DEPARTMENT OF CIVIL ENGINEERING

Mid Assignment / Quiz (*Spring 2020)*

Subject: Pavement Material Engineering
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Semester: M.S (Civil Engineering)

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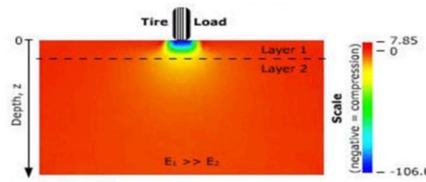
Q1:

Ans (a)



The phenomenon shown in the figure is the **stress and strain phenomenon**. In road the moving traffic load cause complex dynamic loading phenomenon and is considered as three effect….

1; stress in pavement cause by wheel load

2; time dependent response of the road material

3; stress induced by impact load

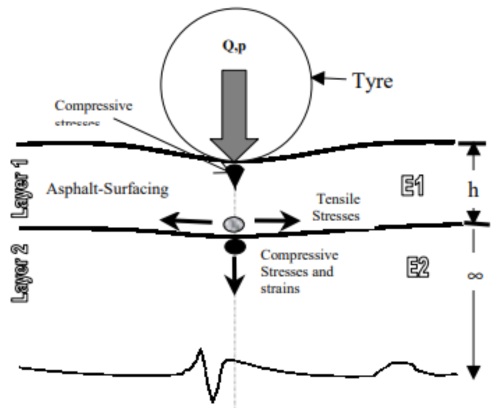
Figure describes the vertical stresses, horizontal stresses and shear stresses in the top of the layers as well as the compressive and tensile stresses in the layers. This shows that the principal stresses rotate before under and after the wheel load. It is important to recognize there are compressive stresses in the bound layers in front of and behind the wheel load, while the stresses are strongly tensile under the wheel load.

Ans (b)

The phenomenon produced under traffic loading refers to stress strain relationship in the pavement layers.

We can sub categorize the stresses and strains according to the axis under considerations vertical and horizontal stress and strains

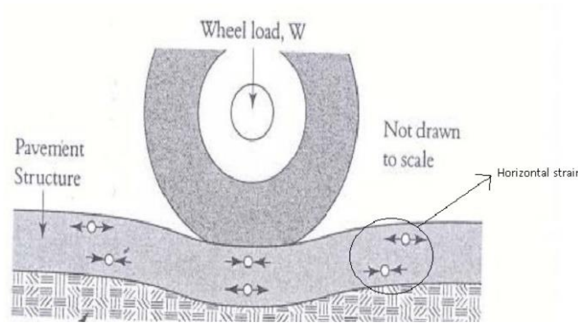
Vertical stress is the standard loading used in pavement design. It refers to the direct critical load which is transferred to each layer under the axis of the wheel load line of action. It is a normal line starting from the surface of wheel touching the pavement to the last layer of the road.



1.

horizontal load is the main cause of pavement interlayer shear stresses in areas where the vehicle accelerates, decelerates, brakes or turns such as toll gates, police check-points, airport runways experience interlayer slipping due to the effect of horizontal shear stress. This stress is not located directly under the wheel but it is the effect of the normal stress on the layers which produces the horizintal stresses.

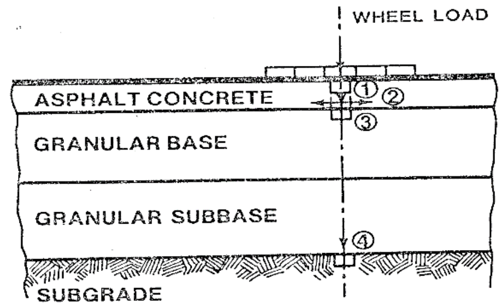
The vertical strain is responsible for the compression of the below layers. The compression is transferred to the sub layers with respect to the above existing layer. It depends upon the stability and load bearing capacity of the layer above the layer under consideration. For example the stresses from the pavement transfers strain to the subgrade and this strain depends upon the compressive strength of the above layer I.e the pavement. If the bearing capacity is low more strain will be transferred to the below layers and vice versa.
The horizontal strain is induced due to the effect of vertical strain which is transferred by grain to grain contact. Eligator cracks are one of the examples of the horizontal strain.
Horizontal strain also arises due to the screaching effect of the wheels of the an accelerating car or due to the slipping effect of the bracking/stoping vehicle.



