

Use of Pavement Condition Data to Predict Vehicle Behavior

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*THE prediction of vehicle performance from pavement condition is made very frequently. The American public, equipped with a free road map from the corner service station and uninitiated in the ways of higher mathematics, deduces from this map the probable behavior of the family vehicle on a prospective road. The route of the family vacation trip is therefore usually planned so as to avoid unimproved roads and to make maximum use of the new Interstate Highway System wherever available. The pavement condition evaluation that is used in this instance is not precise, and the resulting estimate of vehicle behavior is not generally expressed in numbers of several significant figures, but it is evident that an estimate of vehicle behavior is made.

There are, however, those individuals who are interested in a more accurate evaluation of vehicle behavior. These investigators, usually dealing with problems pertaining to either highways or vehicles, generally have two main areas of interest in this regard. One group is interested in the effect of the pavement on the vehicle, whereas the other group is interested in the effect of the vehicle on the pavement.

EFFECT OF PAVEMENT ON VEHICLE

It is interesting to consider various investigations currently being conducted in which the effect of the pavement on the vehicle is of primary concern.

A detailed description of a research activity conducted by the General Motors Corporation has appeared in recent publications. This company has developed a ride simulator in which it is possible for an individual to experience the ride which a passenger vehicle would produce traveling at a selected velocity over a selected highway. An automobile body with the associated suspension system is mounted on servo units so that the effect of the highway on the wheels of the vehicle is carefully reproduced. Without leaving the laboratory it is therefore possible for these investigators to study the effect of different shock absorbers and other suspension components on the riding qualities of the vehicle, and to investigate the changes that result when these components are modified. In this case knowledge of the condition of the pavement is needed to study the riding qualities of the vehicle.

The users of both commercial and military aircraft are also interested in the effect of pavement condition on the behavior of their aircraft. Before take-off and after landing it is necessary to maneuver aircraft on pavements. Under certain conditions of pavement profile and taxiing speed it is sometimes possible to build up large amplitudes of wing vibration due to resonance of the wing structure with disturbances from the pavement. Excessive vertical motion of the wings of an airplane produces high stresses in the wing structure and is detrimental to the aircraft. Investigators in this area have therefore been concerned with minimizing these stresses and have been compelled to consider the condition of the pavement over which the aircraft moves as well as the characteristics of the aircraft. In this situation knowledge of the condition of the pavement is needed to study the response of the wing structure.

The aerospace industry has also shown an interest in pavement condition data. This industry has been charged with the responsibility for supplying ground transportation for the missiles that they manufacture. It may seem surprising, but certain types of missiles are really very fragile, and can easily be damaged when moved from one location to another. Because of this, it is usually necessary to design a special suspension system that will protect the missile from shock and vibration during the time

that it is being transported. Engineers associated with this problem are therefore concerned with pavement condition as a factor causing damage to missiles when carried by a ground transport. Less glamorous industries are also concerned with the relationship between pavement condition and damage to their products in transit.

It is also interesting to note that the effect of the pavement on the vehicle has been taken as a criterion of pavement condition by W. Drake from Kentucky. He has located accelerometers on a passenger seated in a vehicle and has measured these accelerations as the vehicle moves over the highway in question. In this case the effect of the pavement on the passenger is taken as an indication of the condition of the pavement. In passing it should be noted that theoretically it should be possible to predict the accelerations that the passenger will experience if the proper pavement evaluation information is available together with the necessary vehicle characteristics.

EFFECT OF VEHICLE ON PAVEMENT

The effect of the vehicle on the pavement has been of concern to investigators whose primary interest is the pavement itself. Just as the pavement can exert large forces on the vehicle, so can the vehicle exert large forces on the pavement. This is evident when one considers a pavement that contains large faults and potholes. Large forces can also be developed, however, when the pavement surface does not contain sharp discontinuities. Smooth undulations in the highway can result in large forces between highway and vehicle under certain conditions.

The theoretical prediction of the force that a vehicle exerts on the pavement has been undertaken by certain investigators. A mathematical model of the pavement-vehicle system has been developed at the Cornell Aeronautical Laboratory. This model makes possible the study of this problem with the aid of modern computing methods, and estimates of the force that the vehicle exerts on the highway have been obtained as well as other information.

At Purdue University the theoretical prediction of the vehicle forces exerted on the pavement has been approached in a somewhat different manner. Experimentally determined vehicle characteristics have been combined with statistical descriptions of pavements (elevation power spectra) to obtain statistical estimates of the forces (force power spectra) produced by the vehicle. Experimental measurements of these forces indicate that at the present time the predicted forces are larger than those actually encountered. This investigation also includes the measurement and prediction of stresses and deflections in the pavement resulting from these dynamic vehicle loads.

Measuring the dynamic force that the vehicle exerts on the pavement has been undertaken by several organizations including the Bureau of Public Roads, the Michigan State Highway Research Laboratories at East Lansing, and by the AASHO Road Test. A successful procedure for doing this has resulted in which continuous records of tire pressure are taken and are then converted to force measurements.

The results of both the theoretical and the experimental investigations in this area indicate that the rougher the surface of the pavement, the larger the force that is usually produced on the highway by the vehicle. It is thus evident that the condition of the pavement influences the forces to which the pavement is exposed, and it may be that the condition of the pavement is related to the amount of future service that it may give.

CONCLUSIONS

It is therefore seen that the appropriate pavement condition data can be used to estimate the effect of the vehicle on the highway as well as the effect of the highway on the vehicle. The most commonly used criterion of pavement condition for this purpose to date has consisted of highway elevation measurements, usually taken with a rod and level. The difficulties involved in obtaining and using these data to describe the condition of the pavement are obvious. This information is time-consuming and expensive to obtain and is invalid after the winter frosts have changed the pavement profiles. For many of the investigations previously discussed this information, however, has served as the sole criterion of pavement condition.

Other devices are fortunately being developed to obtain pavement condition data that

may be equally acceptable. The truck-mounted profilometer, used by Housel, has potentialities in this regard. In addition, a special profile measuring device, described at the Annual Meeting in 1962 by representatives of the General Motors Corporation, appears promising. Likewise, the AASHO slope profilometer may also be useful for obtaining pavement condition data that can be used in the investigations just discussed.

In conclusion it should be emphatically stated that there is a pressing need for a fast, cheap way of accurately measuring the characteristics of a pavement that influence the behavior of a vehicle. These measurements should be of such a nature that they can be used, together with the proper vehicle characteristics, to predict the desired vehicle performance.