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Consideration of combined water intrusion/drainage effects in the prediction of road skid resistance

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1. Introduction

Wet road friction models are currently expressed under the following form [1]:

$$\mu = \mu_{BL}.(1 - F_{HL}) \quad (1)$$

where: μ_{BL} is the boundary-layer friction coefficient; and F_{HL} is the fraction of contact area in hydrodynamic lubrication mode.

Previous models incorporated only partly in F_{HL} the effect of main influential factors like water depth (WD), speed (V), tire tread depth (TD), and road surface macrotexture (MPD). In this paper, it is assumed that:

$$F_{HL} = w(WD).w(V).w(TD).w(MPD) \quad (2)$$

where: (w) are weighting functions, varying between 0 and 1, to be determined.

The purpose of the paper is to determine F_{HL} based on physical phenomena occurring in the tire/road contact area. In particular, it makes use of recent research conducted on the relationship between tire/road friction and water depth [2].

2. Weighting function related to water depth

Experimental evidence shows that the variation of friction with water depth (Fig. 1) can be likened to a Stribeck curve, whatever the test speed [2].

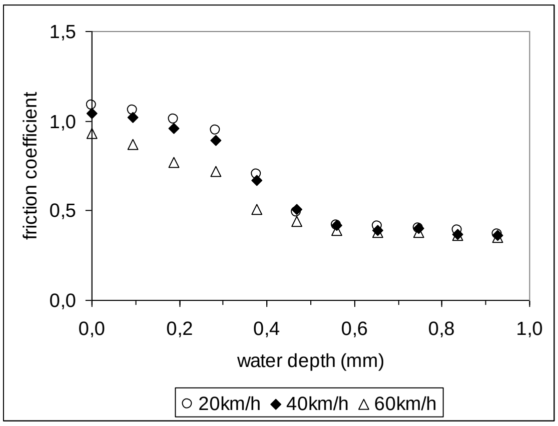

Fig.1 Variation of friction with water depth [2]

Applying formula (1), it is deduced that the weighting function w(WD) has the following form:

$$w(WD) = 1 - \exp\left(-\left(\frac{WD}{WD_{ref}}\right)^{c}\right) \quad (3)$$

where: c, WD_{ref} are constants to be determined.

3. Other weighting functions

With respect to hydrodynamic lubrication, as the speed acts as the water depth (intrusion mechanisms), w(V) performs as w(WD). Conversely, as the tire tread depth and the road surface macrotexture help to drain water, w(TD) and w(MPD) perform as (1 – w(WD)).

4. Experimental data

Full friction-slip ratio curves are measured on different surfaces - representative of French roads - of Ifsttar test track at different speeds, tire tread depths and water depths.

5. Model calibration

Figure 2 shows that the model fits fairly well experimental data, except for thick water depth (8mm) at high speed (> 80km/h) (these conditions induce mechanisms like dragging that are not considered in the model).

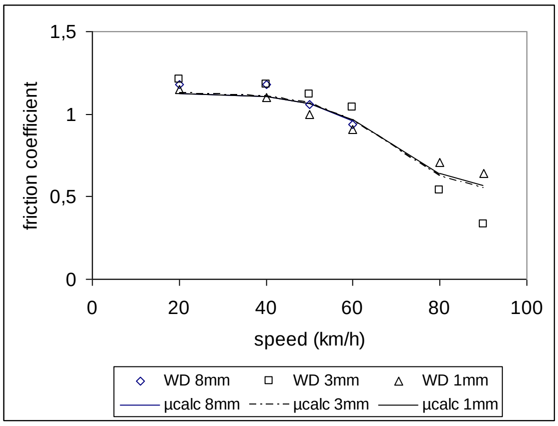

Fig.2 Model calibration

Comparison with experimental data (expressed in terms of the peak friction coefficient μ_{peak} deduced from braking tests) shows that the model predicts $\mu_{peak} \pm 0.1$ in more than 80% of cases.

6. References

[1] Veith, A. G., "Tires – Roads – Rainfall – Vehicles: The Traction Connection. Frictional Interaction of Tire and Pavement", ASTM STP 793, W.E. Meyer and J.Reichter Eds., ASTM, pp. 3-40.

[2] Do, M. T., Cerezo, V., Beautru, Y., Kane, M., "Modeling of the Connection Road Surface Microtexture/Water Depth/Friction", WOM Conf., April 14-18, 2013, Portland OR, USA.