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Horizontal Forces on Crane Runway Caused by Skewing of the Crane

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Abstract. Horizontal forces between the crane and the crane runway girder occur during a motion of an overhead travelling crane on the crane runway. These forces can be caused by skewing, acceleration or braking of the crane. As a result of these forces wear of wheel rims can occur and drive ability of overhead crane can get worse. There are several procedures for determination of these horizontal loads varying both in physical model and magnitude of forces. Historically, these procedures have been developed. The first methods were based on empirical bases and experiences. The main problem of determining of these forces is a large number of factors which affect a magnitude of these horizontal forces. These factors are in addition difficult to describe, to measure etc. However, with the increasing possibilities of science and technology some methods based on a scientific and experimental basis were developed. This paper summarizes some of the methods used in past and in present and also show possibility to calculate the horizontal forces between crane runway and the overhead crane by dynamic model.

1. Introduction

Recently, new computational procedures were adopted in Czech Republic to determine the horizontal load of the overhead crane. These new procedures are largely contained in [1]. These procedures have replaced old procedures, which were described for example in [2] or [3]. However, when comparing new and former computational models and procedures, we find significant differences. In addition, if we compare the procedures of [2] and [3], we find that the calculation models and approaches to the crane acting on the crane runway also differ considerably.

Several works have been worked out on the issue of horizontal acting of the crane on crane runway – especially about skewing of crane. The aim is to determine the force effects between the crane and the crane runway. However, in solving, it is always necessary to accept certain assumptions that will allow a viable solution. The problem is that different assumptions lead to different results.

It also turned out that the physical models of crane skewing is not uniform when we compare the procedures for determination of horizontal forces of skewing from different literature. However, in present, after adoption of European standard [1] the physical model of skewing crane was exactly defined and described. This model was developed theoretically and experimentally and is described in [4-6].

This paper contains a brief description of some methods for determination of horizontal forces from skewing in past and in present. Then the paper also shows a possibility to solve the problem of



skewing crane by a dynamic model and calculation. Finally, there are compared results get from some of these different approaches.

2. Calculation of skewing forces according to national standard ČSN 730035 (no longer valid)

The calculation according to [2] is done according to the following scheme (see Figure 1):

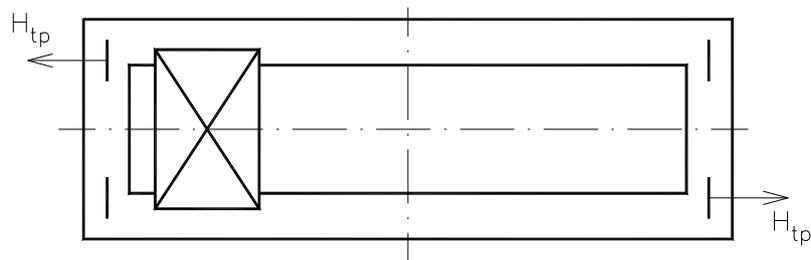


Figure 1. Scheme for calculation according to ČSN 730035

3. Calculation of skewing forces according to national standard ČSN 270103 (no longer valid)

The calculation according to [3] was taken from French sources according to the Figure 2. The scheme for calculation is for example the same like in [7].

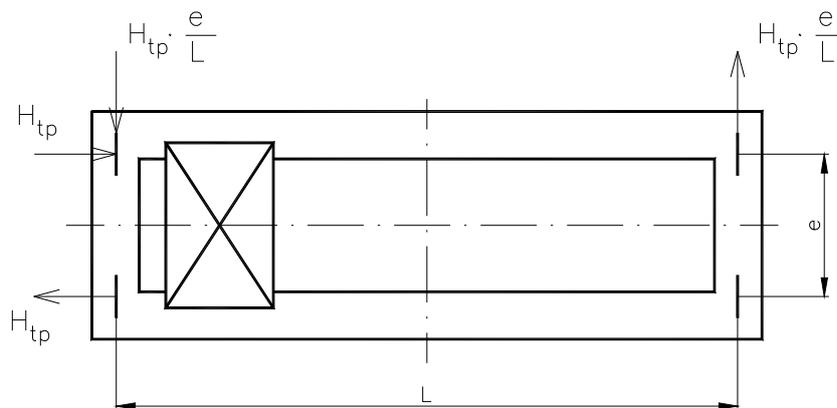


Figure 2. Scheme for calculation according to ČSN 270103

The calculation according to this procedure corresponds to the idea that one side of the crane overtakes the other side, for example due to unequal wheel pressures. The magnitude of the horizontal forces is calculated by the same formulas like in [2], so it is possible to see the incompatibility of both physical models.

