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Experimental Analysis to Evaluate Quality and Properties of Bitumen for Pavements

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Abstract—*It is a universal truth that if assets once created are not adequately maintained and managed, then the possibility of erosion in asset values are not only high but the danger of losing the entire asset is also high. The road sector is a highly complex sector and can be termed as a "Strategic Infrastructure Sector" also for a country/economy/society. In this paper an experimental analysis is carried out to study bituminous materials which are used as binders during road construction. The results conclude that these materials pose benefits and provide extra life for the roads by binding the materials together.*

1. INTRODUCTION

Because of excellent water retention properties and binding properties, bituminous materials are excellent materials being used as road construction materials [1]. Also, these are relatively lower in cost as compared to other binders available for roadways construction [2]. The properties of bituminous material mainly depend on the type of mixtures added and the construction which is being carried out using these bituminous material.

2. TESTS ON BITUMEN

Various tests are carried out to evaluate the properties of bituminous materials being used during construction. To evaluate various properties of bituminous materials many tests are being conducted. Some tests being conducted on site are described below.

2.1 Penetration test

This test is being conducted to measure the hardness or softness of bitumen [3]. It is done by measuring depth of the material in tenths of a millimeter to which a standard loaded needle will penetrate vertically in 5 seconds. The standardisation of the equipment and test procedure is done by BIS. The penetrometer used for this test consists of needle assembly which has a total weight of 100g and a device for releasing and locking the device in different positions being used. In this test, bitumen is softened to pouring consistency, stirred properly and poured into containers which has a depth at least 15 mm in excess of the penetration which we generally expect from the bitumen material being tested. The test is conducted at a specific temperature of 25^{o}C only. The important point that should be noted while performing this test is that the penetration values are largely influenced by any inaccuracy, so proper eye should be maintained in order to get the best results. After results grades are assigned, A grade of 40/50 bitumen means penetration value is in range 40 to 50 at standard test conditions. When we are constructing the roads in hot climates, preference is given to a lower penetration grade.

2.2 Water content test

This test is conducted to test the water present in the bitumen sample. The desirable property of the bitumen is that it contains minimum water content in order to prevent foaming of bitumen during the process of heating the sample above the boiling point of water. The water content of bitumen is calculated by mixing known weight of sample in pure petroleum distillate which is completely free from water. It is then heated and distillation of the water is carried out. The weight of the water which is condensed is collected and it is denoted as percentage by weight of sample taken. The maximum water content which is allowable cannot be more than 0.2% by weight of the sample.

2.3 Loss on heating test

Heating ofbitumen causes loss of the volatility and it gets hardened. Initially to start the test, about 50gm of sample is taken and is heated to temperature of 163ºC for 5 hours inan oven which is specifically designed for this test. After heating, the sample specimen is weighed again and loss in weight is denoted as percentage by weight of the sample examined. The allowable standards for bitumen used for pavement constructioncannot be more than 1% loss in weight, but for bitumen which has penetration values of 150-200, 2% loss in weight is also allowed.

2.4 Consolidation test

Consolidation test [4] is conducted to evaluatethe magnitude and rate of volume decrease of a laterally confined soil sample when different amounts of vertical pressures are imposed on it. From the data available after measurement, the consolidation curve (pressure-void ratio relationship) isplotted. This data is used to determine the compression index, the recompression index and pre-consolidation pressure (or maximum past pressure) of the soil under test [4]. The data obtained is also used to determine the coefficient of consolidation and the coefficient of secondary compression of the soil under test. Figure 1 depictsASTM D 2435 - Standard Test Method for One-Dimensional Consolidation Properties of Soils [5-9]. The consolidation properties calculated from the consolidation test are being used to evaluate the magnitude and rate of primary and secondary consolidation settlement of a structure or an earth fill [10]. This test is of key importance in the design of engineered structures and the evaluation of their performance.

2.4.1 Equipment Required

For conducting this test, Consolidation device (including ring, porous stones, water reservoir, and load plate), Dial gauge (0.0001 inch = 1.0 on dial), Sample trimming device, glass plate, Metal straight edge, Clock, Moisture can and Filter paper are required.

