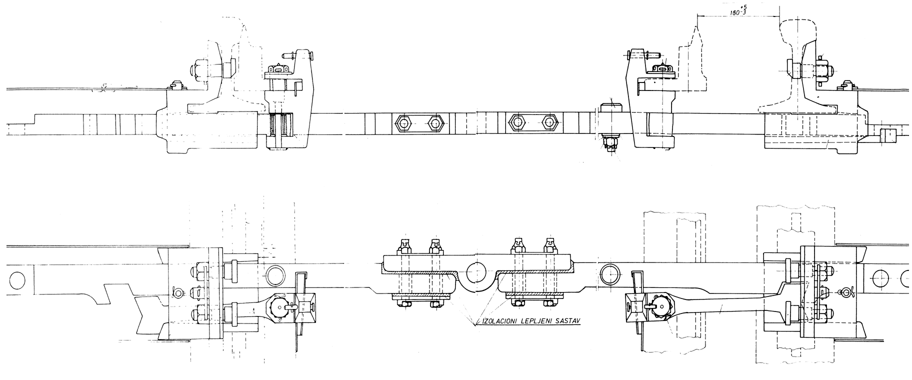

Fig. 3a

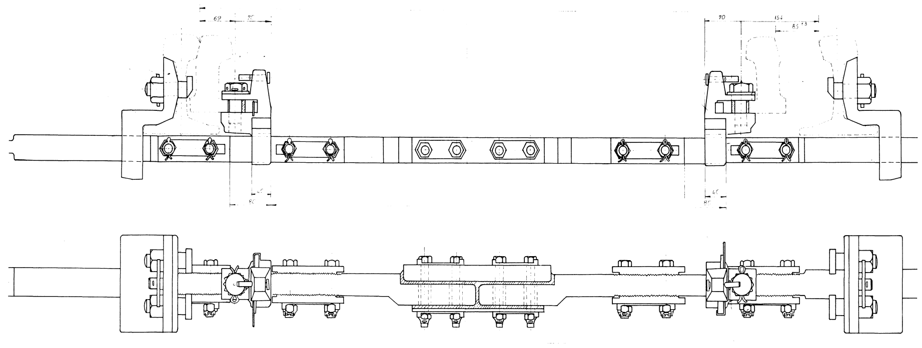

Fig. 3b

Schematic representation of locking device working phases is given on the Fig. 4. Locking device, depending of train riding direction (straight or diverging), firmly clining ane tongue to the main rail and betwen other tongue and its main rail provides the wheel passage. In this way, exact position of the tongues and safe train passing are made possible.

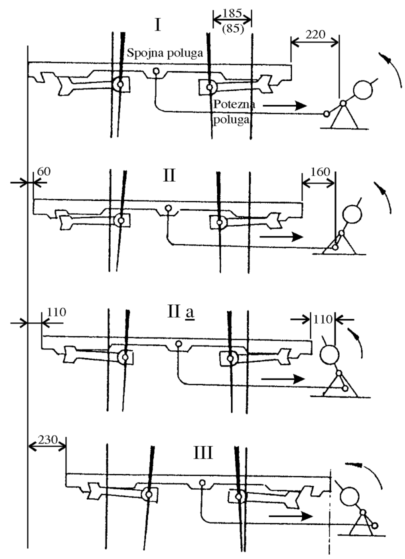

Fig. 4.

2. Models for Calculating the Tongue Switch Force

Determination of switch force necessary to overcome the friction between the sliding baseplates and tongue and switching the turnout is considered for the three characteristic stages of its work:

1. Tongue acting as the coutilever, that takes place at the beginning of switching and

lasts till the tongue contatcts the main rail.

2. Tongue as the girder fixed at one and free supported on the other end that takes place from touching till clinging the tongue to main rail.

3. Tongue as the girder fixed at both ends, that takes place from clinging till the switch is completely locked.

Modelling and calcultatin the required tongue switch force are carried out using the girder finite element method. During modelling the geometrical characteristics of tongue structure are taken into accout by selection of the dimension and type of elements.

The calculation includes two groups each contain three models, appropriate to cases that take place during setting the moving tongue (switching, clinging, locking up of tongue). The basic model remains the same, but the supporting and loading conditions are changeable.

