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A RESEARCH ON STRUCTURAL EVALUATION OF FLEXIBLE PAVEMENTS USING FALLING WEIGHT DEFLECTOMETER

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***Abstract*- For flexible pavement Overlay design processes, the new Mechanistic-Empirical Pavement Design approach relies heavily on the material stiffness, back calculated from the deflection measurements taken from existing pavements. These measurements are typically made using Falling Weight Deflectometer (FWD). In order to provide high quality and consistent material stiffness data for the Mechanistic-Empirical Pavement Design the deflection results obtained at radial distance in between 0 and 1800 mm through geophone in FWD is highly useful. This research sought to examine the remaining life in FWD testing, analysis procedures and its research findings at national and international scenario. The deflection value obtained from FWD load application is directly used to estimate the structural and function condition of pavement is highlighted. Back calculation methods, correction to seasonal variations and calibration of FWD are not reviewed.**

Keywords- *FWD-Falling weight deflectometer, Structural Evaluation, Layer moduli, Geophone*

I. INTRODUCTION

All structures fail at some point but the life of structure is extending by the maintenance and rehabilitation activities. The maintenance and rehabilitation activities of pavement structures become increasingly important as pavements deteriorate with time and traffic operation. The combined effects of traffic loading and the environment will cause every pavement, no matter how well-designed/constructed to deteriorate over time. In structural evaluation method, the response of a pavement to a test load is observed. Structural response of a pavement can be measured in terms of stresses, strains and deflections, surface deflection is the most common parameter used in almost all pavement evaluation system, as it is very easy to measure. Measurement of surface deflection is rapid, relatively inexpensive and nondestructive.

Structural Evaluation by Dynamic Loading:
Two types of devices are, in general, considered in this category. While vibratory loading is produced in one category of equipment, the other category consists of impulse loading equipment. Dynaflect, Heavy Vibrator and Road Rater are some of the vibratory equipment used for pavement evaluation. Falling Weight Deflectometer (FWD), and Rolling Weight Deflectometer (RWD) fall into the category of impulse equipment. The development of an impulse loading equipment, which closely simulates the timing and amplitude of a rolling wheel load.

Purpose of Structural Evaluation of Pavements:
Structural evaluation of in-service pavements is generally carried out to

1. Assess the structural strength.
2. Estimate the remaining life of pavements.
3. The thickness of overlay required.
4. Establish a pavement management system based on the performance of the road

Working Principle of Falling Weight Deflectometer (FWD)
In general, FWD consists of an arrangement to raise a specified mass to specified height and to let it fall freely on a loading plate placed on the pavement surface through a spring. The mass, the height to which the mass is raised and the stiffness of the spring are suitably selected to produce a load of magnitude and duration that are like those of the load pulses produced by moving traffic on the pavement.

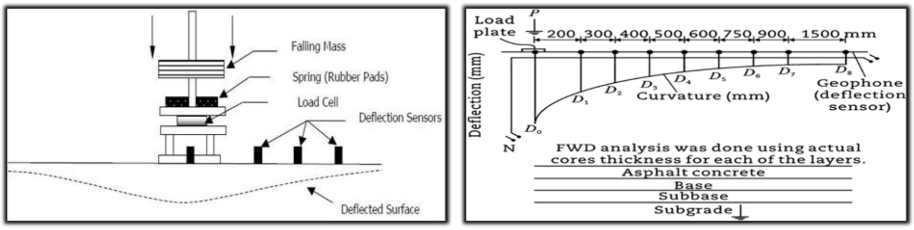

Figure: Working Principle of FWD

II. LITERATURE REVIEW

Murillo Feo C.A. and Bejarano Urrego L.E, (2013) Correlation between deflections measurements on flexible pavements obtained under static and dynamic load techniques the paper published in 18th international conference on soil mechanics and geotechnical engineering. Paris, 2013. Aim of this paper is Correlation between deflections measurements on flexible pavements obtained under static and dynamic load techniques.

Ujjval J. Solanki, Dr. Pradip J. Gundaliya, (2015) A Review on Structural Evaluation of Flexible Pavements using Falling Weight Deflectometer" published in Trends in Transport Engineering and Applications (STM) Journals, The researcher has made effort to identify the pavement condition based on deflection bowl observation. Parameters typically represent the stiffness of the upper layer. Typical indices are available to identify homogeneous Sub-sections of pavement also try to replace back-calculation n process, for overall structural evaluation the Structural Strength Index (SSI) was calculated by equation with criteria to differentiate good or poor pavement structural condition.

