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Original Article

The study of pavements in transportation engineering with special reference to N.H.- 1

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Abstract

Rigid pavements are those which posses note worthy flexural strength or flexural rigidity. The stresses are not transferred from grain to grain to the lower layers as in the ease of flexible pavements layers the rigid pavements are made of Portland cement concrete-either plain, reinforced or prestressed concrete. The plain cement concrete slabs are expected to take up about 40 kg/cm2 flexural stress. As the rigid pavements slab has tensile strength, tensile stresses are developed due to the bending of the slab under wheel load and temperature variations thus the type of stress develop and their distribution within the cement concrete slab are quite different. The rigid pavement does not get deformed to the shape of the lower surface as it can bridge the minor variation of lower layer.

1. Introduction

Civil engineering is a professional engineering discipline that deals with the design, construction and maintenance of the physical and naturally built environment, including works such as bridges, roads, canals, dams and buildings. Civil engineering is the oldest engineering discipline after military engineering, and it was defined to distinguish non-military engineering from military engineering. It is traditionally broken into several sub-disciplines including environmental engineering, geotechnical engineering, structural engineering, transportation engineering, municipal or urban engineering, water resources engineering, materials engineering, coastal engineering, surveying, and construction engineering. Civil engineering takes place on all levels: in the public sector from municipal through to federal levels, and in the private sector from individual homeowners through to international companies.

1.1 Geotechnical engineering

Geotechnical engineering is an area of civil engineering concerned with the rock and soil that civil engineering systems are supported by. Knowledge from the fields of geology, material science and testing, mechanics, and hydraulics are applied by geotechnical engineers to safely and economically design foundations, retaining walls, and similar structures. Environmental concerns in relation to groundwater and waste disposal have spawned a new area of study called geo environmental engineering where biology and chemistry are important.

Some of the unique difficulties of geotechnical engineering are the result of the variability and properties of soil. Boundary conditions are often well defined in other branches of civil engineering, but with soil, clearly defining these conditions can be impossible. The material properties and behaviour of soil are also difficult to predict due to the variability of soil and limited investigation. This contrasts with the relatively well defined material properties of steel and concrete used in other areas of civil engineering. Soil mechanics, which define the behaviour of soil, is complex due to stress-dependent material properties such as volume change, stress–strain relationship, and strength.

1.2 Water resources engineering

Types of pavement structure

Based on the structural behavior, pavement are generally classified into two categories

1. Flexible pavement
2. Rigid pavement

The cement concrete pavement slab can very well serve as a wearing surface as well an effective base course. Therefore usually the rigid pavement structure consists of a cement concrete slab, below which a granular base or subbase course may be provided. Providing a good base or subbase course layer under the cement concrete slab, increases the pavement life considerable and therefore works out more economical in the long run. The rigid pavements are usually designed and the stresses are analysis using the elastic theory, assuming the pavements as an elastic plate resting over elastic or a viscous foundation.

1.3 Flexible Pavements

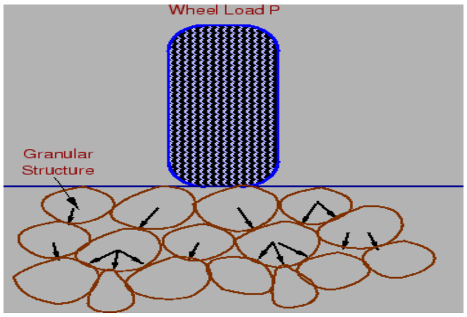
Flexible pavements are those having negligible flexural strength and are flexible in structural actions under the loads. The term flexible is associated with those pavements which reflect the formation of sub grade and of subsequent layers on to the surface. The design of flexible pavement is based on load distributing characteristics of the component layers. Flexible pavements do possess some flexural strength which is however negligible.

The flexible pavement layers transmit the vertical or the compressive stress to the lower layers by grain to grain transfer through the points of contact of the granular structure. A well compacted granular structure consisting of strong graded aggregate (interlocked aggregate structure with or without binder material) can transfer the compressive stress through a wider are and thus forms a good flexible pavement layer. The load spreading ability of this layer therefore depends on the type of material and the mix design factor. Bituminous concrete is one o the best flexible pavement layer materials. Other materials which fall under the group are, all granular materials with or without bituminous binder, granular base and subbase course materials like the Water Bound macadam, crushed aggregate, gravel, soil aggregates mixes etc.