4. Calculation of skewing forces according to European standard EN 1991-3

The calculation according to [1] is based on the work of Hannover [4-6] which dealt with the sloping crane running along the crane track. Based on experiments, Hannover defined the dependence between transverse forces, depending on the angle of inclination of the crane. For the calculation according to [1], the calculation includes the effect of the arrangement of the drive and crane travel. The calculation is based on the concept of the rotary motion which the crane performs as a result of the force of the first guide means. The scheme is on Figure 3:

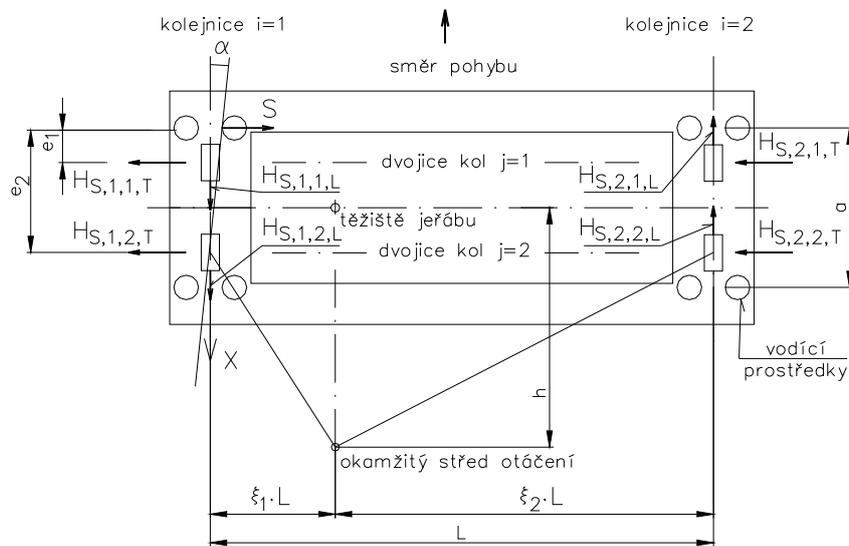


Figure 3. Scheme for calculation according to EN 1991-3

5. Calculation of horizontal forces caused by acceleration of crane according to European standard EN 1991-3

These forces doesn't belong according to [1] into a skewing. However, the computational model is similar to one in [3]. In addition, these both models also give similar results. The scheme for horizontal forces caused by acceleration of crane is on Figure 4

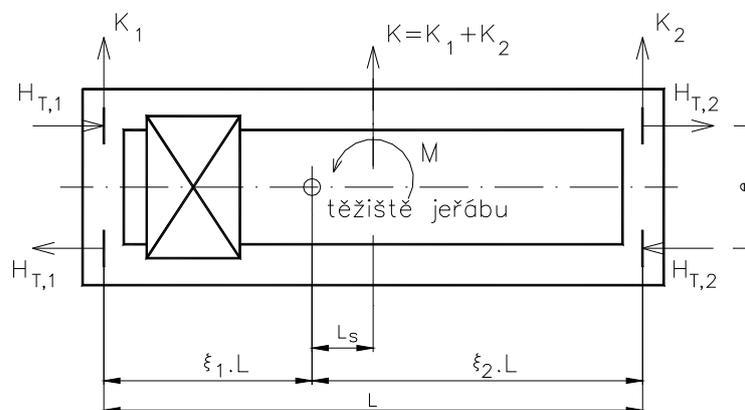


Figure 4. Scheme for acceleration of crane according to EN 1991-3

6. Dynamic model for calculation of horizontal forces between the overhead crane and the craneway

The dynamic model is similar to the model designed by Lobov in [8,9]. Designed model is like the Lobov model dynamic, but it includes the flexibility of swinging load during crane driving. The model neglects the deformation of the crane runway girders and the stiffness of the crane is taken into account by stiffness at the end of the end carriages. The model also neglects reality such as bad rail condition, clearance in mechanical crane gears, etc. The impact of load swinging during the ride of crane is included by spring attaching the load to the crane frame. Crane drives are defined by forces based on torque characteristics of driven electric motors. Figure 5 shows computational models. The

left picture applies to guide rails not touching the rails. The right picture shows the case of contact of the front guide means with the crane rail