Deming Zhang (2016) Discussion on FWD and beckman beam detection method. Introduction by Falling Weight Deflectometer act (FWD) and Beckman Beam Deflection assay (BBD), and comparative analysis of the results showed that, FWD method in accuracy, detection efficiency, ease of operation and other aspects are better than Baker Man beam deflection detection method.

III. STUDY AREA

Ahmedabad city is the administrative Centre of Gujarat, India. Located at latitude 23.0300° North and longitude 72.5800° East, the city is the Centre for social, educational, commercial, residential, cultural, political and economic activities of Ahmedabad district. Divine Road (230 33' 53.16" N 720 25' 30.55" E) is one of the Urban Highway in Ahmedabad city in Gujarat State. It is Near to Science City Road, Sola Ahmedabad. The Urban highway connecting the Sola Gam Road is taken as study area having of 1.5 km.

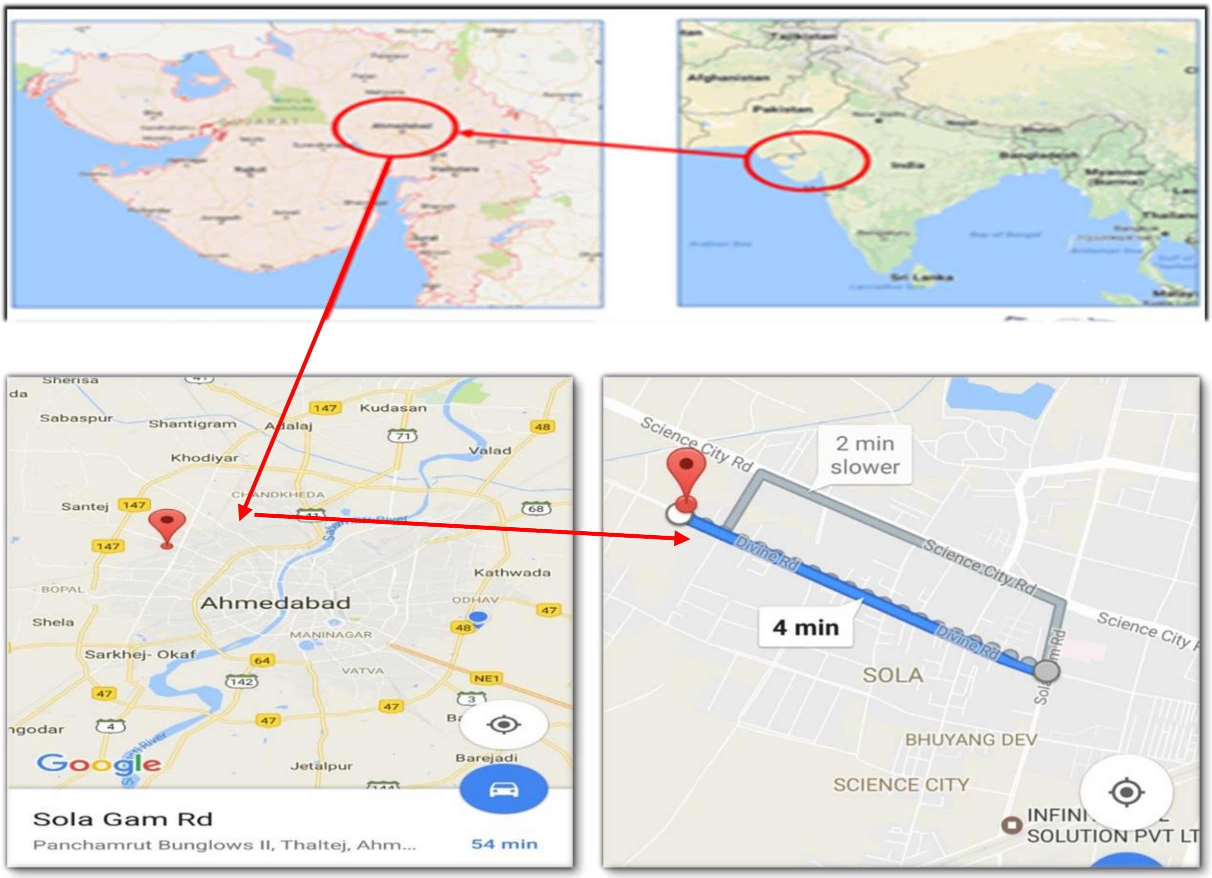

Figure: Study Area Divine Road Ahmedabad

IV. DATA COLLECTION AND ANALYSIS

FWD test on study area location are shown in above figure Deflection data recorded on the selected observation points as per IRC: 115-2014. Load and deflection data are acquired with the help of a data acquisition system in the car with computer system and data recorded by technician. FWD working procedure are shown in below figures.