Now lets relate the above discussed constraints with respect to the **granullar and stabilized base** of pavement.

Typical Flexible Pavement with Granullar Base:-

The wheel creates four types of stresses under the layer. The position of these stresses depends upon the layers and their respective properties i.e bearing capacity, compressional strength, tensile strength, permeability and water content etc. The four stresses are descibed as under



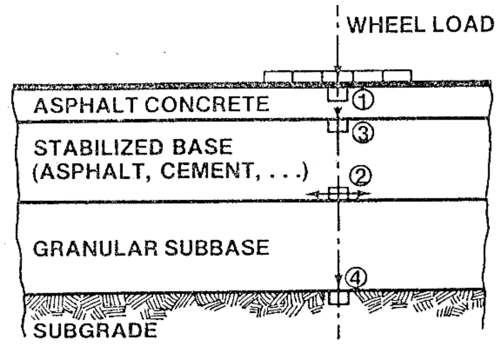
TYPICAL FLEXIBLE PAVEMENT
WITH GRANULAR BASE

i. In the first layer i.e asphalt concrete, compression is produced due to wheel load which is adjacent to the contact area of wheel and pavement. The compressive stress produces compressive strains which inturn causes rutting. This compressive strain is the representation of the vertical stresses and its consiquent strain.
ii. In asphalt concrete layer at its bottom tensile stresses are produced which are the effects of horizontal stresses and its strains which causes fatigue or aligator cracking.
iii. In the third layer of granullar base compressive stresses and their strains are produced at the top which produces rutting.
iv. In the fourth layer of grannular subbase compressive stresses and their strains are induced which inturns cause rutting and due to its position of being the last layer it also produces depression in the subgrade.

Typical Flexible Pavement with Stabalized Base:-

Base Stabilization is a process whereby the existing underlying materials (base, sub-base and/or sub-grade) is pulverized and mixed into a homogeneous base material without the presence of heat during the recycling process. The treatment used can be mechanical, chemical or bituminous. The purpose of a stabilized base or subbase layer is to provide a transitional load-bearing strata between the pavement layer, which directly receives the wheel loadings of vehicular traffic, and the underlying subgrade soil.

The wheel creates four types of stresses under the layer. The position of these stresses depends upon the layers and their respective properties i.e bearing capacity, compressional strength, tensile strength, permeability and water content etc. the four layer of road having stabilized base are as under….



TYPICAL FLEXIBLE PAVEMENT
WITH STABILIZED BASE

i. In the first layer of asphalt concrete due to wheel load compressive stresses are produced which in turns produces copressive strains.
ii. In the seconde layer of stabilized base tensile strains are induced in the lower zone which causes transvese reflective cracking or fatigue craching.
iii. Also in the second layer of stabilized base copressive strain are produced which cause rutting
iv. In the fourth layer of grannular sub base compressive strain is induced which inturn causes ruttuoing and depression in the subgrade.

Q.2

Ans (a):

Steps (procedure) considered while soil investigation and preparation of geotechnical report…

Soil investigation and soil explorations are conducted for the purpose of site investigation to get clear information about the soil properties and hydrological conditions at the site.

(i) **Desk study :** All possible info about all candidate sites are gathered.
(ii) **Site reconnaisance:** Site is visited to gather the initial data.
(iii) **Preliminary investigation:** It includes preliminary BHs and premilinary tests.
(iv) **Main investigation:** Detailed investigations,insitu tests, sampling and Lab test.
(v) **Geotachnical Report:** All findings are prepared and recommendations are made.

Ans (b):

Investigation of soil is done so as to determine geologic,sesmologic and hydrological and other sub surface conditions that influence selection of the project sites.

Now we will discuss the procedure/steps of soil exploration in detail.

