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Comparison Study of Overlay Design for Pavementusing Light Weight Deflectometer and Benkelman Beam

Engineering

KEYWORDS : Light Weight Deflectometer, Overlay Design, Pavement Layer Modulus, Non-Destructive.

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ABSTRACT

Pavements are one of the most crucial factors to connect the society. Health of the pavements is not assessed from time to time and it results in their poor performance not only leading to many accidents but also increased running cost. The condition of pavement gets deteriorated as time passes unless maintenance is properly done. The reason behind the negligence of pavement maintenance is lack of availability of the required scientific tools or the difficulties faced in using the available tools. Light Weight Deflectometer, shortly called as LWD is a modern tool which can be used for in-situ evaluation of pavements thereby overlay design can be reliably done. Light Weight Deflectometer is a recently developed handheld, portable and user friendly device which determines the pavement layer modulus and also generates the overlay design thickness. Various correlation studies with other non-destructive road testing devices have been done worldwide and proposed that the LWD is very useful for construction quality control and assurance purposes. The primary objective of this study is to investigate the pavements of the entire campus of Government College of technology, Coimbatore and determining overlay design using LWD and comparing the results obtained with Benkelman Beam.

INTRODUCTION

Deflection measurements of pavements are used to do its analyses for the purpose of rehabilitation design as well as for network monitoring of pavement networks. The conventional equipment like the Benkelman beam was used extensively in the past and various empirical relations were developed for analysis and overlay design. The extensive use of the modified Benkelman beam, the road surface deflectometer coupled with the use of the in depth deflection measurements with the multi-depth deflectometer (MDD), helped to give credibility to the back-calculation of elastic moduli with various multi-layered linear elastic computer models. The test programme helped to correlate such back-calculated elastic moduli with pavement performance and deterioration modeling and helped to increase the credibility and use of back-calculated elastic moduli derived from surface deflection measurements. The device has different versions due to different manufacturers and different country of origin, but they are very similar in principle. The one that is used in this research is the Dynatest LWD 3031.

OBJECTIVE

The main objective of this study is to investigate the pavements of the entire campus of Government College of Technology, Coimbatore by dividing them into 4 groups namely A,B,C and D comprising of 19 different sections and conducting LWD tests over 120 different locations.Using the LWDmod software, elastic modulus of the existing pavements is determined and overlay thickness has been designed.Benkelman Beam test has also been conducted following IRC 81 – 1997on the entire road network to design the overlay. The design results obtained from both the methods are compared.

LWD

Deflectometer devices are dynamic non–destructive testing tools commonly used in the field of pavement systems to measure a layer or surface modulus. Among the various testing devices used for non-destructive insitu assessment of pavement layers the Light Weight Deflectometer (LWD) has become the focus of increasing interest.

The device is easy to handle and is an alternative to plate load tests, enabling rapid measurements without disturbing the soil. It weighs 26 kg in total with a 10, 15 or 20 kg falling mass that falls on the bearing plate via four rubber buffers. It can be used on all construction sites and materials. It consists of up to three sensors with the associated electronics, which measure deflections. The electronic equipment in the LWD is dust-proof and watertight for safe outdoor use. A load cell is mounted by rubber buffers over which the load falls. Falling weight (sliding hammer), varies from 10kg to 20kg. It has a rechargeable battery pack, providing approximately 2000 measurements or, the equivalent of more than twelve hours of continuous operation. Also, a trolley is provided to move the instrument to various locations.

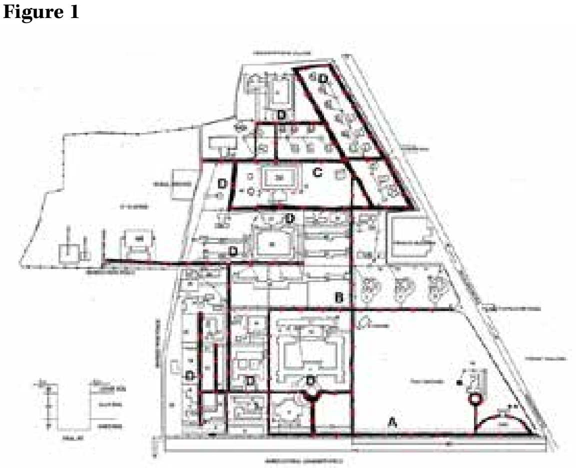
FIELD STUDY

Field investigation is carried out extensively to determine the health of the pavement of road network at Government College of Technology, Coimbatore.GCT campus road network were selected as the area study for overlay design.Government College of technology, Coimbatore being an educational institution is spread over an area of about 45 acres. It has more than 45 buildings scattered in the entire campus which comprises of administrative building, various departments, laboratories, library auditorium, hostels and staff quarters. Taking the pavement from Main Entrance to Power House as the central axis, southern side of the road consists of institutional buildings and northern side of the axis comprises of hostels and staff quarters. For connecting them, there is a network of pavements running throughout the campus. Most of the pavements being not maintained from a longer time are worn out partially or completely. LWD and Benkelman Beam tests were carried out on these pavements inside the campus. Since there is a not much of the heavy traffic inside the campus, pavements are assumed to carry light traffic.

LWD TEST

LWD was taken to the identified locations and tests were carried out. Pavements analyzed and test locations are shown in the Figure 1.

Figure 1



LWD test, as shown in figure 2 was conducted at each location by releasing a 10,15 or 20 kg hammer from a certain height. Impact load imposed to the plate was measured by a load cell and the resulting deflection was measured by a geophone sensor mounted at the bottom of the plate.