2.1. Geometrical characteristics of models

The tongue as the girder of changeable cross section is estimated. As the cross section changes iregularly, the girder is devided in segments with the constant characteristics. This way, the six different cross sections are adopted. For these cross sections the folowing geometrical characteristics are calculated:

- area (A_x),
- sliding coefficients (A_y, A_z),
- torsion constants (I_x),
- moment of intertia for both axes (I_y, I_z).

In the following Shedule 1 geometrical characteristics of cross sections are given:

Shedule 1.

cross section	A_x cm^2	A_y cm^2	A_z cm^2	I_x cm^4	I_y cm^4	I_z cm^4
1-1, 2-2	59.	49.	49.	221.	528.	476.
3-3	61.	51.	51.	225.	540.	518.
4-4	67.	56.	56.	270.	526.	840.
5-5	81.	67.	67.	377.	573.	1392.
6-6	94.	78.	78.	433.	757.	1749.

These models permit easy and quick changes, as they can be used for calculation of vehicle induced stresses in tongue.

2.2. Loading of models

To determine the force needed for setting the switching structure of turnout the only load is the weight of tongue. The friction resistance between the movable tongue and the baseplates appears as the reactive load. This load is taken as the uniform load along the whole tongue lenght:

$$t = \mu g$$

where: μ is the friction coefficient between the base of movable tongue and the plates, g is the weight per unit of tongue length for the corresponding cross section.

In the Shedule 2 the weights and the corresponding friction resistances (determined for friction coefficient $\mu = 0,25$) for the segments of tongue model are given:

Shedule 2.

cross section	g N/cm	t N/m
1-1, 2-2	463.15	115.8
3-3	478.85	119.7
4-4	525.95	131.5
5-5	635.85	158.9
6-6	737.90	184.5

2.3. Modelling

In the paper the two structures of setting device for overturning the tongues are considered:
- with one switch rod and
- with two switch rods.

According to these structures the corresponding models of tongues are analyzed.

2.3.1 Turnout with one setting device

The first group of models are those with one setting device. The mathematical model for calculation the switch force in the first stage of work is presented in Fig. 5. The model is considered as a contilever of 21753 mm leght and the changeable cross section according to Shedule 1. The calculating procedure is the same as given in the paper [1].

The model is loaded with a unit force $\overline{P}=1$ acting at the point where the switch rod acts on movable tongue. The switch force is obtained from the proportion:

$$Py_{\overline{P}=1} = y_1$$

where: $y_1 = 160$mm is the gap between the tongue free end (joint 2 in the model) and the main rail,

$y_{\overline{P}=1}$ is the lateral deflection of the tongue and due to unit force.

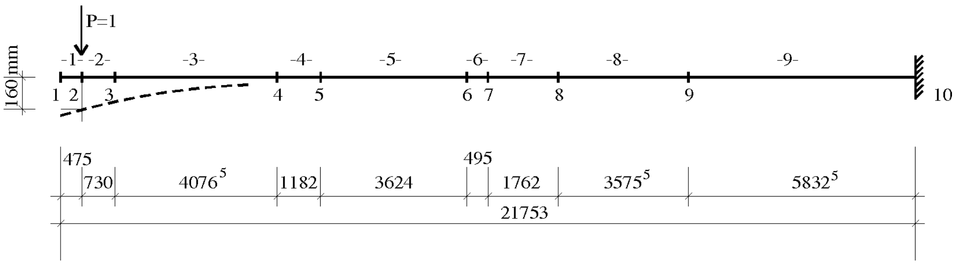

Fig. 5.

In order to realize the gap of the free end of movable tongue in the amount of

160 mm, the needed switch force in calculation model from the mentioned eqation has to be: P = 0,07 kN.

In the second phase of switching the tongue (Fig. 6), when the peak of the tongue touches the mean rail, the model can be considered as the girder supported at one end and the other end remains fixed (root of the tongue). As the reactive load, friction, appears between the movable tongue and the baseplates along the whole tongue lenght.