Figure: Falling weight deflectometer test on study location

Deflection measurements were made using FWD on an Urban road in the month of February. The FWD test data has been collected for the all homogeneous section or study stretch of 1.5 km.

Selection of deflection: From study stretch CH 0.00 to CH 1.5 km, deflection measured at different observation points are normalized for 40 kN standard load. Ten deflection points normalization are given in the below table.

Table: Normalized deflection at a radial distance

Sl. No	Observed Deflection in mm normalized at 40KN									
	KN	0	200	300	450	600	900	1200	1500	1800
		D1	D2	D3	D4	D5	D6	D7	D8	D9
1	40.00	0.5371	0.4393	0.3811	0.3098	0.2419	0.1571	0.1092	0.0794	0.0635
2	40.00	0.1877	0.1524	0.1311	0.1064	0.0848	0.0569	0.0431	0.0342	0.0283
3	40.00	0.5499	0.4442	0.3761	0.2906	0.2169	0.1309	0.0862	0.0643	0.0512
4	40.00	0.7021	0.5551	0.4614	0.3552	0.2657	0.1613	0.1062	0.0784	0.0622
5	40.00	1.0464	0.7881	0.6138	0.4143	0.2718	0.1478	0.0992	0.0756	0.0604
6	40.00	0.3610	0.2945	0.2686	0.2347	0.1959	0.1402	0.0996	0.0736	0.0555
7	40.00	0.9254	0.6766	0.5145	0.3455	0.2399	0.1461	0.1029	0.0781	0.0636
8	40.00	0.6056	0.4739	0.3842	0.2790	0.1976	0.1126	0.0759	0.0584	0.0475
9	40.00	0.8400	0.6514	0.5303	0.3842	0.2674	0.1484	0.0978	0.0734	0.0583
10	40.00	1.3072	0.9521	0.6932	0.4375	0.2776	0.1461	0.0942	0.0682	0.0550

Remaining life of in service layers: Remaining fatigue life of the pavement obtained using equation and remaining rutting life as obtained from the equation of the IRC: 115-2014.

Fatigue criteria for bituminous layer: $N_f = 0.711 \times 10^{-04} \times [1/\varepsilon_t]^{3.89} \times [1/M_R]^{0.854}$

Rutting criteria for subgrade layer: $N = 1.41 \times 10^{-08} \times [1/\varepsilon_v]^{4.5337}$

Analysis of the pavement with a bituminous concrete overlay (with VG-30 binder) of 130 mm thickness yields a tensile strain of 290.4 microstrain and 345.3 vertical subgrade strain. Elastic modulus value of BC mix has been taken as 1700 MPa.

The fatigue life for this overlaid pavement will be 15.87 msa and rutting life will be 69.83 msa. Hence, design overlay thickness is 130 mm of bituminous concrete with VG-30 binder

Table: Calculation of Remaining life

Design traffic	E-value			Remaining life	
	BC	Gran	SG	Fatigue	Rutting
15 MSA	664.12	59.85	52.09	0.071394	0.453032

Overlay thickness Design as per IRC: 115-2014

The combination of existing pavement and overlay will be analyzed as a four layer system to ensure that fatigue and rutting criteria are satisfied for the assumed design traffic. Trial overlay thicknesses are selected and maximum tensile strain at the bottom of the existing bituminous layer has been computed using the thicknesses and moduli of various layers as inputs.

Table: Overlay Requirements

(microstrain)		Actual life		Overlay requirements		Total	Remark
tensile strain	vertical strain	Fatigue	Rutting	BC	DBM		
0.0002904	0.0003453	15.871	69.823	40	100	170	15 percentile of corrected moduli

V. CONCLUSION

In recent years, fast development of highway enterprise in India, especially in high grade highway construction, the traditional pavement testing and evaluation method cannot have satisfied our country highway construction and management of the actual requirement. The overlay thicknesses in terms of BC/DBM were found for all the stretches, it is 40 mm for BC and 100 mm for DBM. The estimated the cost for both alternatives are compared. From this it is concluded that the flexible overlay over flexible pavement is better from the point of view economy. the study results are useful to quantify the New and old pavement and further old pavement also classified as required strengthening or rehabilitation. So the performance based evaluation is possible with the use of FWD application no need to check material property.

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