2.4.2 Test Procedure

a) The empty consolidation ring is weighed with glass plate.
b) Then, height (h) of the ring and it's inside diameter (d) are measured.
c) Extrude the soil sample from the sampler, generally thin-walled Shelby tube. Determine the initial moisture content and the specific gravity of the soil.
d) A three-inch long sample is cut and is placed on the consolidation ring and is made of the same size of the ring. The ring is rotated and excess soil is removed by cutting tool so that the sample is reduced to the same inside diameter of the ring. It should be noted that correct horizontal position be maintained for the cutting tool while performing this process.
e) As the trimming progresses, press the sample gently into the ring and continue until the sample protrudes a short distance through the bottom of the ring. Be careful throughout the trimming process to insure that there is no void space between the sample and the ring.
f) Turn the ring over carefully and remove the portion of the soil protruding above the ring. Using the metal straight edge, cut the soil surface flush with the surface of the ring. Remove the final portion with extreme care.
g) Place the previously weighed Saran-covered glass plate on the freshly cut surface, turn the ring over again, and carefully cut the other end in a similar manner.
h) Weigh the specimen plus ring plus glass plate.

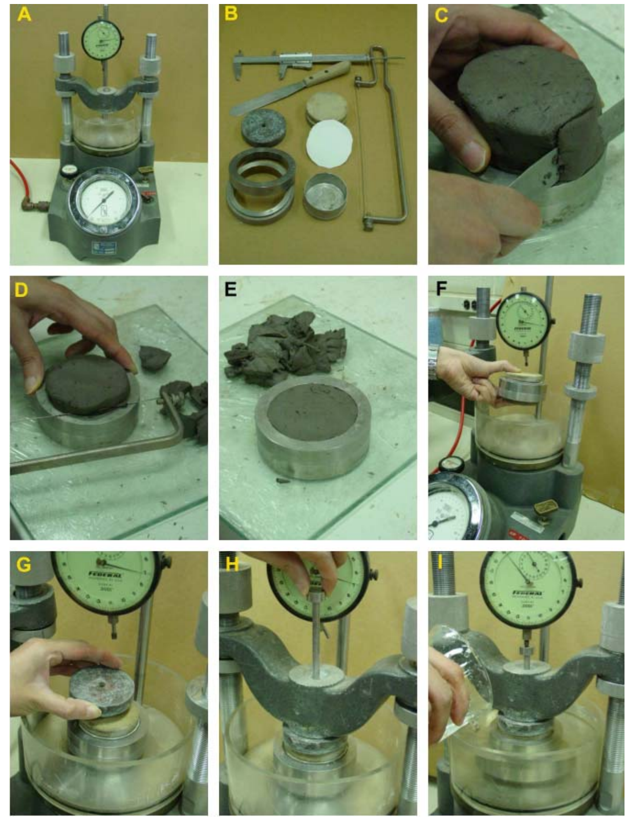

Figure 1: ASTM D 2435 - Standard Test Method for One-Dimensional Consolidation Properties of Soils.

i) Carefully remove the ring with specimen from the Saran-covered glass plate and peel the Saran from the specimen surface. Center the porous stones that have been soaking, on the top and bottom surfaces of sample. The filter papers are placed between porous stones and soil specimen. It is pressed so that the stones adhere to the sample. The assembly is loweredinto the base of the water reservoir. Water reservoir is filled with water until it is completely covered and saturated.
j) Being careful to prevent movement of the ring and porous stones, place the load plate centrally on the upper porous stone and adjust the loading device.
k) Adjust the dial gauge to a zero reading.
l) With the toggle switch in the down (closed) position, set the pressure gauge dial (based on calibration curve) to result in an applied pressure of 0.5 tsf (tons per square foot).
m) Simultaneously, open the valve (by quickly lifting the toggle switch to the up (open) position) and start the timing clock.
n) Record the consolidation dial readings at the elapsed times given on the data sheet.
o) Repeat Steps 11 to 13 for different pressures (generally includes loading pressures of 1.0, 2.0, 4.0, 8.0, and 16.0 tsf and unloading pressures of 8.0, 4.0, 2.0, 1.0 and 0.5 tsf)
p) At the last elapsed time reading, record the final consolidation dial reading and time, release the load, and

quickly disassemble the consolidation device and remove the specimen. Quickly but carefully blot the surfaces dry with paper toweling. (The specimen will tend to absorb water after the load is released).

