PAVEMENT WIDENING AND OVERLAY DESIGN BY USING FALLING WEIGHT DEFLECTOMETER

Saurabh Kumar Yadav[1]

[1]*M.TechStudent, Department of Civil Engineering, Mewar University.*

Abstract - *Establishing the characteristics of the pavement material and its structural capability is a prerequisite for creating effective maintenance and management strategies for pavements. Studying how the pavement reacts to the imposed weight will help with this. By examining the deflection in response to the load applied at specific spots along the highway, the Falling Weight Deflectometer (FWD) and KGPBACK were used in this study to assess the performance of a road portion of the State Highway (KUNOL RELLAVADA ISARI) in the Indian state of Gujrat. An existing pavement was subjected to a dynamic load using FWD, and the pavement's response to the load was measured.The KGPBACK programme used the deflection values so acquired to calculate the elastic moduli of the modelled layers of the pavement.The IITPAVE software then used the discovered in-situ elastic moduli to build the pavement's overlay. In order to conserve and manage the Indian Highway Road network, administrators could employ the study presented in this paper's guidelines methodology.*

Key Words: Pavement, Remaining life, Bituminous, FWD, KGPBACK, IITPAVE, IRC-115-2014.

1.INTRODUCTION

The Indian government sees the nation's road system as essential to its economic and social development. Because of this, significant investments have been made in recent years to promote the growth of India's road networks, making them one of the largest in the world today. A collection of geophones spaced at various radial distances measure the pavement's deflection shape using a FWD impulse loading device, which applies a transient impulse load to the pavement surface. The elastic moduli of the various pavement layers are estimated, together with the in-service life of the pavement, on top of the bituminous coating of the present road. The FWD tests have been carried out in accordance with the IRC: 115- 2014 "Guidelines for structural evaluation and strengthening of flexible road pavements using Falling Weight Deflectometer (FWD) Technique". Using a suitable analysis technique and the KGPBACK software, the surface deflections obtained from the FWD testing were used to back-calculate the in situ material properties. The deflection values estimated for specific assumed elastic moduli values are compared with the observed deflection values in KGPBACK using an iterative process. Using the IITPAVE program, the elastic forecast the appropriate overlay design.

1.1 Principle

A falling mass in the range of 50 to 350kg is drop ped from a heigh to fall in the range of 100to600mm to produce load pulses of desired peak load. The corresponding peak vertical surface deflections at different radial ocations are measured and recorded. A sufficient number of deflection transducers shall be used to adequately capture the shape of the deflection bowl. Six to nine velocity transducers (geophones) are generally adequate.

A peak load of 40 kN (+/-4 kN) and pulse duration of 20-30 ms is required for flexible pavement. The target peak load of 40 kN (+/- 4 kN) applied on bituminous pavements corresponds to the load on a dual wheel set of an 80 kN standard axle load and a duration of 20-30 ms simulates traffic moving at a speed of 60 kmph. If the applied peak load differs from 40 kN within the above-mentioned range, the measured deflections have to be normalized linearly during the analysis to correspond to the standard target load of 40 kN.

1.2 Falling Weight Deflectometer

According to the FWD's guiding concept, deflection in a pavement structure caused by a vertical load is measured. A 300 mm diameter plate with springs installed on it and resting on the pavement receives a weight that is dumped onto it. Due to the springs' properties, the load pulse caused by a falling object is similar to the loading of a turning wheel. The load exerted on the pavement surface is measured using a load cell that is installed immediately on top of the loading plate. The deflections are directly obtained and recorded while the geophones measure the pavement's velocity

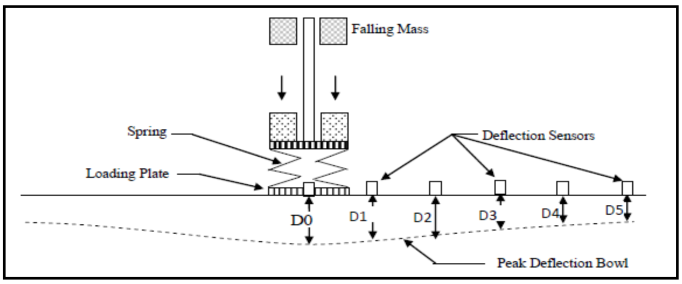
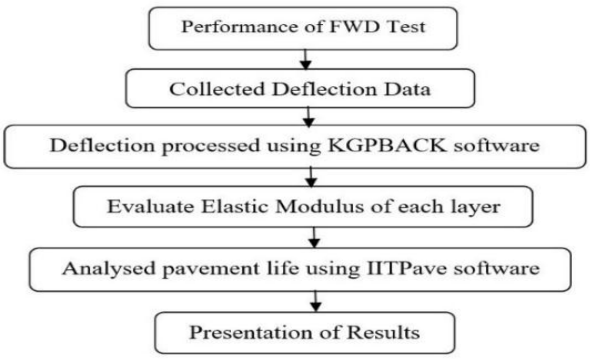


Fig 1. Working Principle of Falling Weight Deflectometer

The deflections measured at 6 geo-phonic sensors are located at 0, 300, 600, 900, 1200, and 1500 mm radial distances, respectively, at the flexible pavement section. The guidelines for the selection of the deflection point along the homogenous sections were selected based on the pavement condition data.

2. METHODOLOGY



3. ANALYSIS OF FWD DATA

Surface deflection measurements have been scaled to a load of 40 kN. The elastic moduli of the various layers of the existing pavement are back-calculated using an appropriate back-calculation technique along with other inputs like the radial distances at which deflections are measured, layer thicknesses, Poisson's ratio values of the various layers, applied peak load, and loading plate radius.

