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MODELLING THE SWING NOSE FROG OF TURNOUT

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Abstract. *In order to qualify Yugoslav railways for high speeds, the turnout type UIC60-1200-1:18,5 with movable frog is designed. Modelling the movable frog in order to calculate its switching force is presented in this paper. After that a prototype is manifactured.*

1. INTRODUCTION

Introducing high speed in Yugoslav railways couses increasing demands for turnouts. The turnout type UIC60-1200-1:18,5 for placement in the high speed line Subotica-Beograd-Niš-Dimitrovgrad is adopted.

There are two frog designs commonly used. The standard rail bound rigid frog has a gap that has to be jumped by the wheels. It requirs quard rails on each route that quide a wheelset trought the troat of the frog. The second design, which is compulsory in hight speed lines, is the movable paint frog. In this design, a specially shaped rall similar to the switch point is moved simultaneously with the switch, providing an uninterrupted, smoother ride on the selected track. This design does not generate high impacts, wheel and rail wear is lower and train speed on the mainline is not limited. There are two posibilities: swing nose frog or swing wing frog. Both solutions do not require the use of quard rails.

By our turnout the swing nose frog is possible owing to the dilatation device built in the one heel of the crossing (splice rail). For setting the nose frog at the right position, two mechanisms similar to switch rods are installed. The main dimensions of swing nose frog are given in Fig. 1.

If the turnout is in the automatic block-signal territory, the value of the switch force is of great importance, becouse on one hand it is restricted, and on the other hand it is not possible to record its foult. By measuring on the frog prototype or by calculating using the

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model the values of switch force can be estimated.

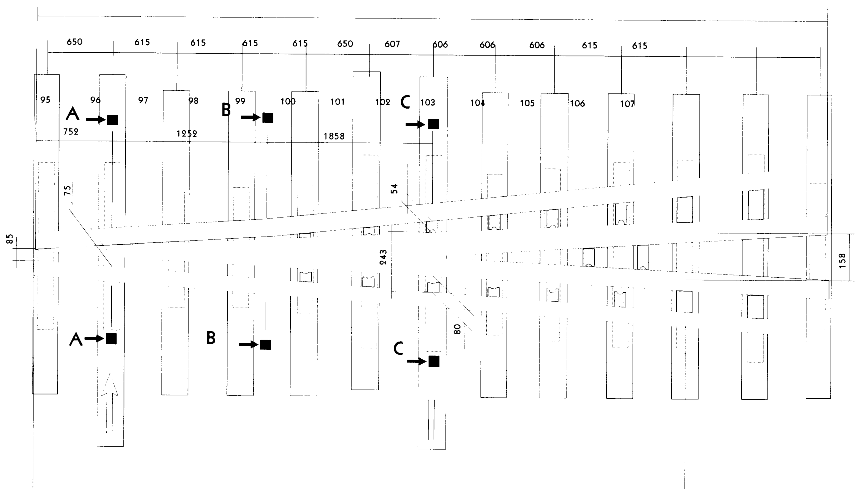

Fig. 1.

2. Models for calculating the nose switch force

Determination of switch force necessary for overcaming the friction between the sliding baseplates and swing nose and switching the frog is considered for the three characteristic cases of its work:

1. Swing nose as the coutilever, that takes place at the beginning of switching and lasts till the nose contacts the wing rail (Fig. 2).
2. Swing nose as the girder fixed at one and free supported on the other end that takes place from touching till clinging nose to wing rail (Fig. 3).
3. Swing nose as the girder fixed at the both ends, that takes place from clinging till total locking up the frog (Fig. 4).