1.4 A typical flexible pavement consists of four components namely:

1. Soil sub-grade
2. Sub base
3. Base course

Figure 1: Surface course



The maximum vertical compressive stresses on pavement surface directly under the wheel load and are equal to the contact pressure under wheels. Due to ability to distribute the stresses to a larger area in space in shape of a truncated cone, the stresses get decreased at the lower layers. Therefore “layer system concept” was developed. According to this, the flexible pavements may be constructed in a number of layers and the top layer has to be strongest as the highest compressive stresses are to be sustained by this layer, in addition to wear and tear due to the traffic. The lowest layer is prepared surface consisting of the local soil itself, called the sub grade. Each layer above the sub grade i.e. sub-base, base course and the surface course may consists of one of more number of layers of the same or different material.

Figure 2: Bituminous Macadam

2. Consolidation

After placement of material, road surface shall be compacted by a power roller of 8 to 10 tonnes, starting at edges and moving towards centre. Each pass of roller shall overlap not less than one third of track made in preceding pass. Consolidation shall be considered complete when stone chipping are firmly embedded.

3. Specification to be followed:

Grade of bitumen: 60/70, Binder content used: 3 – 4.5% by weight of mix. Amount of aggregates required for 10 meter: 0.60-0.75 meter cube and 0.90-1.10 meter cube for 50 and 75 respectively.

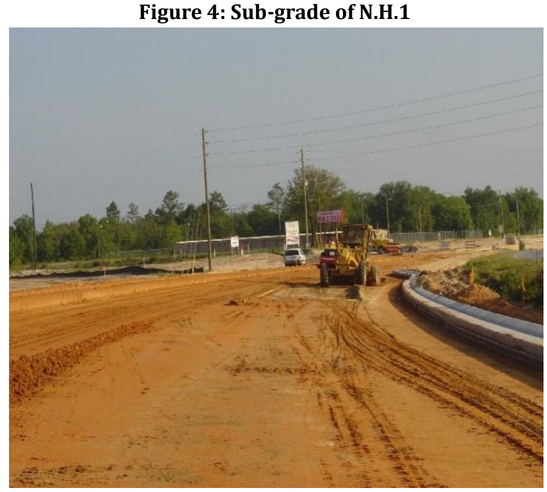
Figure 3: N.H.1 in India

4. Soil subgrade and its Construction

The soil sub grade is a layer of natural soil prepared to receive the layers of pavements materials placed over it. The loads on the pavement are ultimately received by the soil subgrade for dispersion to the earth mass. It is essential that at no time the soil subgrade is overstressed.

It means that the pressure transmitted on top of sub grade is within the allowable limit, Not to cause excessive stress condition or to deform the same beyond the elastic limit.

Figure 4: Sub-grade of N.H.1



The sub-grade layer of a pavement is, essentially, the underlying ground. It is also known as the "Formation Level", which can be defined as the level at which excavation ceases and construction starts: it's the lowest point of the pavement structure, Therefore it is desirable that at least 50 cm layer of the sub grade soil is well compacted Under controlled conditions of optimum moisture and maximum dry density.

CBR TEST

The California bearing ratio (CBR) is a penetration test for evaluation of the mechanical strength of road sub-grades and base-courses. To determine the California bearing ratio by conducting a load penetration test in the laboratory. The California bearing ratio test is penetration test meant for the evaluation of subgrade strength of roads and pavements. The results obtained by these tests are used with the empirical curves to determine the thickness of pavement and its component layers. This is the most widely used method for the design of flexible pavement.

Equipments and tool required.

1. Loading machine. With a capacity of atleast 5000 kg and equipped with a movable head or base that travels at an uniform rate of 1.25 mm/min. Complete with load indicating device.

2. Metal penetration piston 50 mm dia and minimum of 100 mm in length.

3. Two dial gauges reading to 0.01 mm.

4. Sieves. 4.75 mm and 20 mm I.S. Sieves.

4. Miscellaneous apparatus, such as a mixing bowl, straight edge, scales soaking tank or pan, drying oven, filter paper and containers of 100%

Penetration of plunger (mm)	Standard load (kg)
2.5	1370
5.0	2055
7.5	2630
10.0	3180
12.5	3600

The test may be performed on undisturbed specimens and on remoulded specimens which may be compacted either statically or dynamically.

$$CBR = \frac{p}{p_s} \cdot 100$$

CBR = CBR [%]

p = measured pressure for site soils [N/mm^2]

p_s = pressure to achieve equal penetration on standard soil [N/mm^2]

The above description is slightly simplistic: the moisture content of the sample can (and does) have a dramatic effect on the actual CBR value, and this has to be taken into account.