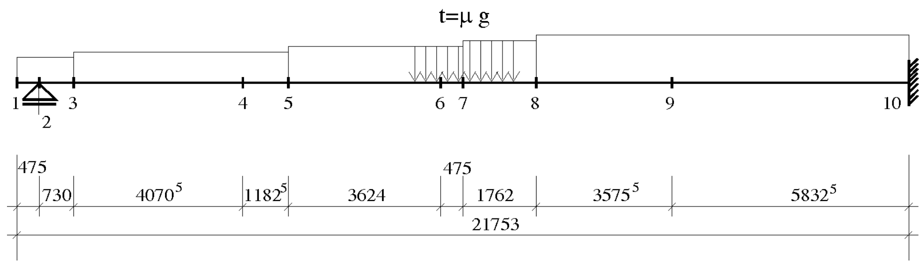

Fig. 6.

After the calculation is completed, the force of the support in the model joint in the tongue peak is obrained in the amount: P = 1,1 kN. This is the force needed to overcome the friction between the tongue base and the plates under the assumption that the friction coefficient is 0,25.

In the final stage of switching (Fig. 7), when the tongues are locked to the main rails, the calculating model is changing, so that both ends become totally fixed. The load remains the same as in the previous model. The switching force after calculation is: P = 1,45 kN.

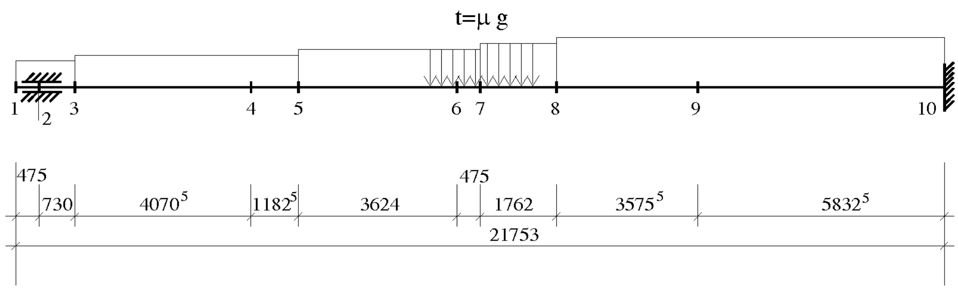

Fig. 7 .

2.3.2. Turnout with two setting devices

The behaviour of the switching structure in all stages of its work is analyzed. The model is changing so that the setting devices act in two joints (joints number 2 and 6 in model).

In the first stage model remains the same (Fig. 8) and the switching forces are calculated from the conditions that the gap in joint 2 has to be 160 mm and in joint 6 85 mm, and their values are:

- at the joint 2 (first setting device): P_1 = 0,05 kN
- at the joint 6 (second setting device): P_2 = 0,07 kN.

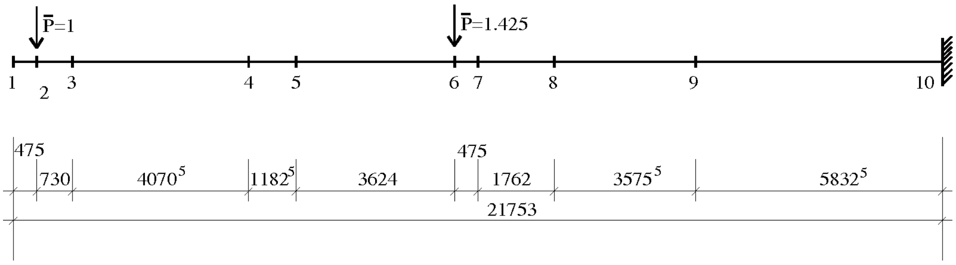

Fig. 8.

In the stage of clinging (Fig. 9) the peak off the tongue the model is a girder fixed in the root of the tongue and in joint number 6 (second setting device) and supported in joint number 2 (first setting device). The loading remains the same as in the corresponding case at the first group of models and the switching forces are:

- at the first setting device: $P_1 = 0{,}55$ kN
- at the second setting device: $P_2 = 1{,}2$ kN.