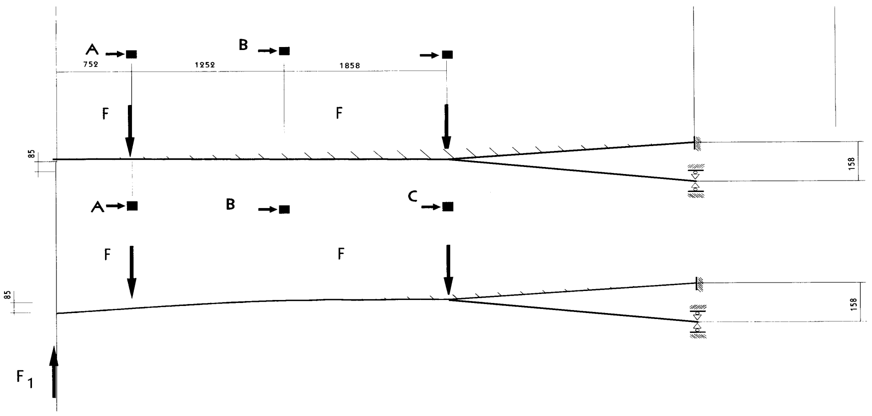

Fig. 2a

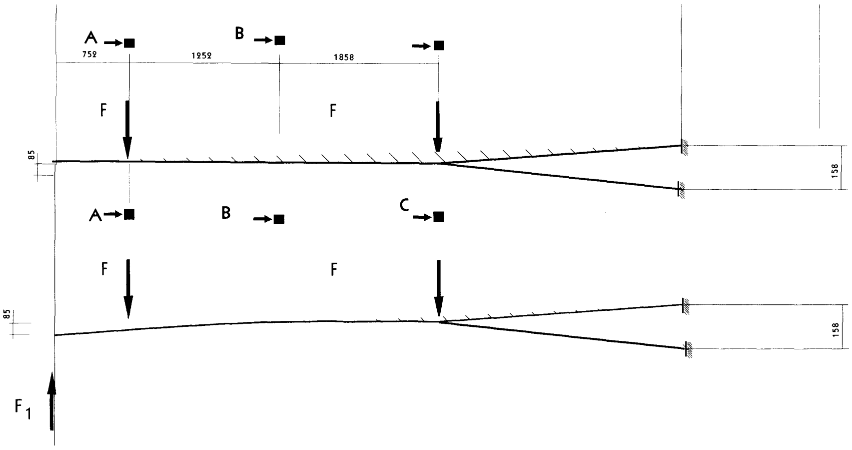

Fig. 2b

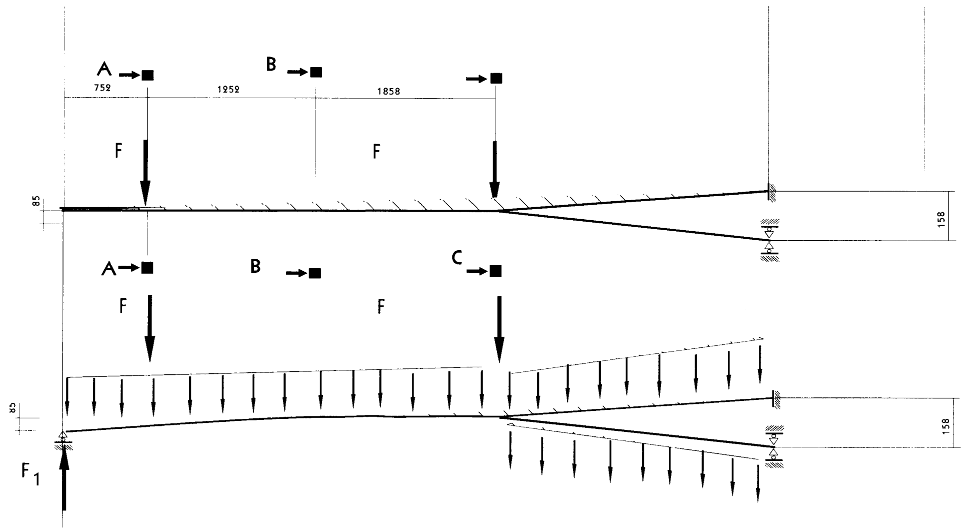

Fig. 3.

Modelling and calculating the searching frog switch force are carried out using the girder in finite element method. During modelling the geometrical characteristics of moving frog structure are respected by selecting the dimension and type of elements.

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

The moving nose frog as the girder of changeable cross section is estimated. As the cross section changes irregulary, the girder is devided in segments with the constant characteristic. In this way, the eight different cross section are adopted. For these cross sections the folowing geometrical characteristics are calculated:

- area and sliding coefficients,
- torsion constants and
- moment of inercia for both axes.

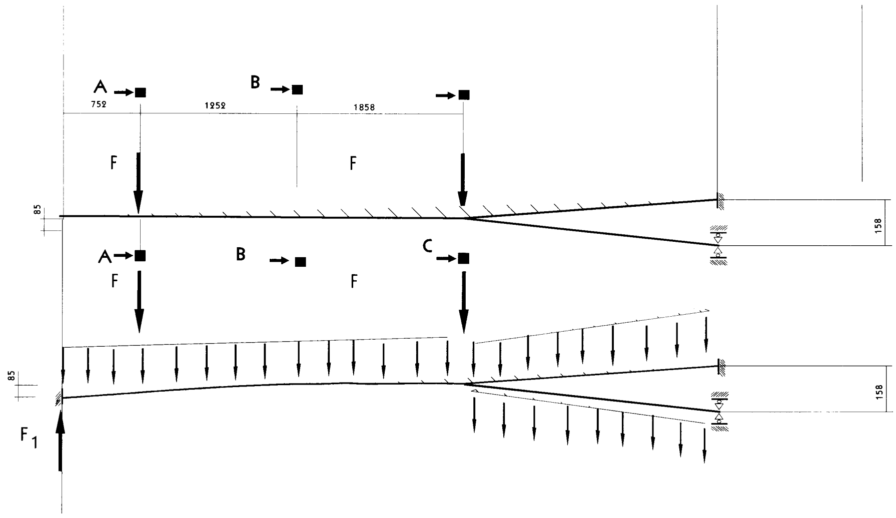

Fig. 4.

In the folowing schedule geometrical characteristics of cross sections and corresponding weight are given in Table 1.