q) Place sample and ring on Saran-covered glass plate and, once again, weigh them together.

r) Weigh an empty large moisture can and lid.

s) Carefully remove the specimen from the consolidation ring, being sure not to lose too much soil, and place the specimen in the previously weighed moisture can. Place the moisture can containing the specimen in the oven and let it dry for 12 to 18 hours.

t) Weigh the dry specimen in the moisture can.

2.4.3 Experimental Analysis

The initial water content and specific gravity of the soil are calculated.

For each pressure increment, construct a semi log plot of the consolidation dial readings versus the log time (in minutes). Determine D0, D50, D100, and the coefficient of consolidation (cv) using Casagrande's logarithm of time fitting method.

Calculate the void ratio at the end of primary consolidation for each pressure increment. Plot log pressure versus void ratio. Based on this plot, calculate compression index, recompression index and pre consolidation pressure (maximum past pressure).

RESULT SHEET

Date Tested: April 2, 2015

Tested By: REWARI PROJECT GROUP 4

Sample Number: MD G-IV

Visual Classification: Gray silty clay

Before test:

Consolidation type	= Floating type
Mass of the ring + glass plate	= 465.9 g
Inside diameter of the ring	= 6.3 cm
Height of specimen, Hi	= 2.7 cm
Area of specimen, A	= 31.172cm2
Mass of specimen + ring	= 646.4 g
Initial moisture content of specimen, wi (%)	= 19.5 %
Specific gravity of solids, Gs	= 2.67

After test:

Mass of wet sample + ring + glass plate	= 636.5 g
Mass of can	= 59.3 g
Mass of can + wet soil	= 229.8 g
Mass of wet specimen	= 170.50 g
Mass of can + dry soil	= 208.5 g
Mass of dry specimen, Ms	= 149.2 g
Final moisture content of specimen, wf	= 14.27 %

Calculations:

Mass of solids in specimen, Ms = 149.2 g

(Mass of dry specimen after test)

Mass of water in specimen before test, Mwi =wi x Ms = 0.195*149.2 = 29.094 g

Mass of water in specimen after test, Mwf (g) = wf x Ms = 0.1427*149.2 = 21.29 g

Height of solids, Hs = Ms/(A*Gs*pw) = 1.792cm

Height of water Before test, Hwl = Mwl/(A*pw) =0.933cm

Height of water after test, Hwf = Mwf/(A*pw) = 0.683cm

Change in height after specimen test = 0.257cm

Height of specimen after test, Ht =Hi-change in height =2.443cm

Void ratio before test, eo= (Hi-Hs)/Hs =0.506

Void ratio after test, ef=(Hf-Hs)/Hs =0.3617

Degree of saturation before test, Si= Hwi/(Hi-Hs) = 102.7%

Degree of saturation after test, Sf= Hwf/(Hf-Hs) = 105.08%

Dry density Before test ρd =Ms/(Hs*A) =1.77g/cm3

Final Results:

Compression Index (Cc) = 0.11

Recompression Index (Cr) = 0.013

Preconsolidation pressure (Pc) or Maximum past pressure (σvmax) = 3.5 tsf

Coefficient of consolidation (Cv)= 1.54x10-2 to 9.01x10-3 in2/min (depends on the pressure)

Coefficient of secondary compression (Cα) = 0.001

3. CONCLUSION

The results calculated from the consolidation test are of great importance as they are used to estimate the magnitude and rate of both differential and total settlement of a structure or earth fill. Various methods are available for carrying out consolidation test as mentioned in papers. By carrying out such estimates and using the correct sample for design is of key importance in the design of engineered structures and the evaluation of their performance.

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