IQRA NATIONAL UNIVERSITY

DEPARTMENT OF CIVIL ENGINEERING

Mid Assignment spring 2020

Subject: Pavement Material Engineering (CE-577)
Instructor: Engr.Shabir Ahmad
Department & Semester: MS (CEM) Final semester
Submitted By: Engr.Haroon Khan **ID#15212**

Q. No. (01)
1. Given Figure. 1 refers to which phenomena of the pavement conditions?
2. Find the phenomena and discus that phenomena / behavior for flexible pavement with granular base and stabilized base.

<u>**Ans (1)**</u>

The figure given represent stress and strain phenomenon for flexible pavement.
There are various modes in which the pavement fails. Cracking of the surface layer and permanent deformation of the pavement system which manifests as rutting on the pavement surface. Larger and more concentrated loads produce larger stresses and strains, with thicker layer carrying higher flexural stresses than thinner layers. In pavement analysis, loads on the surface of the pavement produce two strains which are believed to be critical for design purposes. These are the horizontal tensile strain; at the bottom of the asphalt layer and the vertical compressive strain; at the top of the subgrade layer. The design criteria will be used for an analytical approach of pavement design

<u>**Ans (2)**</u>

The phenomenon of Burmister two layer theory is adopted in the present diagram.
Burmister proposed a method for design of a two layer flexible pavement by the Simplifying assumption that the subgrade is the bottom layer and the surfacing, base and Sub base combine to form the top layer .Burmister further assumed that the op layer can be treated as an elastic slab infinite in the horizontal plane . The top layer is supposed to be resting on the bottom the bottom layer (in the case of subgrade) which is assumed to be semi infinite solid of lower modulus of elasticity compared to that of the top layer.

The diagram show deflection of road at the center of wheel

The figure show the deflection of flexible pavement under the center of wheel load when the load applied on it.

It is generally accepted that pavements are best modeled as a layered system, consisting of layers of various materials (concrete, asphalt, granular base, sub-base etc.) resting on the natural subgrade. The behavior of such a system can be analyzed using the classical theory of elasticity (*Burmister, 1945).*

The Layered Elastic Analysis (LEA) is a mechanistic procedure capable of determining pavement responses (stress and strain) in asphalt pavement. The major assumptions in the use of layered elastic analysis are that;

The pavement structure is regarded as a linear elastic multilayered system in which the stress-strain solution of the material are characterized by the Young's modulus of Elasticity E and poison's ratio µ.
ii) Each layer has a finite thickness h except the lower layer, and all are infinite in the horizontal direction.
iii) The surface loading P can be represented vertically by a uniformly distributed vertical stress over a circular area.

Flexible Pavement
Flexible pavements are most commonly used for low to medium volume roads with significant usage also found in high volume interstate highways and airfield runways, taxiways and aprons subjected to heavy aircraft gear/wheel loads. As the demand for applied wheel loads and number of load applications increases, it becomes very important to properly characterize the behavior of subgrade soils and unbound aggregate layers as the foundations of the layered pavement structure.
Flexible pavements will transmit wheel load stresses to the lower layers by grain-to-grain transfer through the points of contact in the granular structure. The wheel load acting on the pavement will be distributed to a wider area, and the stress decreases with the depth.

Contour plot through plane that show different plot results, maximum, minimum, mean and their graphics are presented in diagram,
to incorporate the material properties of the pavement layers and the moving traffic load, in the analysis of the flexible pavement, using the finite element method.

As observed above analysis from laboratory test result and standard specification result, the vertical deflection reduces as the modulus increases at all values of E.

Q. No. (02)

Being a material design expert, if client department award you the consultancy for preparation of the geotechnical report for the upcoming road project.

1. **Which steps (General Procedure) you would consider while soil investigation and preparation of Geotechnical Report?**
2. **Also elaborate the steps briefly in your own words**

Ans (1)

For construction of a road project, a knowledge about the ground conditions is important. The soil structure, capacity and behavior under various loading conditions will help design the substructures and Retaining Structures, and to suggest remedial actions to improve ground conditions when required.