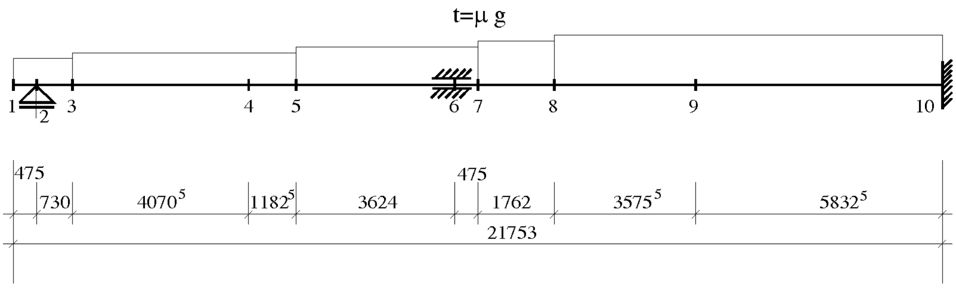

Fig. 9.

In the stage of locking (Fig. 10) the tongue of the callculating model is a girder fixed in the root of the tongue and also fixed at the places where the setting devices act. The loading remains the same as in the corresponding case of the previous group of models and the switching forces as the reactions at the joints of model number 2 and 6 are:

- at the first setting device: $P_1 = 0{,}65$ kN
- at the second setting device: $P_2 = 1{,}0$ kN

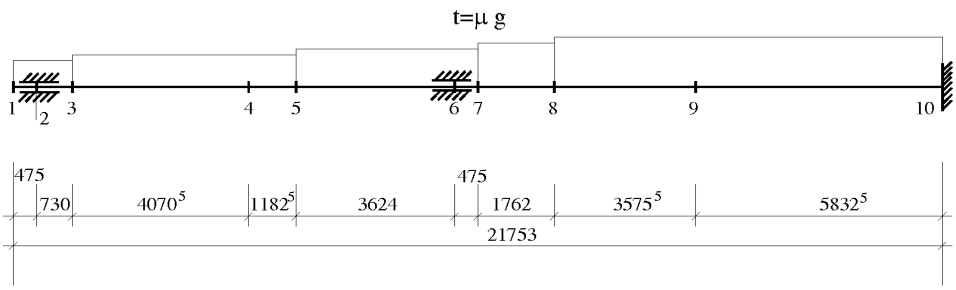

Fig. 10.

The influence of obstruction (particle of ballast, for example) between the tongue and the main rail in two positions, are analyzed:

- in the middle of distance between the two setting devices and
- in the middle of distance between the root of tongue and the second setting device.

For the size of obstacle of 30 mm, the minimum value of switch force is 2,65 kN pro one tongue, that means that the turnout switch would not work.

3. Conclusion

The maximim switching force for the turnout with one setting device is $P_{max} = 2 \times 1,45 = 2,9$ kN, that is much higher than the regulations G2.402/87 and the turnout must have two setting devices.

In order to realize the value of the gaps between the tongue and the main rail where the setting devices are placed, the switch force at the second device must be 1,5 times larger. The maximum switching force is $P_{max} = 2 \times 1,2 = 2,4$ kN at the second setting device, whichl is within the permited limits.

This kind of calculation needs be the part od documents for turnout switch. That way the switch forces become approximately known, that is important for controlling the correct assembling in the site. The exceeding of switch forces values points to the faults in switch devices. It is obvious that during turnout exploatation, attention has to be paid to perfect maintenance of switching devices, that includes cleaning and greasing as well as the geometrical precision in all their parts.

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MODELIRANJE SKRETNIČKE MENJALICE ZA PRORAČUN SILE PREBACIVANJA

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U radu je dat proračun za određivanje potrebne sile za postavljanje skretničke konstrukcije jezička u svim njenim fazama postavljanja. Analizirane su tri faze postavljanja konstrukcije skretničkog jezička:

- Početna faza (I faza),
- Trenutak kada jezičak skretnice dodirne glavnu šinu (II faza),
- Slučaj potpunog priljubljenja jezička uz glavnu šinu (III faza).

Na primeru skretnice UIC 60-1200-1:18.5 prikazan je ovaj proračun, a na modelu u fabrici (radionici) rezultati će uskoro biti provereni.