CONSIDERATIONS ON THE IMPROVEMENT OF SUPERELEVATIONS RAMPS ON ROAD CURVES

Assistant Profesor Eng. **Dan ZAROJANU** PhD

University „Ştefan cel Mare" from Suceava

REZUMAT. Lucrarea prezintă o nouă formă de rampă a supraînălţării, obţinută din condiţia anulării totale a forţei centrifuge în orice punct al curbei progresive. Se obţine o parabolă cubică şi sunt analizate avantajele şi dezavantajele unei astfel de abordări.

Cuvinte cheie: supraînălțare, forță centrifugă, clotoidă.

ABSTRACT. This paper presents a new form of superelevation ramp, obtained from the condition of centrifugal force total cancellation, at any point of the route. It is obtained a cubic parabola and there are analyzed the advantages and disadvantages of such an approach.

Keywords: superelevation, centrifugal force, clothoid.

1. INTRODUCTION

It is known the importance of the various forces acting on the vehicle (centrifugal force, the force caused by ascending the superelevation ramp, the force caused by vehicle trajectory twisting on the progressive curve / superelevation ramp). It is also known that the most aggressive one is the centrifugal force. Actually, this is not completely canceled by road layouts, but only decreased to avoid side-slipping or overturning. [1]

This paper makes an analysis of vehicle movement on the progressive curve from the perspective of a hypothetical cancellation of centrifugal force [2]. For this purpose is presented how to build a superelevation ramp that solve this problem.

2. BUILDING THE PROPOSED RAMP

We want to build a superelevation ramp which totally cancels the centrifugal force at any point of the progressive curve. We will consider the clothoid as progressive curve, having a length determined by the limiting condition of normal acceleration variation.

The above condition means the equalization in any point on the progressive curve / superelevation ramp length of normal acceleration with the component parallel to road transverse direction of the gravitational acceleration. It will have the following form [2]:

$$\frac{v^2}{\rho}\cdot\cos\alpha = g\cdot\sin\alpha \Leftrightarrow$$
$$\Leftrightarrow \frac{v^2}{\rho} = g\cdot\frac{2h}{e} \Leftrightarrow h = \frac{1}{\rho}\cdot\frac{v^2\cdot e}{2g} \quad (1)$$

where: v is the vehicle running speed; h is the superelevation in the track center line; ρ is the curvature radius in the considered point; g is the gravitational acceleration; e is the gauge (see Fig. 1).

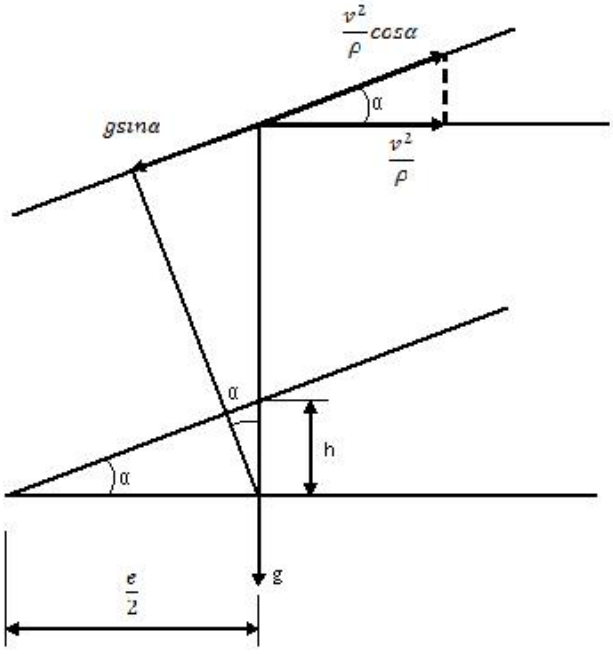

Fig. 1. The forces equilibrium in a point on the progressive curve / superelevation ramp.

But speaking of a clothoid [1], then:

$$\rho = \frac{L_a\cdot v}{\omega\cdot s} \quad (2)$$

where: L_a is the vehicle wheelbase; ω is the angular speed; s is the clothoid arc length from the origin to the considered point.

But, $\omega = \frac{v}{\rho}$ and taking account of (1), then:

$$h = k_1 \cdot \frac{s}{\rho} \cdot v^2 \quad (3)$$

where: k_1 is a constant, $k_1 = \frac{e}{2g \cdot L_a}$.

We take into account that

$$\rho = \frac{L_a}{\theta} \quad (4)$$

where: θ is the angular distance traveled by the vehicle to the considered point;

$$\omega = a_\omega \cdot t ,$$

where: a_ω is the angular acceleration; t is the time, and taking account of (3), we will have:

$$h = k_1 \cdot k_2 \cdot s^3 \quad (5)$$

where: $k_2 = \frac{a_\omega}{L_a}$ and represents a constant, if it is accepted a limit value for the angular acceleration.

3. CONCLUSIONS

• The curve obtained for the ramp superelevation form is a cubic parabola, this meaning that the superelevation required for centrifugal force cancellation greatly increases (proportional to the cube of the covered arc length). From this point of view, it would appear that very long progressive curves are not favorable, although they provide a smooth increase of the centrifugal force. It requires therefore an optimization of this length, given two opposite trends.

• Currently, the superelevation aims to avoid sideslipping and less ensuring an increased comfort, therefore the centrifugal force cancellation. Taking into account the previous conclusion, it appears that towards the end of progressive curve the comfort greatly decreases.

• When determining the superelevation ramp form from the centrifugal force cancellation condition the running speed does not interfere, this counting, thus, only to find the appropriate progressive curve. It appears that, even from this point of view, it would be necessary to find another progressive curve, possibly another clothoid, or simply another radioid.

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About the author

Assistant professor Eng. **Dan ZAROJANU** PhD
University „Ştefan cel Mare” from Suceava

Construction engineer at the University „Ştefan cel Mare“ from Suceava, teaches the Forest Roads course and the Geotechnics and Forestry Constructions course. He worked as railway construction engineer, and since 1994 he is lecturer at the University "Ştefan cel Mare" from Suceava, and since 2003 he is assistant professor at the same university. He has published numerous monographs and articles in the field of roads and geotechnics. E.mail: zarojanu214@gmail.com