

# Introduction of Light Weight Deflectometer

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**Abstract**—The paper tries to give a brief introduction to the readers, regarding the Light Weight Deflectometer, an instrument useful in determining the soil characteristics immediately and how the usage of the instrument, can save time and money for a multi-croreproject involving heavy construction of embankment for roads and railways.

## I. INTRODUCTION

Light Weight Deflectometer (LWD) is a test equipment to determine the dynamic modulus (Evd) of soils. It was developed in Germany in 1980's. It is based on dynamic portable impulse plate load testing principle. The magnitude of the load, falling height of the load and area of impact are so adjusted that it corresponds to the loading effect on dynamically loaded structures and hence, it is suited for the same. The equipment can be used to determine the degree of compaction and bearing capacity of the soil using co-relation table. The co-relation table between dynamic modulus (Evd) and CBR of soil can also be used for instant determination of CBR of soil.

## II. SOIL TESTS

The basic tests carried out for soil for any project are as follows:

- i. Determination of water content
  - ii. Grain Size Analysis
  - iii. Determination of liquid and plastic limits
  - iv. Determination of water content- dry density relation using heavy compaction
  - v. Laboratory determination of CBR
  - vi. Plate load Test to determine Bearing capacity of Soil.
- The process and methodology of the above tests are explained in IS: 2720.

For Design of Formation of Heavy Axle Load, following guidelines are refered:

- i. IR Guide lines for earth work in Rly projects GE-G-0014 Nov 2009
- ii. Ministry Of Road Transport And Highways – 2
- iii. Morth specification for road and bridge works

The procedure for the soil tests are time taking and laborious. Also, these tests are to be carried out, a number of times, in an infrastructure project such as roads, railways etc. as the stretch of the project are lengthy and indicated in Kilometres. We can only imagine how much tests will be carried out on daily basis in mega projects and the labours required for conducting the tests. Another drawback is that, we have to wait for days to get the results of the soils

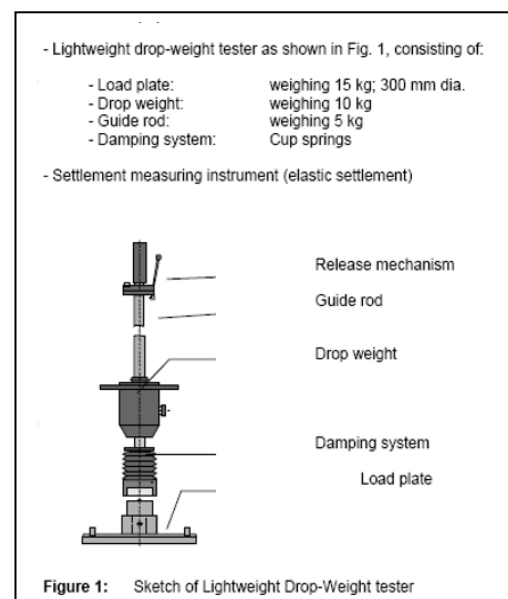
characteristics using Plate Load Test and CBR Test, so that we get it approved from the concerned authorities.

Thus, we need an improved testing instrument, which can predict the soil properties instantly and the work can be started without any delay. Also, the laboratory results can be obtained parallelly to ensure the results are within permissible limits.

## III. WORKING OF LIGHT WEIGHT DEFLECTOMETER

Falling weight Deflectometer (FWD) are in-situ testing devices initially developed in Germany as an alternative to the plate load test. The light-weight versions of this device is known as the Lightweight drop-weight tester or Light-falling Weight Deflectometer (LFW), or Light Weight Deflectometer (LWD).

An impulsive load is transmitted to the ground via a circular steel plate. The required loading device consists of a drop weight, which slides down on a guide tube to a spring damper element after its releasing. The device is equipped with holding magnets that hold the falling weight at a specific height. The loading device is put on a centering ball in the middle of the load plate, so that only vertical loading forces are transmitted to the load plate.



In the middle of the plate a sensor is installed on which an electronic measuring instrument is connected to determine the plate's deformation during the measurement. The sensor is an accelerometer. The Young's modulus is automatically

determined by the embedded software, and is displayed on the LCD screen immediately after each test. The display also provides information on the deflection, the Rebound deflection, and the impulse duration. All other parameters required for the determination of the dynamic modulus of deformation E<sub>vd</sub>, especially the contact tension between the plate and the underground are assumed to be constant.

LWDs are equipped with two types of circular loading plates, one of 140 mm, and the other of 200 mm diameter. The plate of 140 mm diameter is used for soils with Young's modulus varying from 10 Mpa to 1200 MPa. The plate of 200 mm diameter is used for soft soils where the Young's modulus is estimated to be lesser than 10 MPa, and where the deflections are observed to be more than 5 mm when tested with the plate of 140 mm diameter.

#### IV. USING LIGHT WEIGHT DEFLECTOMETER

Only 3 minutes to the Test Result

##### A. Prepare :

Prepare the test ground by positioning the machine on the surface and pre compact the test surface using the equipment itself by dropping the weight 3 times.

##### B. Measure :

Press (Power) to switch on the settlement measuring instrument. Perform 3 impacts in succession. The settlement value in mm is displayed after each impact.

After completion of the test, the average settlement, the deformation modulus E<sub>vd</sub>, the path to-speed ratio s/v and the settlement curve are calculated.

Settlement curves can be viewed on site itself, as shown in Figure 2.

##### C. Document Measured Data By Thermal Printer:

Printing of the measured data from memory can be done for documentation purpose at any time and in any place. Thermal printer is integrated with the LWD unit in the protective case.