Interpretation and recording

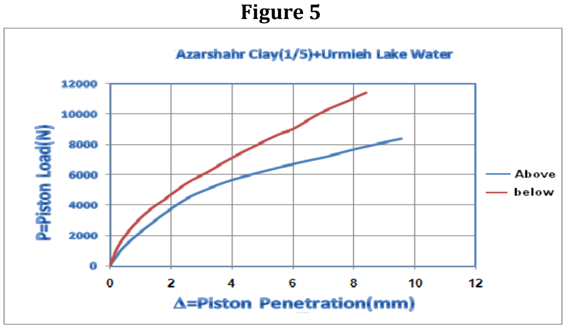
C.B.R. of specimen at 2.5 mm penetration

C.B.R. of specimen at 5.0 mm penetration

C.B.R. of specimen at 2.5 mm penetration

CBR Value	Subgrade strength	Comments
3% and less	Poor	" Capping is required
3% - 5%	Normal	Widely encountered CBR range capping considered according to road category
5% - 15%	Good	"Capping" normally unnecessary except on very heavily trafficked roads.

Figure 5



The test procedure to determine R-value requires that the laboratory prepared samples are fabricated to a moisture and density condition representative of the worst possible in situ condition of a compacted subgrade. The R-value is calculated from the ratio of the applied vertical pressure to the developed lateral pressure and is essentially a measure of the material's resistance to plastic flow. The testing apparatus used in the R-value test is called a stabilometer .Values obtained from the stabilometer are inserted into the following equation to obtain an R-value:

$$R = 100 - \left\{ \frac{100}{\left(\frac{2.5}{D}\right)\left[\left(\frac{Pv}{Ph}\right) - 1\right] + 1} \right\}$$

where: R = resistance value

Pv = applied vertical pressure (160 psi)

Ph = transmitted horizontal pressure at Pv = 160 psi

D = Displacement of stabilometer fluid necessary to increase horizontal pressure from 5 to 100 psi.

Some typical R-values are:

- Well-graded (dense gradation) crushed stone base course: 80+
- MH silts: 15-30Standard R-Value test methods are:

AASHTO T 190 and ASTM D 2844: Resistance R-Value and Expansion Pressure of Compacted Soils

$$M_R \left(or \ E_R\right) = \frac{\sigma_d}{\varepsilon_r}$$

Where: M_R (or E_R) = resilient modulus (or elastic modulus since resilient modulus is just an estimate of elastic modulus)

σ_d = stress (applied load / sample cross sectional area)

ε_r = recoverable axial strain = D L/L

L = gauge length over which the sample deformation is measured

D L = change in sample length due to applied load

For cohesive soil

q_u (F| = q_u, For cohesionless soil where

q_u ~. = bearing capacity of footing

qu (p, = bearing capacity of test plate

BF. = breadth of footing

Bp. = breadth of test plate

If the above method gives too high bearing capacity, Engineer should use judgment to limit allowable pressure to be more reasonable for each type of soil condition. The prediction of settlement can also be done from the load-settlement curve from the test.

Variation in moisture content:

Considerable variation in moisture condition of subgrade soil are likely during the year, depending on climatic conditions, siol type, ground water level and its variations, drainage conditions, type of pavement and shoulders. The surface water during rains may enter the subgrade either through the pavement edges or through itself if it is porous. The subgrade moisture variations depend upon the fluctuations of ground water table. The moisture movement in subgrade is also caused by capillary action and vapour movement.

ROLLER

The rollers used are Smooth Wheeled Rollers which are of two types: vibratory and tandem roller. The former gross weight is 8-18 tonnes and the latter has 1-14 tonnes. The comcting efficiency depends upon weight, width and diameter of the roller. The smooth wheeled rollers are suitable to roll a wide range of soils, preferably granular soils and pavement material.

- Optimum configuration of drum axle load, amplitudes & centrifugal forces resulting highest compaction performance.
- Superb all-round view & improved front - rear visibility due to new design, resulting in more security & easy handling in confined working areas.
- Imported micron filter for protection of expensive hydraulics. Close - loop hydrostatic drive & vibration system ensuring trouble free operation.

Figure 6: N.H.1

- Full opening steel engine hood (hinge type) ensuring best maintenance-service access. The unique design of engine installation, hydraulic pump at rear resulting easy workability.
- Fully imported hydraulic kit ensures longer life. Fully imported planetary axle with disc brake.

Figure 7: Six Laning of NH-1

Fig.-Dr. Arvind Dewangan in Geotechnology Lab for Compact test of Materials of N.H.-1 on Geotechnology Lab at Haryana college of Technology & Management Kaithal

5. Conclusion

This paper shows the required to evaluate the strength characteristics of the soil subgrade, this helps the designer to adopt the suitable values of the strength parameter for design purposes and in case this supporting layer does not come upto the expectations, the same is treated or conditioned to suit the requirements. Another aspect of Civil engineering is materials science. Material engineering deals with ceramics such as concrete, mix asphalt concrete, metals Focus around increased strength, metals such as aluminum and steel, and polymers such as polymethylmethacrylate (PMMA) and carbon fibers. Materials engineering also consists of protection and prevention like paints and finishes. Alloying is another aspect of material engineering, combining two different types of metals to produce a stronger metal.

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