(i). Desk Study:

- General geology of the site: The process of determing the layers of natural soil,deposits that will underlie a proposed structure and their physical properties as generally refered to as site investigation.
- History of the site: collection of past reports or investigation of the site and finding out the most suitable information for our exploration.
- Pavement details: The initial pavement details are aquired so as to get the idea of the following exploration procedure

(ii). Site Reconnaisance:

- Reconnasisance includes site visit,general topography,general ground slope,property and proposed ROW,presence of water couses,soil stratification from deep cuts.
- An early examination of the site by appropriate experts is most desirable eg. Geologist, land surveyor, soils engineer, hydrologist etc. Information should be collected on the overall site layout, topography, basic geology; details of access, entry and height restrictions. Local conditions should be examined, such as climate, stream flows, groundwater conditions, site utilisation related to weather and time of year. Where possible photographic records should be kept.

(iii): Preliminary investigation:

This phase includes gathering information such as the type of structure to be constructed and its future use, the requirements of local building codes, and the column and load bearing wall loads. This investigation includes site works like

* Test pits

* Boring or drilling

* Sampling

* Insitu density/moisture

*Testing SPT,CPT

Considerable savings in the exploration program can sometimes be realized if the geotechnical engineer in charge of the project thoroughly reviews the existing information regarding the subsoil conditions at the site under consideration. Useful information can be obtained from the following sources.

- Existing soil exploration reports prepared for the construction of nearby structures.
- The engineer should visually inspect the site and the surrounding area. In many cases, the information gathered from such a trip is invaluable for future planning. The type of vegetation at a site may in some instances the type of subsoil that will be encountered. Open cuts near the site provide an indication about the subsoil stratification. Cracks in the existing wall of nearby structures may indicate settlement from the possible existence of soft clay layers or the presence of expansive clay soils

(iv): Detailed investigation:

This phase consists of making several test borings at the site and collecting disturbed and undisturbed soil samples from various depths for visual observation and for laboratory tests. No hard and first rule exists for determining the number of borings or the depth to which the test boring is to be advanced. For most buildings, at least one boring at each corner and one at the center should provide a start. Depending on the uniformity of the subsoil, additional test borings may be made. The test borings should extend through unsuitable foundation materials to firm soil layers

(v): Investigation Report:

Soil reports also called geotechinical reports are prepared by liscnsed engineer or eegestered civil engineer experienced in soil engineering. A soil report may be required depending on the type of structure,load and location of the structure.

The report gives understanding of earth’s condition affecting a building.they are required in areas with expansive or less strength soil. Other times soil reports may be required including buildings where the foundation will be supported by fill, project on steep slopes or where a lot of grading will be done. Location will high ground water may also require a soil investigation report prior to construction activities.

Q(3)

Ans:

The following graph is representing the bearing ratio of a material under consideration wrt standard material(Good crushed rock and crushed gravel bases) of the CBR test.