##### D. Data Storage:

Up to 1000 tests can be stored. Evaluation via PC Software (\*): Series of measured data can be transferred to a PC for evaluation by software. Connect the PC to the settlement measuring instrument (or transfer data by USB stick). Evaluate, revise & archive measured values on PC.

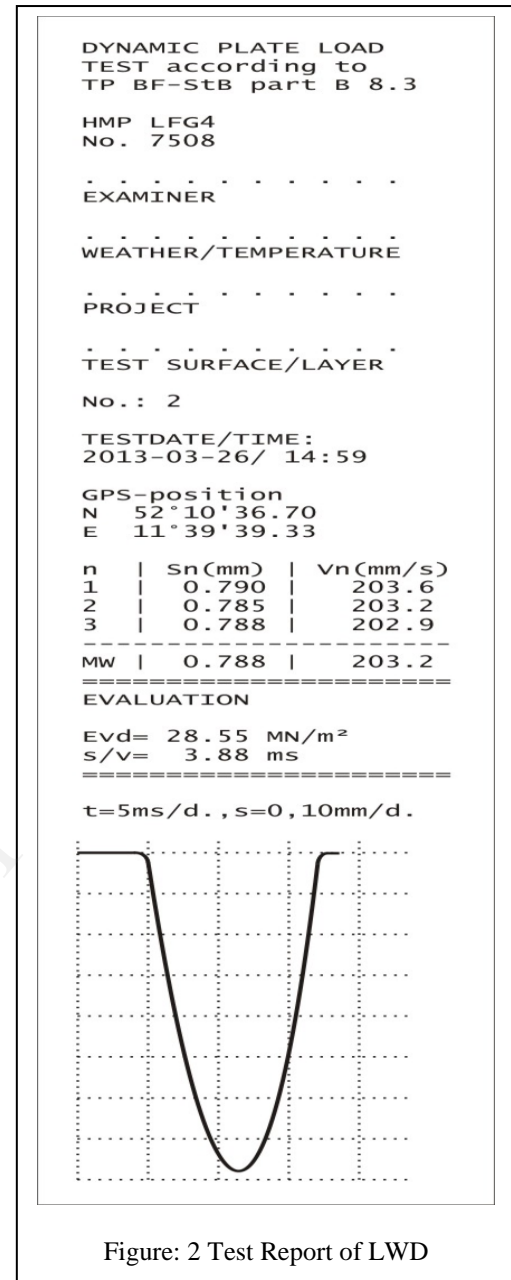


Figure: 2 Test Report of LWD

##### E. Compare:

To determine the CBR of the ground, compare the obtained dynamic Modulus of deformation (E<sub>vd</sub>) with the corresponding CBR values, as shown in Table No. 1. It is recommended to carry your own test results and co-relations as these values tend to change with respect to changes in Grainsize distribution and geological conditions from place to place.

Evd [MN/m <sup>2</sup> ]	CBR [%]
5	2
10	4
15	6
20	10
25	13
30	17
35	19
40	23
45	25
50	30
55	34
60	37
65	42
70	46
75	50
80	55
85	60
90	65
95	70
100	80

Table No. 1 Evaluation of CBR from  
“CBR-Evd table”

#### V. APPLICATION OF LIGHT WEIGHT DEFLECTOMETER

Though the traditional testing of CBR and Plate Load Test is the most widely adopted technique in India, for evaluating the characteristics of the soil, it is a laborious task and time taking to evaluate the results. So, a simpler, faster and reliable method to determine the same will always be preferred; because the CBR and the modulus of elasticity of the local soil strata changes from place to place, depending upon the local conditions.

We can check the significance of LWD on the project cost and schedule, with an example:

In a railway project (assume 100 kilometre), the Field Dry Density (FDD) Test is carried for original ground level using sand replacement test. The FDD test is needed to determine Bearing Capacity of Soil and CBR value also. The frequency of test changes from place to place depending upon the strata conditions. Consider frequency for FDD Test to be, 1 test in every 250 m length, hence 400 tests are to be carried out for stretch of 100 Km.

Practically, to perform one FDD test in the field it takes about 1 hour, hence we will consider that 6 tests are carried out in one day which covers  $250\text{m} \times 6 = 1.5 \text{ Km}$ . Therefore, it will take 67 working days with one team (1 Supervisor and 3 Labours). We will deploy 3 Teams, thus the days required to complete the activity is 24 Days, after which Bearing Capacity of Soil and CBR can be evaluated.

Now, we will analyse, what impact LWD will have on the same activity. To practically setup the LWD and to perform the test, it requires less than 30 minutes. Still, we will consider 30 minutes for carrying out one test. And, in one day with Team of 1 Supervisor and 1 Labour, tests can be carried out in 12 locations, covering  $250\text{m} \times 12 = 3.0 \text{ Km}$ . It will take 34 Days to complete the activity with only 1 Team and with 3

Teams it will take 12 days only. Additional to it, the results are instantly observed after each test and Bearing Capacity of soil and CBR can be calculated easily with co-relating table.

Therefore, LWD is undoubtedly an ideal replacement for laborious tests such as CBR, Plate Load Tests, FDD test etc.

#### VI. CONCLUSION

The performance and life of the pavement depends upon the characteristics of the subgrade. Hence, precise evaluation of the CBR, using dynamic modulus of soil (Evd) values depends upon the characteristics of the soil layer. The simple working systems of the LWD and instant results of the soil layer, makes it an effective equipment in the line of construction industry, saving precious time and money. The use of LWD has already gained popularity in Developed Countries and it is time the Indian Construction Sector also start reaping the benefits of modern technologies such as Light Weight Deflectometer.

#### VII. ACKNOWLEDGMENT

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