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A Review Paper on Comparative Study of Density of Bituminous Layer by Various Methods

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Abstract: ***The density of a bituminous pavement is an important parameter for assessing the pavement quality. Traditionally, the density of a bituminous pavement is determined by core sample; though accurate it has some disadvantages. It causes damage to pavement after construction. Therefore to overcome this problem non-destructive method to provide quick and furthermore accurate reading of density were evolved. They also can measure temperature, moisture content of bituminous pavement layer. The goal of this paper is to evaluate and identify the most suitable type of method used to find out the density of bituminous layer among traditional methods i.e. core sample, nuclear density gauge and non-nuclear density gauge by considering environmental condition, establishing speed, accuracy and consequently precision in the density measurement.***
Keywords: Bituminous pavement, density, core sample, nuclear density gauge, non-nuclear density gauge.

I. INTRODUCTION

India has a 2nd largest road network in the world of over 66,03,293 kilometers as on 31st March 2018 report of Basic Road Statistics of India under the Ministry of Road, Transport and Highways. This large road network requires a huge fund to keep road network in good condition to minimize the loss in vehicle operating cost and maintain the quality of pavement. The allocation of fund in India is 50-60% of its requirement only. So, it is necessary to assure good quality of construction from the beginning, such as to have higher useful life of pavement. Old pavements also require overlays for renewal of surface periodically and they may need strengthening too due to increase in traffic volumes or traffic loads. Needless to say that quality control plays vital role in achieving these objectives. The density of a bituminous pavement is an important parameter for quality control/quality assurance[1]. The density requirements and methods of measuring density vary considerably for material, mixture specification and measuring equipment[2]. Density measuring equipment should preferably be non-destructive and provide quick and accurate reading. In the late fifties and early sixties nuclear density gauge was manufactured to measure the density of soil, aggregate and bituminous pavement but this type of instrument is heavy, required radioactive material license and special precaution during storage and transportation. The need of instrument without the difficulty of special handling, radioactive material license and a more operator friendly was realized. Therefore, a few manufacturing company developed a light weight non-nuclear density gauge to measure the density of the bituminous pavement[3]. Nevertheless, the literature is unclear whether the readings of non-nuclear devices are equal to those from nuclear density gauge and core cutter sample.

II. METHODS USED TO MEASURE THE DENSITY

There has always been need of instrument which in addition to quick and accurate determination of density can also measure temperature, moisture content on bituminous pavement layer and makes any correction if so required[4]. In a long time practice, density of a pavement layer is determined by laboratory measurements of core cutter samples and at site through nuclear density gauges. Lately, non-nuclear density devices which measure the electromagnetic properties of pavements have been developed and are used to measure density of pavement.

A. Coring Method

Core testing is an extremely precious tool which provide sample for laboratory measurement to determine density. Coring method for determining the density of the bituminous pavement is most accurate method according to the MORTH 5th revision but this is destructive, time-consuming and can create defects to the pavement[6]. Samples obtained in the field in accordance with the procedure are used for measuring pavement thickness and density. Core diameter may range from 5.08cm (2 inch) to 30.48cm (12 inch) though generally 7.5 cm to 10 cm diameter is common.

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B. Nuclear Density Gauge

The nuclear density device is the micro-processor based units which automatically compute the values and makes correction to the measurements[7]. Nuclear density gauge is designed to measure the moisture content and density of construction material like soils, cement treated materials, and bituminous mixes[3]. It offers the Inspector and Contractor a method of obtaining fast, accurate, non-destructive and in-place measurement of densities and moisture of pavement layer. Although the nuclear method is a relatively quick and non-destructive method for obtaining field densities, poor correlation between nuclear and core densities have been documented. The device uses a small radioactive source i.e. gamma ray to measure the moisture content and density of the material to be tested[3]. A potential hazard does exist if improperly handled or stored. Before operating a nuclear gauge a person must pass a Nuclear Safety course to avoid the adverse health effect due to gamma radiations[8].

C. Non-Nuclear Density Gauge

Non-nuclear density gauge is designed for quick non-destructive testing of density, assessment of homogeneity and degree of compaction of bituminous pavement. The thickness up to which measurement can be made varies with the model and company of the instrument used to measure the density of the bituminous mix. Typically measurement can be made for a depth range from 10 mm to 100 mm. The calibration of the non-nuclear meter to a core sample is very important for each mix design for the reliability and consistency of the density measurements for each material. The density determined by the non-nuclear density gauge is highly material dependent hence it is important that the mix information for each mix design is feed accurately into the meter. The meter uses correlation between the density and the dielectric field transmitted through the material from the sensor plate of the meter. The dielectric constant is then measured and used in the calculation of the density for that specific bituminous pavement.

