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Mobile Laser Scanning System for Assessment of the Rainwater Runoff and Drainage Conditions on Road Pavements

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Abstract: Lack of runoff and drainage on a road surface, due to its unevenness and non optimal alignment, is a significant safety issue. In the presence of water, friction and skid resistance are markedly reduced compared with the dry value, with increasing risk of accident. An efficient maintenance programme, based on a high performance survey system, can identify the sections having the greatest risk. The technique, known as Mobile Laser Scanning System (MLS), can be a very useful tool, allowing a large amount of data to be acquired in a short time and at low cost. Based on a MLS survey, the authors used the obtained data to identify the critical issues related to drainage and water runoff, verifying gradients, evenness, proper design of the drainage elements and the surface characteristics of the pavement. In particular, they have implemented the calculation of the water depth in a GIS environment to understand the existing runoff conditions. A comprehensive analysis of the functional characteristics allows defining an appropriate maintenance. The case study demonstrated how the proposed approach can be used to rationalize operations, implement pre-emptive measures and thereby optimize timing, use of materials and road work.

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***Key words**: Maintenance; Mobile laser scanning system; Road alignment; Road drainage; Water depth.*

Introduction

Driving on wet road surface is always followed by a great risk. In fact, thick water film thickness on the pavement leads to a decrease of the available friction in the tyre-pavement contact area. In addition, the splash and spray of water, produced by the vehicle running over a flooded surface, causes the reduction of the driving visibility and this can decrease road safety.

In literature there are several research studies on the calculation of the water depth and its relationship with the geometric and surface characteristics of the pavement, that underline the effect of water on pavement structure and safety risk.

Domenichini et al. [1] presented a comparison between different water depth calculation measurements. All the formulations take into account the length of the stream line, the drainage gradient and the rain intensity; in some cases the mean texture depth is also considered.

Jeong [2] showed that the distribution of sheet flow is closely related to cross slope, longitudinal slope, rainfall intensity and road width. The analysis of sheet flow characteristics on superelevation transition areas suggests that the optimal longitudinal slope in the range of 0.3–0.4% minimizes the depth of storm-water runoff on the road surface.

Hsieh [3] investigated the profiles of surface water flow over a pervious pavement, for example a highway, during a uniform rainfall and employed a numerical technique to find the flow profiles on the pavement surface related to not only the rainfall excess, cross slope and road width but also the material and structure of the pavement.

Prevost [4] proposed a new way to estimate local water depths under the tyres as the car is running, with a direct measurement of the water droplets amount thrown from rotating tyres of the vehicle.

Moreover the safety risk is strictly related to the road friction of the pavement. Kuttesch [5] used accident and skid resistance data from the Virginia wet-accident reduction program as well as from sections without pre-identified accident or skid problems. He found a statistically significant effect of skid resistance on wet-accident rates indicating that wet-accident rates increase with decreasing skid numbers.

Beautru [6] showed the friction/water depth relationship, estimating local water depths trapped between the tyre and the road asperities and defining a so-called “critical” water depth which can be used for driver assistance systems.

Cenek [7] developed statistically relationships between rut depths and dry and wet road fatal and injury crashes on New Zealand’s state highway network.

An improper runoff of surface waters may lead to damage of the entire pavement structure. The presence of moisture combined with repeated traffic can adversely affect the performance of asphalt pavements. Moisture damage is caused by a loss of adhesion, commonly referred to as “stripping” of the asphalt film from the aggregate surface or a loss of cohesion within the asphalt binder itself, resulting in a reduction in asphalt mix stiffness [8]. Heavy traffic on a moisture-weakened asphalt pavement can result in premature rutting or fatigue cracking. The presence of moisture can also accelerate the formulation of potholes or promote delamination between pavement layers. Excessive standing water on roads surfaces can enter the surface of the asphalt mix from precipitation by gravity or hydraulic pressure from tyre action [9].

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