Table-2 Raw Data obtained from FWD

Side	Chainage	Peak Load Applied (KN)	Peak Deflection (micron) observed at a distance (mm) of					
			0	200	300	600	900	1200
LHS	0.000	40.7	313.37	235.74	175.03	86.00	40.09	6.64
LHS	0.130	40.3	309.73	240.65	178.85	84.08	36.81	6.19
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
LHS	10.400	41.9	304.71	226.07	171.33	79.32	32.52	7.48
LHS	10.530	41.7	313.06	224.13	171.14	80.06	32.60	8.88
RHS	0.065	40.0	316.72	256.19	161.84	73.36	28.57	6.76
RHS	0.195	40.5	361.47	221.30	155.65	63.03	19.72	10.08
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
RHS	10.465	41.3	295.44	256.04	186.18	89.88	42.27	4.74
RHS	10.595	42.0	298.21	257.70	188.99	90.47	40.69	7.06

3.1 Back Calculation Process

IRC-115:2014 standards for back-calculation advocate using KGPBACK, a special variant of the BACKGA program created by the Transportation Engineering Section of IIT, Kharagpur.

3.1.1 KGPBACK Inputs:

Table-3 Parameters for KGPBACK

Parameters Values	Values
Single Wheel Load (N)	40000
Contact Pressure (MPa)	0.56 (As per IRC: 115-2014 and IRC 37-2012)
Number of Deflection Measuring Sensors	6
Radial distance (mm)	0, 200,300, 600, 900, 1200
Measured Deflection (mm)	Normalized deflection obtained after normalization of field data
Poisson's ratio values	0.5,0.4,0.4 (Bituminous layer, Granular layers & Subgrade as per IRC 115-2014)
Moduli range of layers	BT Layer (750 to 3000 MPa)
	Granular Layer (100 to 500 MPa)
	Subgrade (20 to 100 MPa)

3.2 Temperature Correction

Following Temperature corrections were applied as per the below equation based on IRC 115 Clause (6.4.2).

$E_{T1} = \lambda E_{T2}$

Where,

λ= Temperature correction factor isgiven by,

T_1=Standard Pavement Temperature recommended at 35°C

T_2=Pavement Temperature at time of Testing

$$\lambda = \frac{(1-0.238\ln(T_1))}{(1-0.238\ln(T_2))}$$

3.3 Correction for seasonal variation

Following Correction for seasonal variation were applied as per below equation based on IRC115 Clause (6.5.2).

Correctionfactors for sub grade	Correction factors for Granular layer
E_{sub_mon}=3.351 ×(E_{sub_win}) $^{0.7688}$ – 28.9	E_{gran_mon}= 10.5523×(E_{gran_win})$^{0.624}$ – 113.857
Esub_mon=subgrademodulus in monsoon (MPa) Esub_win=subgrade modulus in winter (MPa)	Egran_mon=granularlayermodulus in monsoon (MPa) Egran_win=granularlayermodulus in winter (MPa)

3.4 Back Calculated Moduli

The following deflection values are Back Calculated using KGPBACK Software.

Table-4 Deflection values

Existing Chainage (Km)	Lane Position	Temperature Corrected Bituminous Layer (E1) Mpa	Seasonal CorrectedGranular Layer (E2) Mpa	Seasonal Corrected Subgrade Layer(E3) Mpa
0.000	LHS	1157.57	75.25	86.65
0.065	RHS	1010.21	75.25	86.56
0.130	LHS	1060.07	74.79	86.56
0.195	RHS	1097.06	80.53	86.65
-	-	-	-	-
-	-	-	-	-
-	-	-	-	-
10.400	LHS	1100.24	79.73	86.65
10.465	RHS	1075.62	73.86	86.65
10.530	LHS	1085.98	75.60	86.56
10.595	RHS	875.75	74.33	86.56

3.5 Delineation of Homogenous Section

Homogeneous sections are taken based on previously submitted reports and crust thickness as mentioned in below table 5.3. After applying the required correction,15 percentile corrected E moduli values are taken considering the homogeneous section as per **Clause (6.2) IRC-115-2014.**

Table-5 Corrected E-value

Homogeneous section	Chainage		15 percentile modulus,Mpa			Layer	
	From	To	Bitumious layer	Granularlayer	Subgrade	Bituminouslayer	Granular layer
HS-1	0.000	1.430	1038.07	74.33	86.56	95	450
HS-2	1.430	4.160	982.08	73.40	86.56	95	450
HS-3	4.160	7.000	996.26	74.00	86.56	95	450
HS-4	7.000	9.600	973.21	72.93	86.56	95	450
HS-5	9.600	10.600	1043.63	73.98	86.56	95	450

3.6 Check for Fatigue and Rutting Criteria:

The following equations are used for calculationsasperIRC-115-2014:

$N_F=2.021x10^{-4}x[1/e_t]^{3.89}x[1/E]^{0.854}$

$N_R=1.41x10^{-8}x[1/e_z]^{4.5337}$

4. CONCLUSIONS

IRJET Falling Weight Deflectometer (FWD) is considered to be the most appropriate equipment as it is possible to simulate closely the loading conditions of a moving wheel. This study uses the key characteristics of KGPBACK and IITPAVE to forecast the overlay that will be applied over the current pavement of the Major District Road in the Indian state of Gujrat.

In this investigation, pavement deflection measurements were made using the established FWD system on five selected sections that were categorized as H-1, H-2, H-3, H-4, and H-5 based on the state of the pavement.

Through the use of the KGPBACK software, the deflection data were used to determine the elastic moduli of each layer. With the aid of the IIT PAVE programme, the overlay was predicted

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