III.METHODOLOGY

Different studies have been done by many researchers to compare the various methods of density calculation with different models of nuclear, non-nuclear density gauge. In this paper the study of the density measurement is done by nuclear density gauge of model HS-5001Ez HUMBOLDT and non-nuclear density gauge of model PAB 1.2 and its value is compared with the core sample density measured according to AASHTO T166.

A. Coring Method

1) Cores to be taken out by cutting the core at compacted pavement layer from the area where nuclear and non-nuclear density gauge reading have been used.
2) Important care needs to be taken when drilling to prevent additional pavement lifts included in the core sample.
3) After the cores have been drilled, measure the bulk specific gravity of the saturated surface dry method as specified in AASHTO T166 on similar.

B. Nuclear Density Gauge

1) The test site must be properly selected and prepared well in advance.
2) Switch on the gauge to allow the device to get ready before testing is to being. This should be done while the test site is being prepared for testing.
3) To obtain correct results, the nuclear device must be seated flush against the compacted layer.
4) Selected site should be levelled before placing the device.
5) If significant voids remain in the area where the device is to be placed, the voids should be filled with small amount of fine cement and soil common to the site, and lightly tamped in place with the scraper plate and remove excess material.

C. Non-Nuclear Density Gauge

1) Levelled site must be selected to take the reading.
2) The non-nuclear density gauge is designed to be an extremely flexible unit, with several useful modes of operation. Each mode of operation is accessed through the touch screen controls. The number, letter and arrow keys have several functions.
3) The immediate function is shown by the text in the display panel. The display can show four lines of text at a time called a page.
4) The display tells the operator the non-nuclear density gauge unit is ready to do or indicates that a reading is being taken or that more key setting information is needed from the operator.
5) Pressing the key causes the non-nuclear density gauge to “beep” indicating that the keystroke has been entered.

Fig. 1 Nuclear density gauge and non-nuclear density gaug

IV. FIELD DEMONSTRATION AND CALIBRATION

Coring method is most accurate method in terms of density calculation but speed of measurement is slow. To take the advantages of both accuracy and speed of measurement a location calibration and standardization of the device on time is must for both nuclear and non-nuclear density gauge.

A. Measurement by Nuclear Density Gauge

1) *Calibration:* The calibration of nuclear density gauge will be valid for a minimum of one year and probably much longer if reasonable care is taken to prevent the application of heavy shock load to the gauge base. Any conflict in this measurement or questionable error in field data will indicate the need of calibration. The gauges are calibrated in accordance with the method recommended by ASTM D2950, D6938, D7759, and AASHTO 310. No additional equipment is required for the adjustment other than a sample of the material at a known density. No additional equipment is required for an entirely new calibration other than a suitable set of standards. Initially calibration characteristic is provided by the manufacturer, it is performed on five standard density samples with the density in a range of 1100-2700 kg/m^3.
2) *Standardization:* Every day before use of the gauge, a set of *standard count*s must be taken to cut the effect of radioactive element decay and used for all the measurements to be made on that particular day. These counts can also be done to logged for verification of proper operation and provide a history for service if required.

Steps to be followed for standardization of nuclear density gauge:

a) Place the reference block on a compacted surface and remove any debris or loose material.
b) Place the gauge on the reference block with the handle end of the reference block away from the operator.
c) The gauge must be seated inside the guide rail along the edges of the reference block.
d) The source rod of the gauge is up above the handle of the reference block.
e) Remove the Gauge lock and make certain that the handle is latched in the “SAFE” position.
f) The standard count measurement time can be changed from setup option from 4 minutes to 16 minutes. More the count more will be the error free standard count.
g) To being the standard count press STD/STAT key. Screen will show the last standard count of DS and MS.
h) To take new count press F3. Stay away for 4 minutes from the gauge.
i) After 4 minute note down the standard values of DS and MS.

B. Measurement by Non-Nuclear density Gauge

1) *Calibration:* The calibration of the meter to a density standard (core) for each material is very important for the reliability and consistency of the density measurements. This is due to the various bituminous mixtures being used in the field now days. Changes in the aggregate type and size as well as change in the binders produce a wide variety of electrical properties. Once calibrated to a sample (core) the meter will maintain optimal precision and accuracy for that particular type of bituminous

mixture. Basic calibration characteristic is provided by the manufacturer, it is performed on three standard density samples with the density in a range of 2000-2700 kg/m³.

2) *Standardization:* If the meter is calibrated once for a particular type of bituminous mixture then there is no need to standardize meter every day before the start of measurement.