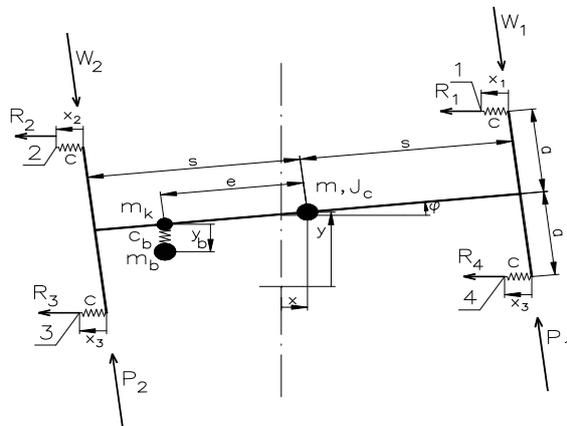
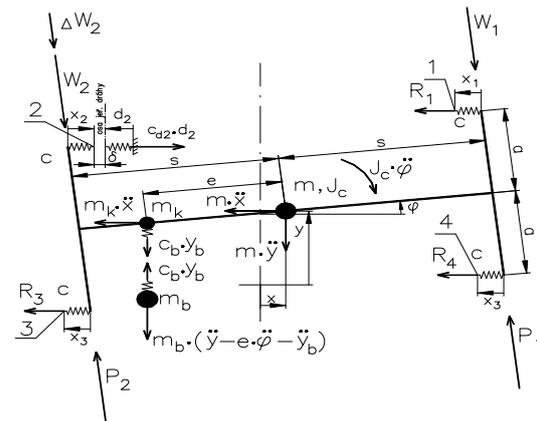


Figure 5 Dynamic model for calculation of horizontal forces between the crane and crane runway



The calculation by the dynamic model was performed for the situation where the crane was in the straight position without contacting the guide means with the rail. The crane was loaded with the load and moved to the extreme position to the crane runway. After starting the crane, the crane touches the crane track by his guide mean as a result of the rotation of the crane, and a force occurs on the guide mean. Crane parameters: load capacity 32t, span 20.1 m, wheel base 4.5m. The force (in N) between the guide mean and the crane runway in time (in sec) after the contact the guide mean and the crane runway is shown on Figure 6.

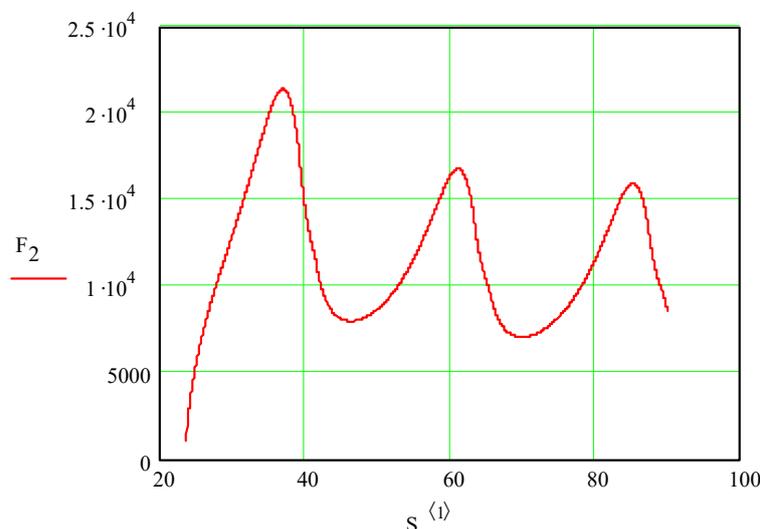


Figure 6. Force on the guide mean in time

7. Comparison of models

The models presented in chapters 2, 4 and 6 were compared. A comparative calculation was performed on 7 cranes with a load capacity 32 tons. The ratio crane span / wheel base (in further called “p”) considered in the calculation differed from 2,5 to 6,5. The force at the first wheel in direction of crane ride was calculated a compered. The contact between guide mean and rail was assumed. From

