Overview

In order to develop better methods for managing our highway systems, the highway engineers, administrators, and economists responsible for those systems need clear and meaningful information about the pavement surface conditions. Among the numerous properties indicative of pavement condition, a measurement of the roughness provides a rich source of information to aid in the management process.

From the beginning, road roughness was viewed as a subjective quality. Thus, early efforts to develop ways to measure roughness resulted in hardware that could generate a measurement closely correlated to subjective judgements. The rolling straightedge, the Bureau of Public Roads (BPR) roughometer, CHLOE, and other devices were inventions conceived from an intuitive understanding of the physical properties of interest. As more roughness measuring devices have been developed, the focus has shifted toward objective measurements of road roughness.

Current practice in the United States concentrates primarily on two types of equipment—road meters and profilometers. Road meters, measuring the vehicle's dynamic response to the road, have a clear intuitive link to the roughness directly encountered by the road user. They reduce roughness to the simple concept of a numerical index indicative of the average level of vibration produced on a motor vehicle. Though profilometers measure a much broader range of properties by means of a recorded profile, they, too, are capable of reducing the roughness information to a single index.

The highway community is at a juncture. With the widespread practice of reducing roughness to a single index, there is need for acceptance of a common roughness index as a basis for communication and understanding. The choice of such an index must be made from those used in past practice if data bases are to be maintained. At the same time, a rational choice must weigh all the utilitarian advantages and disadvantages associated with each of the available alternatives.

On 7 Dec. 1983 an ASTM symposium on Roughness Methodology was held as a forum for presenting recent technical findings relevant to the objective measurement of road roughness. This publication contains the papers from that symposium. The first few papers describe two alternative conceptual approaches to a roughness index, both anchored in past practice. The root-mean-square vertical acceleration (RMSVA) technique described in the paper by *Hudson et al* represents the viewpoint that roughness should be quantified by an index derived from geometrical properties that have been empirically

linked to effects on road-user vehicles. The approach is attractive for its simplicity in that a road has a unique roughness value, but it does not recognize that the roughness effects on vehicles are dependent on the speed. The other papers examine the alternative approach of using a quarter-car simulation (QCS) to calculate an index based directly on vehicle response to roughness. The QCS directly replicates the behavior of road meters, such as the Mays meter on cars and trailers and the BPR roughometer. The paper by *Sayers* provides an overview of the QCS, including its history and details for performing the QCS calculations. Results are presented that link the QCS index to the ride quality of passenger cars and trucks and to the dynamic loading on pavement caused by the wheels of heavy trucks. The paper by *Watugala and Hayhoe* presents recent developments relating to an alternative means for performing calculations in a QCS that are well suited for automated profilometers. Additional background on the QCS modeling of vehicle dynamics is provided in the last paper, by *Wambold*, which is based on the 1982 Kummer Lecture.

The practical side of measuring and using roughness information is addressed in three of the papers. *Paterson and Watanatada* examine the relationships between roughness measurements from the QCS and the operating speed, with interesting findings on the limitations of travel speed because of roughness. The second paper by *Paterson* addresses the practical problems of obtaining accurate measurements of a QCS-based roughness index using road meter vehicles. The subjective evaluation of roughness is the subject of the paper by *Janoff and Nick*, which concludes that vehicle size and speed do not significantly affect subjective ratings of roads in a properly designed experiment.

The remainder of the papers address the impact of road roughness on vehicles using the roads. *Zaniewski and Butler* report on a correlation study dealing with roughness and vehicle operating costs by consideration of the fuel, oil, and tire consumption and the maintenance, repair, and depreciation costs. The effect of roughness on vehicle rolling resistance is addressed by *Lu* in a theoretical study that defines the various mechanisms by which additional energy dissipation arises from road surface roughness. Finally, the influence of roughness on the pressure distribution under a tire is analyzed in the paper by *Clapp et al.*

The technical papers published here provide additional reference material for those in the highway community concerned with roughness measurement and characterization. The editors hope that this publication will help to clarify the issues and to speed the day that a common language for roughness can be achieved. To this end, the editors acknowledge each of the authors for his contribution and the staff within ASTM responsible for organization of the symposium and publication of this volume.

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