IRI MEASUREMENT BY VIMS: CASE STUDY IN KENYA

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1. INTRODUCTION

Road network is an important factor to promote economic activities and also the foundation of nation-building, especially in developing countries. However, pavement in developing counties, even constructed by international aid, has been deteriorated much faster than expected, due to overloaded vehicles and improper maintenance associated with lack of budget. Thus the World Bank obligates the aid recipient to adopt proper management system to maintain their asset such as roads when they are donated by the international aid.

To accomplish PDCA cycle in road management, road assessment must be done in the Check process. In Japan, MCI is usually used for road assessment but in developing counties International Roughness Index (IRI) is widely accepted. IRI is originally proposed by the World Bank for developing countries but getting a standard index for road assessment in the world. IRI, which is a kind of index to represent riding comfort, can be defined as cumulative displacement of QC model at an interval of 200m. In general the systems to obtain IRI can be classified into four classes according to its accuracy. Most of the systems used in developing countries are Class 3 system where vehicle responses are converted into IRI. So far conventional systems based on axle displacement are widely adopted but IRI measurement has been hardly implemented partly because the conventional system is still relatively expensive and limited to specific vehicles, and it takes much time to install the system to the vehicle.

To overcome such limitations, VIMS(Vehicle Intelligent Measurement System) has been proposed by the University of Tokyo. VIMS simply requires an accelerometer and GPS installed inside the vehicle and then IRI can be obtained by any vehicle after the vehicle is calibrated. In February 2012, joint research team of Kyoto University and the University of Tokyo visited Kenya to have workshop with KeNHA (Kenya National Highway Authority) and the other organizations of urban and local road authorities. The purpose of this workshop is to introduce VIMS to them, because KeNHA plans to conduct road assessment such as IRI measurement over 14,909km of national and provincial roads and they have much interest in VIMS for its simplicity and easiness. Herein we report on the workshop and demonstration of VIMS including IRI measurement on A104 national road from Nairobi to Nakuru.

2. VIMS

VIMS estimates IRI through the measurement of acceleration responses of a vehicle driving at a constant speed[1]. Measured acceleration is first converted from the time domain to the distance domain using GPS record synchronous with the acceleration record. The next step is to estimate IRI from the distance domain acceleration. The vehicle response is multiplied, in the spatial frequency domain, by a transfer function from the vehicle acceleration to QC sprung mass acceleration. While the transfer function can be obtained in several calibration approaches, this case study employs one using portable humps. By comparing responses of vehicle driving over the humps with corresponding simulation of a vehicle model, its mechanical characteristics and the transfer function are assessed. As RMS (Root Mean Square) of sprung mass acceleration correlates strongly with IRI, the regression line between these two quantities is utilized to convert RMS of sprung mass acceleration to IRI.

One of difficulties in this case study is the limitation of constant speed driving. Because the transfer function depends upon driving speed, change in driving speed results in IRI estimation error. Even when traffic is not heavy, keeping a constant speed over a long distance is not easily achieved. As this case study involves road evaluation of hundreds of kilometers, the constant speed limitation is critical. To remove this limitation, the average driving speed for each evaluation distance of 200m is estimated from the GPS record and the corresponding transfer function is estimated and employed[2]. Transfer functions at several driving speeds ranging target driving speeds are first experimentally obtained by driving a test course of about 1km at these speeds and then they are interpolated to obtain the transfer functions at specific driving speeds.

3. WORKSHOP IN KeNHA

On February 21st in 2012, the workshop was held in KIBIT (Kenya Institute of Highways and Buildings Technology) as shown in Figure 1. Before the workshop, VIMS was installed on a vehicle and the vehicle was calibrated to identify its response characteristics by hump calibration test (Figure 2) in M&T (Material and testing) and its speed dependency by speed calibration test. In this workshop 51 officers from MOR, KRB, KeNHA, KURA, KeRRA, KWS and JICA were participated. First, the installation and measurement was demonstrated by joint team and then participants discuss the feasibility of VIMS in Kenya. In the discussion, the officers had question about how to

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identify pot holes by VIMS and about the feasibility of measurement at quite a low velocity, because in Kenya pot hole is one of the serious distresses of pavement and also they have serious traffic jam in Nairobi city. Even in rural area, pot holes or humps for crossing pedestrian may reduce the velocity of vehicles. As for the low velocity, VIMS has little limitation in velocity and IRI can be obtained even at any speed in the range of calibrated speed. So far 30km/h is the lowest boundary of velocity and the reliability of the results at low speed less than 30km/h is not ensured, but this limitation will be resolved by modify the system in the next stage. Anyway the practical issues on VIMS revealed in this workshop will be resolved in the further research.

Figure 1. Workshop on VIMS in KIBIT

Figure 2. Calibration test in M&T

4. IRI MEASUREMENT NAIROBI TO NAKURU

Finally we conducted IRI measurement by VIMS on A104 national road from Nairobi to Nakuru and also some provincial roads in Nakuru municipal. Measurement was implemented without any significant trouble, even for rural area where larger IRI was confirmed. Figure 3 shows the results of IRI plotted in Google earth. In this figure, the location of each measurement point as well as its degree of IRI can be clearly identified: the number besides the plot is the value of IRI and its color indicates the degree of IRI. Figure 4 also shows the magnified view in Nakuru national park of unpaved roads.

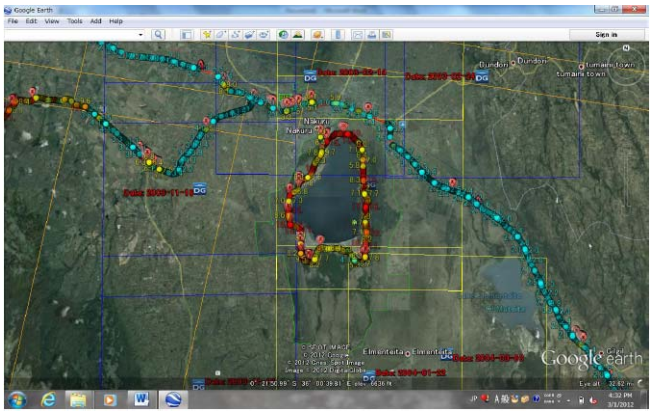

Figure 3. IRI mapping in Google earth

Figure 4. Unpaved road in Nakuru National Park

5. SUMMARY

Though the workshop and practical measurement in A104 road, the feasibility of VIMS in Kenya was confirmed. However several practical issues related to pot holes and speed limitation were also clarified. For further development, these issues should be resolved to apply VIMS to the road assessment in developing countries.

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