the model in chapter 6 the maximum forces were considered. The comparison is possible to see on Figure 7. The blue curve belongs to the model presented in the chapter 2, the black curve belongs to the model presented in chapter 4 and the red one belongs to the model presented in chapter 6.

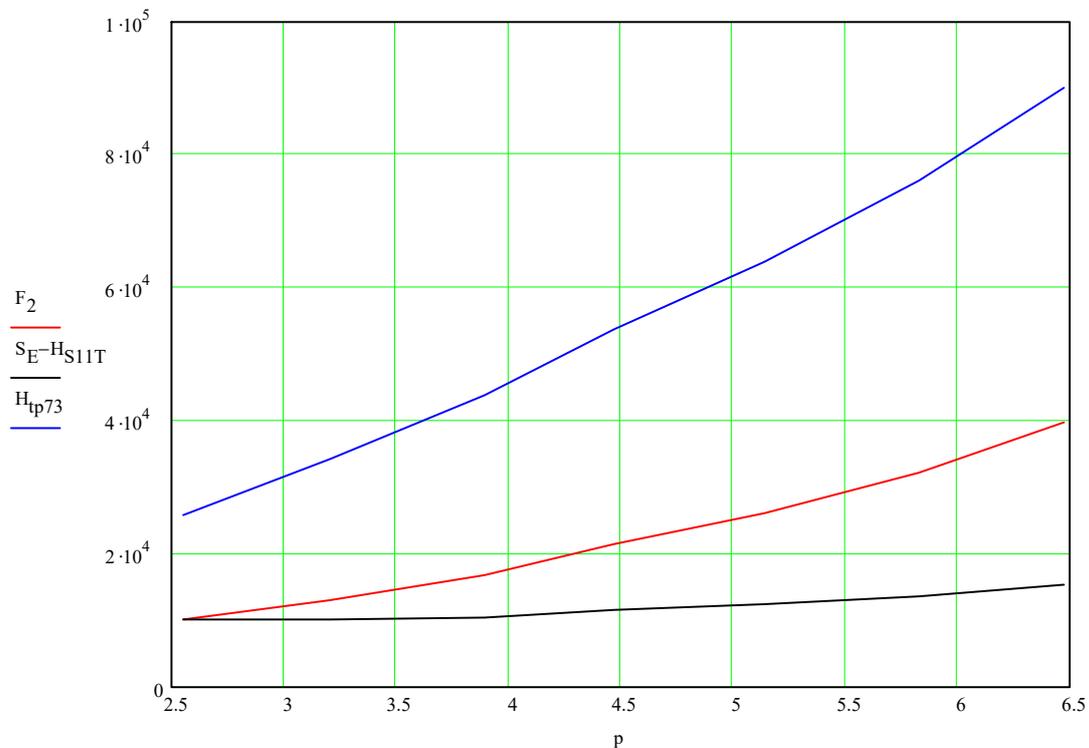


Figure 7. Horizontal forces acting on the first wheel

8. Results and discussions

It can be seen from the Figure 7 that the procedure according to [2] (blue curve) gives the highest values. The lowest value gives the procedure in [1] (black curve). It is also apparent that the magnitude of the force determined by [1] is almost independent of the “p” ratio. The red curve presents the results obtained from the model of chapter 6. It shows the dependence of the force on the ratio “p”. It is possible to see that the maximum force on the wheel grows with the increasing ratio “p”

9. Conclusions

Some models for calculation of horizontal forces from skewing were presented in this paper. The focus was put on the present physical model which is presented in present European standards and on the dynamical model which tries to describe the skewing of crane as a dynamic task by creating a dynamic model. The comparison of results got from some models was made. It was found that different procedures give different results. This issue is the subject of the further research.

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