Figure 2

SOFTWARE ANALYSIS

The field test inputs were recorded in PDA and then analyzed using LWDmod software. Field data collected in the PDA was first transferred to LWDmod software using which the elastic modulus of the pavement is determined and overlay thickness was then designed.Based on the FEM/LET/MET module from ELMOD, LWDMod provides an ideal analysis package for the Light Weight Deflectometer. LWDmodsoftrware window is shown in Figure 2. The LWD is very versatile and has been used directly on subbases, subgrades, trench restorations; trial pits, and recycled materials bound by foamed bitumen.

Figure 3

BENKELMAN BEAM TEST

The Benkelman Beam developed at the Western Association of State Highway Organizations (WASHO) Road Test in 1952, is a simple device that operates on the lever arm principle. The Benkelman Beam was used with a loaded of 8170kg on a single axle with dual tires inflated to 75 psi. Measurement is made by placing the tip of the beam between the dual tires and measuring the pavement surface rebound as the truck is moved away (Figure 4). Starting, intermediate and final deflection readings have been measured at 0, 2.7 and 11.4 mts interval.

Figure 4

RESULTS AND DISCUSSION

The overlay design values obtained from Benkelman Beam as well as LWD have been tabulated. The results obtained are discussed based upon which conclusions are made.

OVERLAY DESIGN BY LWD

The data obtained using PDA were fed into the software and the results are analyzed using LWDmod and it suggested the following overlays.

Table1.Overlay design for each stretch of the pavement by LWD

Road Stretch	COORDINATES	Design Overlay (mm)
A	11.017634,76.939849 to 11.01720,76.935311	90.27
B	11.019365,76.938637 to 11.019222,76.934539	191.17
B	11.017406,76.934523 to 11.019917,76.934469	145.40
C	11.01720,76.935311 to 11.019222,76.935198	156.50
D	11.017190,76.936899 to 11.021233,76.936550	182.71
D	11.017917,76.934050 to 11.017911,76.936534	169.17
D	11.017996,76.935917 to 11.017148,76.935966	172.43
D	11.018675,76.935150 to 11.018685,76.934635	125.33
D	11.017474,76.934050 to 11.019586,76.933934	172.00
D	11.017838,76.934276 to 11.018385,76.934276	148.20
D	11.019960,76.933643 to 11.020007,76.935805	163.00
D	11.020786,76.937645 to 11.020776,76.934485	177.57
D	11.021129,76.937462 to 11.021655,76.934018	152.75
D	11.022008,76.936588 to 11.022466,76.935700	174.33
D	11.020965,76.936679 to 11.022755,76.935574	164.25
D	11.021729,76.934657 to 11.022192,76.934646	177.00
D	11.021797,76.935032 to 11.022350,76.934936	167.67
D	11.017753,76.938908 to 11.017187,76.939093	153.50
D	11.017208,76.939718 to 11.017235,76.939243	154.63

OVERLAY DESIGN BY BENKELMAN BEAM

The deflection values obtained by the dial gauge of Benkelman Beam are applied with suitable corrections and the characteristic deflection has been obtained. Overlay design has been done based upon the characteristic pavement deflection using design curves as per IRC 81-1997.

Table 2.Overlay design for each stretch of the pavement by Benkelman Beam

Road Stretch	COORDINATES	Design Overlay (mm)
A	11.017634,76.939849 to 11.01720,76.935311	112.41
B	11.019365,76.938637 to 11.019222,76.934539	213.29
B	11.017406,76.934523 to 11.019917,76.934469	168.01
C	11.01720,76.935311 to 11.019222,76.935198	171.84
D	11.017190,76.936899 to 11.021233,76.936550	197.38
D	11.017917,76.934050 to 11.017911,76.936534	191.33
D	11.017996,76.935917 to 11.017148,76.935966	188.94
D	11.018675,76.935150 to 11.018685,76.934635	142.64
D	11.017474,76.934050 to 11.019586,76.933934	196.83
D	11.017838,76.934276 to 11.018385,76.934276	172.93
D	11.019960,76.933643 to 11.020007,76.935805	181.34
D	11.020786,76.937645 to 11.020776,76.934485	203.12
D	11.021129,76.937462 to 11.021655,76.934018	174.71
D	11.022008,76.936588 to 11.022466,76.935700	195.72
D	11.020965,76.936679 to 11.022755,76.935574	189.91
D	11.021729,76.934657 to 11.022192,76.934646	193.74
D	11.021797,76.935032 to 11.022350,76.934936	191.37
D	11.017753,76.938908 to 11.017187,76.939093	174.02
D	11.017208,76.939718 to 11.017235,76.939243	181.16

- It is clearly observed from the analysis that most of the studied pavements are needed to be overlaid.
- As per LWD, maximum overlay of 191.17 mm and minimum overlay of 90.27 mm is recommended whereas Benkelman Beam recommends maximum overlay of 213.29 mm and minimum overlay of 112.41 mm.
- Group B being the central axis road of the campus and most often used shows a high value of overlay design whereas Group A being the road to be used least has a low value of overlay design.

CONCLUSION

- LWD has a usability to design the overlay thickness of the pavement where pavements are worn out.
- The Benkelman Beam is low cost but is also slow and labor intensive.
- Pavements of GCT Campus have been identified to be provided with overlay and the overlay thickness has been designed using LWD and Benkelman Beam.
- Overlay design done by using Benkelman Beam gives an elevated value when compared with the one designed using LWDmod.
- Elastic Modulus obtained by the LWDmod can be used to determine the field CBR which in turn can be used for designing a pavement.
- Reliability of LWD for in-situ assessment of pavements is acceptable to an extent which can prove to be an effective tool in the field of geotechnical engineering.
- LWD can be used for QA/QC for pavements.

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