Table 1.

cross section	area A m^2	moment of inercia I_y m^4	moment of inercia I_z m^4	sliding coefficient Y	sliding coefficient Z	torsion constant cm^4	weight N/m
A-A	7.588E-03	1.613E-06	1.386E-05	1.130	1.261.	5355	596.66
B-B	1.261E-02	5.741E-06	2.974E-05	1.159	1.172	17470	989.89
C-C	1.319E-02	6.498E-06	3.176E-05	1.168	1.164	19240	1035.42
D-D	2.728E-02	5.730E-05	6.652E-05	1.170	1.172	105900	2141.48
E1-E1	6.664E-03	1.999E-06	2.423E-05	2.262	1.305	2265	532.12
E2-E2	1.263E-02	5.697E-06	3.070E-05	1.173	1.163	17010	991.46
F-F	2.327E-02	3.561E-05	5.639E-05	1.169	1.170	75790	1826.70
G-G	5.866E-03	9.008E-07	8.989E-05	1.121	1.288	3013	460.48

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

The First group of models

Both ends of frog in its heel are considered as completely fixed, so that the displacements and rotations in X, Y and Z directions are prevented.

Phase I: Switching the swing nose frog

Model can be considered as a coutilever of 6276 mm lenght. The switch force is obtained from the eqation:

$$P y_{P=1} = y_1$$

where: y_1= 85 mm is the value of the gap between frog nose and wing rail
$y_{P=1}$ is deflection of free and of movable frog due of unit force.

The model is loaded with two unit forces $\overline{P} = 1$ actaing at the points where switch rod acts on movable frog. After the calculation has been done, the displacement coused by unit force on free end of movable frog is obtained:

$$y_{P=1} = 2{,}73 \text{ cm.}$$

The switch force is obtained on the basis of proportation, and for case of two unit forces action in the points where the switch mechanisms act on the frog. For realization of the gap on the free end of morable frog in amount of 85 mm, the needed switch force in calculating model from the mentioned eqation has to be: P = 3114 N.

Phase II: Clinging the swing nose frog

The end phase of switching when the friction along the whole lenght of movable frog is observed. This case takes place at the moment when the peak of the frog touchs the head of the wing rail. Than the movable frog can be considered as the girder supported at one end and the other end becomes fixed, namely the displacements in X, Y i Z directions are permited, but the rotations in X, Y and Z directions are possible. As the reactive load in this case the friction between the movable frog and the baseplates appears. This load is taken as the uniform load along the whole frog length:

$$t_n = 0{,}25 p_n$$

where: 0,25 is the frictions coefficient between the base of movable frog and the plates
p_n is the weight pro unit of frog lenght for the corresponding cross section.

After the calculation is done, the reactive force of the support in the model point in the peak of the frog is obtained in amount P=229 N and this is the force needed to overcome the friction between the base of movable frog and the plates under the assumption that the friction coefficient is 0,25.

Phase III: Locking the swing nose frog

The calculating model is changing in relation to the previous model, so that both ends of movable frog become totaly fixed. The load remains the same as in the previous model. The reaction force in the peak of the frog after calculation is P = 416N.

The Second group of models

By the second group of models the supporting conditions in ist heel are changed, so one end remains fixed but the another end is made as a joint where the displacements in Y and Z directions are prevented and the displacement in X direction and the rotations in X, Y and Z directions are permitted. In such a case of supporting the switch force becomes smaller.

Phase I: Switching the swing nose frog

The loading of model remains the same as in the corresponding case of the first group of models, but the displacement of free end for the unit force after the calculation is: $y_{P=1}$=11,43 cm and the switch force is P=744N, that is essentially smaller value than in the first group of models.

Phase II: Clinging the swing nose frog

The loading of model remains the same as in the corresponding case of first group of models and the reaction in the characteristic joint of model after the calculation is P=549N.

Phase III: Locking the swing nose frog

The loading remains the same as in the corresponding case of first group of models and the reaction in the peak joint of frog after the calculation is P=688N.

Fig. 5.

3. CONCLUSION

After manufacturing the movable frog prototype of turnout type UIC60-1200-1:18,5 and its installation in the plant MIN "Turnouts" Ni{ (fig. 5), the checking of calculating models results in three characteristic phases: switching, clinging, locking, are performed. As during the modelling the friction condition of frog peak on the sliding plates is hard to determined, as well as the boundary conditions in the heel of frog (in the dilatation device) which are found between fixed end and longitudinal movable support, the results obrained in both metods (measuring on prototype and calculating the models) are considered satisfactorily accurate.

So this kind of calculation needs be the part of documentation for swing nose frog. In that way the switch force become approximately known, that is important for controlling the correct assembling on site. The exceeding of switch force value points to the faulty switch equipment. It is obvious that during turnout exploatation, attention has to be paid on perfect maintenance of switching device in frog, that includes cleaning and greasing as well as the geometrical precision in all its parts.

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MODELIRANJE POKRETNOG SRCA SKRETNICE

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U cilju osposobljavanja naših pruga za velike brzine projektovana je domaća skretnica UIC 60-1200-1:18,5 sa pokretnim vrhom srca. Modeliranje pokretnog srca skretnice je izvršeno radi proračuna sile prebacivanja a potom je u fabrici izradjen njegov prototip.