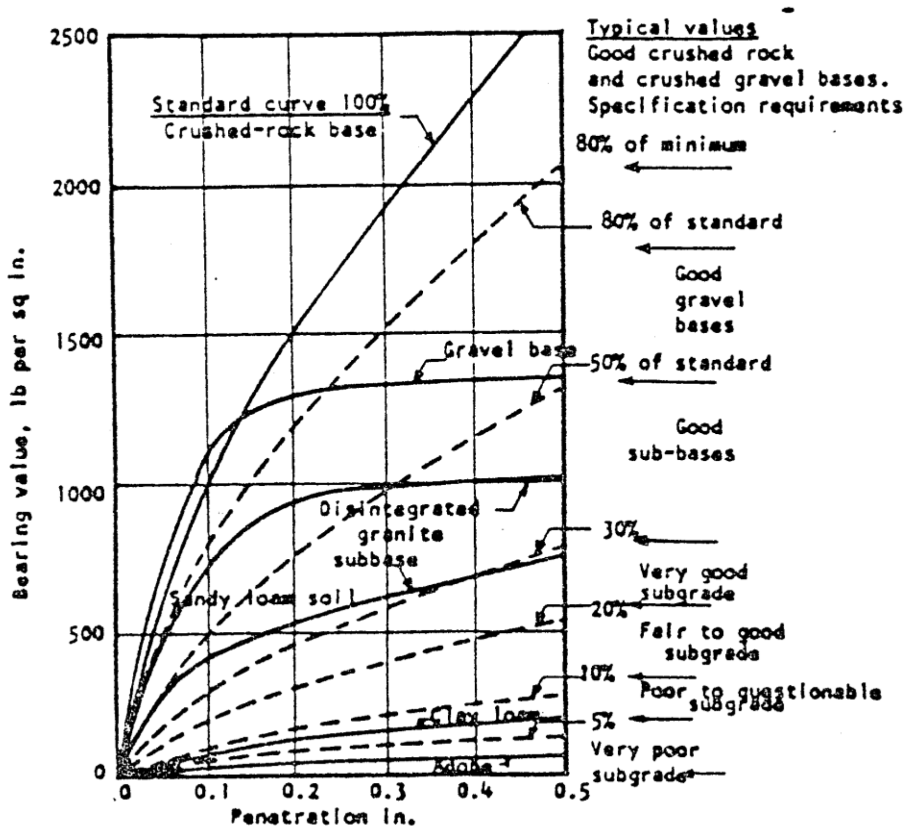


Figure 2-1.7. CBR Testing Procedure and Load-Penetration Curves for Typical Soils.

- The graph abscisa represents the penetration of the plunger in inches.
- The oblongata of the graph represents the bearing value i.e lb per square inch.
- The graph is denoting the standard curve i.e 100% value on a bold line.
- Starting from the bottom the first line indicates a very poor subgrade as the penetration value has reached its maximum value of 0.5 inch by applying a very small fraction of load. Its less than 2% of the standard curve.
- The first bold curve from the bottom that indicates 5% of the standard curve is of a clay loam.the graph is clearly showing the looseness of the soil as it is poor in holding the stress i.e the full penetration (0.5 inch) in reached by merely holding 5% of the standard load which 125 lb/inch. It is also reffered as poor to questionable subgrade.
- The adjacent curve to the clay laom is the one which holds 10% of the standard penetration and is designated as fair to good subgrade. There is not much difference between it and the 5% curve.

- The curve representing 20% of standard bearing value is designated as very good subgrade.the difference between this and the predecisive graphs is that its slope is bit increased. Which is a sign of increase in bearing capacity.
- Now the 2nd bold curve is crossed by the dotted curve line of the 30%. If a closer look is given the bold curve(Sandy loamy soil) drops at the end which indicates that there might be shear failure under high stresses.
- The 3rd bold curve which indicates disintegrated granite subbase have a linear start upto approximately 700 lb/inch, after that the graph slopes started deceasing and the got flat which shows that the material is good at handling the lighter stresses but weaker at higher points. The graph the initial stages if interpolated would have reached upto 70% of the standard stregth but it declined after 700lnb/inch.
- The 4th bold curve which indicates the gravel base is same as the standard graph uptill approximately 1300 lb/inch stress but than a rapid diclination is observed and than reached to the point of 50% of the standard strength. This graph also indicated the behaviour of gravel base same as that of disintegrated granite subbase which is that it is weaker at higher loads.

A final conclusion obtained will be that the the soils or material uptill 20% of the standard material shows consistency in the graph progression i.e the weak materials remain weaker till the full application of load, while if considered above the 20% we can see that the graphs loses their consistencies i.e the graphs start a very steep progression or they are linear at the start but after some points they loose their consistencies and almost get flattened at the end.

Q. 4 :

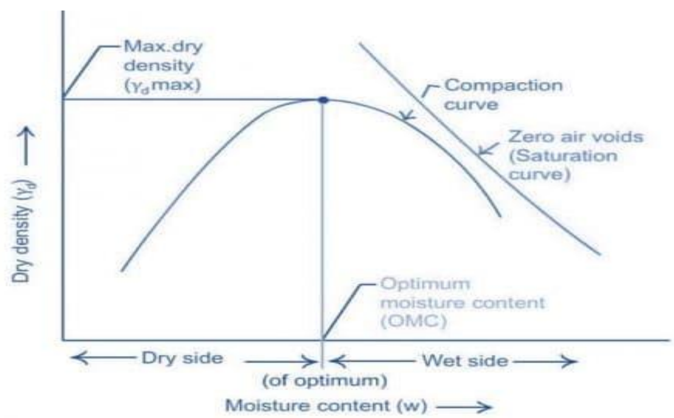
Ans (a)

It is known that the soil becomes dense when it undergoes compaction. To facilitate easy compaction, some amount of water is added to the soil and the water content at which the maximum dry density of soil can be obtained is known as **optimum moisture content**. It can be seen in the compaction curve(fig-1).

