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Integration of Pavement Layer Evaluation Using LWD for Road Safety Control

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Abstract

As one of Thailand transport policies currently aims to reduce the death rate of road and traffic accident, the Department of Highways authorities shall involve and raise awareness of the road construction quality control and its long-term performance. Light Weight Deflectometer (LWD) is gaining acceptance and popularity over years as the pavement and transportation geotechnics community is currently moving toward more mechanistic-based design and quality control evaluation of pavement layers and fill embankment. In this study, the LWD was used to measure the surface deflection, d, and elastic modulus, E_{LWD}, of pavement layers over 11 highway construction sites in Thailand as well as to evaluate for the feasible adoption by Thailand Department of Highways as a construction quality control device on the routine basis. A range of d and E_{LWD} values for four major types of pavement materials commonly used in Thailand highway construction including crushed rock base, soil-aggregate subbase, selected material, and subgrade was reported. The coefficient of variation of the d and E_{LWD} of these pavement materials ranged from 58 to 77% and 49 to 65%, respectively. Such large variability can be explained due to the test site, material, testing configuration, moisture content, density, and compacted thickness. The correction factor applied for different test configurations was also proposed for practical implications. Finally, the number of empirical relationships between the measured values from the LWD and basic properties of various pavement materials indicated that they were generally in agreement with the conceptual relationships. The LWD device was found to be a quick test for direct measurement of pavement surface deflection and layer moduli and it was also simple to operate on any pavement layers. Therefore, increasing frequency of quality control tests can be anticipated, resulting in an improvement in the overall quality of compacted pavement layers and its long-term performance.

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Keywords: light weight deflectometer; surface deflection; elastic modulus; pavement layer; highway construction

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1. Introduction

Current situation of road safety in Thailand was found to be the world's second highest road fatality rate. The death rate was 36.2 per hundred thousand people according to Global Status Report on Road Safety (2015). Reducing road and traffic accidents is becoming one of Thailand transport policies by Ministry of Transport (MOT) with the target death rate of less than 10 per hundred thousand people by 2020. To meet the MOT policy, many studies on road safety were conducted. In particular, a study on factors associated with the road accident for a given median type was explored through the investigation of accidental data, death records, roadside characteristics, traffic volume, percentage of heavy vehicles etc. Results suggested that road conditions, roadside characteristics, traffic volume, and road user behaviors were four key elements that associated with the road accident for a given median type. Obviously, one effective approach is to improve road condition to accommodate the road users. As the Department of Highways (DOH) is the main authority that is responsible for road's quality and service life, the DOH authorities shall involve and raise awareness of the road construction quality control and its long-term performance. Therefore, our expected goal is to improve the road condition for public benefits, especially the most vulnerable road users e.g. pedestrians, bicyclists, and motorcyclists. Safety-conscious planning, design, construction, and maintenance assure regular road assessment for safety control.

Alternative devices for in situ assessment of mechanical properties and quality control evaluations of highway construction practices such as Light Weight Deflectometer (LWD), Soil Stiffness Gauge (SSG), Dynamic Cone Penetrometer (DCP) are currently available in the transportation geotechnics community. In Thailand, such devices become more beneficial for in situ stiffness and strength assessment of pavement materials during highway construction [1], [2], [3], [4], [5]. This paper explores an extensive field study of LWD for assessing in situ elastic modulus of pavement layers from over 11 highway construction sites in Thailand. A range of surface deflection and elastic modulus of compacted layers registered by the LWD is reported and the correction factor applied for different test configurations is proposed for practical implications. The number of empirical relationships between the measured values from the LWD and basic properties of various pavement materials are presented. Finally, the possible adoption by Thailand Department of Highways as a construction quality control device on the routine basis is discussed.

2. Light Weight Deflectometer

A Light Weight Deflectometer (LWD) [6] is a non-destructive and portable device used to measure the in situ elastic modulus of pavement layers and fill embankment. The LWD is primarily used for construction QC/QA and can be used for soil subgrade evaluation prior to pavement design (mechanistic approach) and design verification. It consists of a 10 kg (22 lb) standard drop mass with an adjustable drop height ranging from 0.1 to 0.9 m. The impact force imparted by the drop mass is buffered by elastomeric pads, which produces a pulse load up to 15 kN. The applied force is measured by a built-in load cell while the surface deflection is measured by an integrated center geophone in direct contact with the ground through varied loading plates of 100 mm (4 inches), 200 mm (8 inches), and 300 mm (12 inches) in diameter. Additional geophones can be also used for spectrum response. The LWD interfaces with a handheld PDA device outputting the time history of layer response to applied impulse load in term of deflection (d). The LWD software uses the stress distribution factor (f) of 2.0, which implies a uniform plate-ground contact stress distribution (e.g. flexible plate) and Poisson's ratio (ν) of soil to estimate elastic modulus of compacted materials based on the elastic solution as follows:

$$E_{LWD} = \frac{f\sigma_o r(1-\nu^2)}{d_o} \tag{1}$$

where E_{LWD} = elastic modulus of pavement layer (MPa); σ_o = maximum contact stress (MPa); d_o = maximum surface deflection at center of loading plate (mm); and r = radius of loading plate (mm).