V. CONCLUSION

This study clarifies the basic working principle of core cutter, nuclear density gauge and non-nuclear density gauge. Procedure to be followed in the field and steps that consider in mind while doing field work is also explained.

A. The non nuclear density gauge is comparatively more handy and better to use in the field than nuclear density gauge as it does not require any special training.

B. Nuclear density gauge needs to be standardized daily before taking the measurement to reduce the effect of decay of the radioactive material.

C. The calibration of this device is done by the experts only but in case of non-nuclear density gauge standardization is not needed and if the calibration is done once for a particular type of mix then it can be used at any time for the same mix.

D. Nuclear density gauge can be used for soil density measurement also because it covers the range 1100-2700 kg/m³ but non-nuclear density gauge density measurement ranges 2000-2700 kg/m³ only so it can not be used to measure the density of soil.

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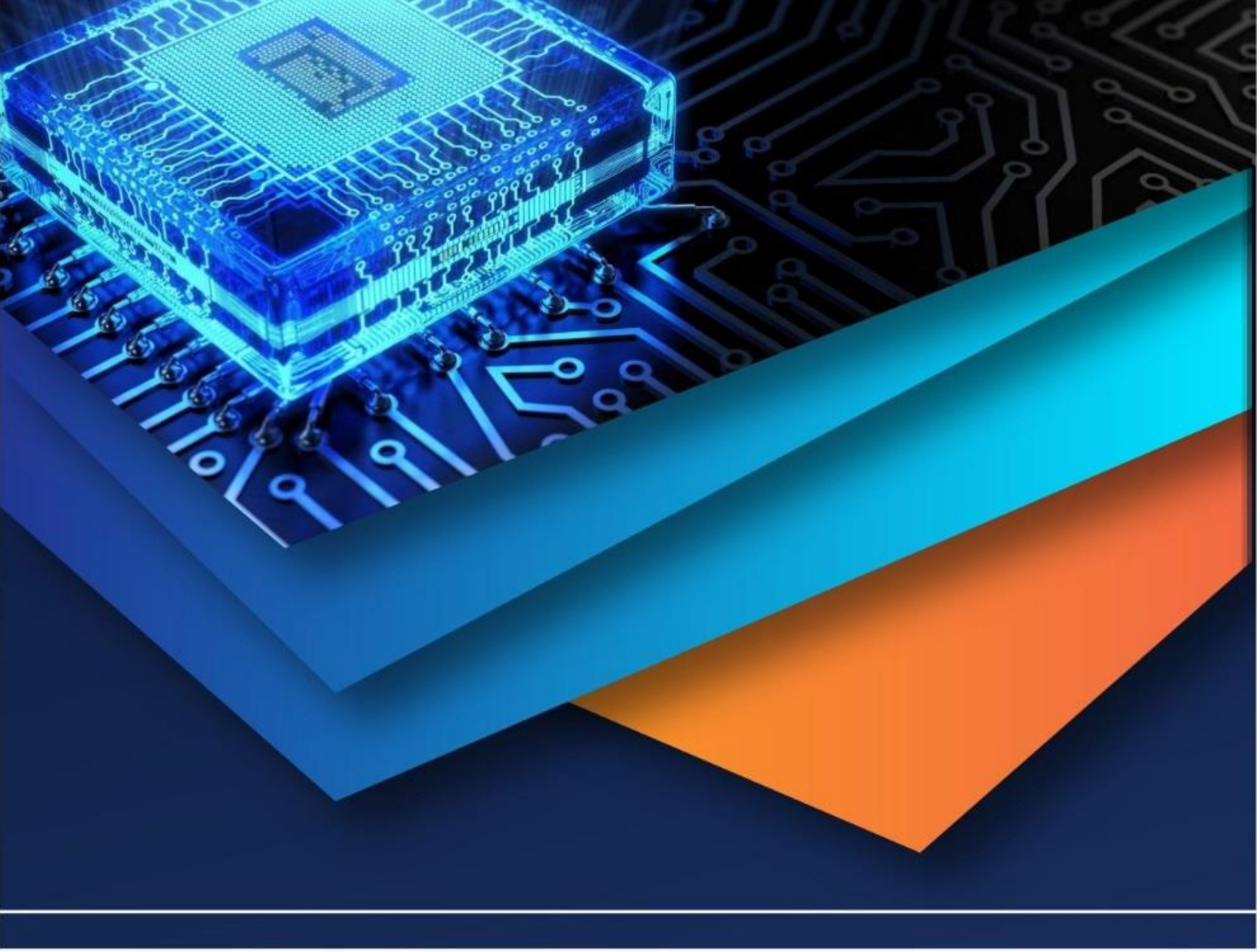

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