<u>Dry of optimum:</u> So, if the amount of water added is less than the optimum moisture content then it is called as **dry of optimum compaction**. OR

Optimum moisture content of the soil to the dry side of OMC is called dry of optimum.
Water as a lubricant here and so become easy for particles to rearrange and orient.

<u>Wet of optimum:</u> If the amount of water added is more than the optimum moisture content then it is called as **wet of optimum compaction**. OR
Optimum moisture content of the soil to the wet side of the OMC is called wet of Optimum.
Here the water are too much and replaces the soil particles.



Ans (b):

Effects of compaction on Engineering properties of soil

Following are the properties of soil which get affected by compaction:

(i) Permeability
(ii) Compressibility
(iii) Shear strength
(iv) Soil structure
(v) Swelling of soil
(vi) Shrinkage of soil
(vii) Pore water pressure
(viii) Stress-strain behavior of soil

(i). Permeability

- Compaction reduces the voids present in the soil hence permeability also reduces.

- At a particular density, for the same soil sample, permeability is more for soils which are compacted to dry of optimum than those compacted to wet of optimum.

(ii). Compressibility

- The Compressibility of compacted soil varies according to the amount of pressure applied.
- For low-pressure range, compressibility is more for soils which are compacted to wet of optimum than soil compacted to dry of optimum.
- Similarly, for high-pressure ranges, compressibility is more for soils which are compacted to dry of optimum than soil compacted to wet of optimum.

(iii). Shear Strength

- Shear strength of soil compacted to dry of optimum is more than those compacted to wet of optimum at lower strains.
- At higher strain, soil compacted to wet of optimum will have more shear strength.
- Type of compaction, drainage conditions and type of soil also influence the shear strength of compacted soil.

(iv). Soil Structure

- Soils compacted to dry of optimum have flocculated structure due to the attraction between soil particles because of low water content.
- Soils compacted to wet of optimum have dispersed structure due to repulsive force between soil particles because of high water content.

Fig 3: Effect of Compaction on Soil Structure

(v). Swelling of Soil

- When the soil is compacted to dry of optimum, the soil is in need of water and it swells easily when contacted with water.
- When water is compacted to wet of optimum, the soil particles are oriented in a dispersed manner and swelling does not occur.
- So, to avoid swelling, soils should be compacted to wet of optimum.

(vi). Shrinkage of Soil

- Shrinkage is more for the soil compacted to wet of optimum than dry of optimum.
- In case of dry of optimum compaction, soil particles are in random orientation and they are in stable condition.
- But in case of wet of optimum, soil particles are in parallel orientation and they are unstable which makes it easy for packing of particles causing shrinkage.

Fig 4: Shrinkage Cracks in Wet Compacted Soil

(vii). Pore Water Pressure

- Pore water pressure is high for those soil whose water content is high. Hence, soils compacted to wet of optimum compaction will exhibit more pore water pressure than soil compacted dry of optimum.

(viii). Stress-strain Behavior of Soil

- Soils compacted to dry side of optimum will take more stress for little strain hence, stress-strain curve of this type of soil is much steeper and elastic modulus is more. Brittle failure occurs in this case.
- Similarly, soils compacted to wet of optimum will produce more stress even for smaller stress. Hence, Stress-Strain curve, in this case, is much flatter and plastic-type failure occurs at a larger strain. These type of soils have low elastic modulus.

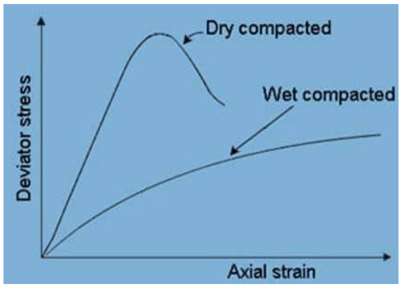


Fig 5: Stress – Strain Behavior of Compacted Soil