- Exploration in soil- involves a site visit, quick visual inspection and detailed tests to determine the behavior
- The field and laboratory investigations required to obtain necessary data regarding the soil, for proper design and successful construction of any structure at the site are collectively called soil exploration."
- Costs 0.05-0.2% of the total project cost- Proper planning must

Objectives of soil Investigation:

Assess the general suitability of site

Bearing capacity of the soil

Select type and depth of foundation for a given structure

Estimate max. Probable settlement (total and differential)

Investigate the nature and depth of each stratum and assess required properties

Study the ground water condition

Predict possible difficulties and problems in the site and suggest remedial actions

Ensure safety of existing structures

Investigate the occurrence of any natural or manmade changes in conditions and the result from those changes

Select suitable construction materials and techniques based on availability and economy

Study of shrinkage and swelling potential

Study of lateral earth pressure on the soil, and drainage at the site

Costs 0.05-0.2%- Even 1% in some cases-So proper planning must!!

- Depends on
- Type and importance of structure
- Nature of subsoil(strata variability)
- Budget/economy
- Involves Location and depth of boreholes
- Tests to be done, and test methods
- Sampling methods

3 important phases:

- Planning
- execution
- report writing

Preliminary Investigations:

- To assess the need for detailed investigation
- Det. of depth, thickness, extent and composition of each layer or stratum within the zones affected by foundation pressure and construction
- Depth of bedrock and Ground water table also studied
- Lab and field tests to assess basic properties
- Chemical and bacteriological tests if needed

Methods:

- Boreholes
- test pits
- Cone penetrometer
- Sounding rods
- Geophysical methods

Detailed Investigation:

- Mainly for big projects- Dams, bridges, multistoried buildings
- Also for newly built up soil
- Involves extensive boring programmed
- sampling
- lab and field testing
- For small projects on site with uniform strata or clear history, info. from reconnaissance and Preliminary Investigation
- sufficient Location of additional boreholes
- confirmatory boreholes
- Aim: Maximum info. With minimum no: of holes
- Uniform strata
- boreholes at regular spacing

Q. No. (03)

The below Figure. 2-1.7 refers to the CBR results showing penetration of the piston in X-axis and bearing value on Y-axis. At y-axis right side of the graph, it shows ranges in percentage from 5% to 100% referring to different degrees of the subgrade (any material) quality in reference to CBR test.

1. **Please elaborate the Figure in your own words in detail**

Ans:

In this graph the X-axis shows the penetration resistance offered by subgrade materials to the standard piston of CBR apparatus while Y-Axis shows the corresponded strength of the materials in pound per square inch.

The graph cure represent the 100% value of CBR as per applied load and given penetration.

From the figure it shows that

At the bottom the value of CBR 5% indicate very poor subgrade.

According to the graph when the penetration value reach to his maximum value 0.5in under very little load less than 200lbs.

The 1st bold curve at the bottom which indicate 5% value of CBR represent clay loam. The graph shows poor condition of soil as it reached to his highest penetration value at the load of above 250lbs,its refereed to be poor to questionable subgrade.

The next cure which represent 10% of the standard penetration value give a fair to good subgrade, its show the diff between 5% and 10%. Its means the penetration value of this cure is more than the previous curve and the same it bearing load which is more than the previous layer.

The next cure give us CBR value of 20% under the bearing load of more than 500lbs at the maximum penetration rate which represent very good subgrade. The main diff b/w this curved and the previous curve is that its slope slightly increased as compared to the previous one which represent high bearing load and same high penetration value.

The next curve are plotted bold at 30% CBR value which represent very good subgrade, and show sandy loam soil. The curve drops at the end which shows that their must happening shear failure under high stresses.

The third bold line the graph represent disintegrated granite sub base have a linear start up to approximately 700lbs, after that graph slopes started deceasing and get flattened which represent that the materials is good at handling the lighter stresses but weaker at higher point, the graph if interpolated we get up to 70% of the strength but it declined after 700lbs

The fourth bold curve indicate that the gravel base is same as the standard graph up tp approximately 1300lbs stress but than a rapid declination is observed and then reached to the point of 50% of the standard strength. This graph also indicate the behaviors of gravel base same as that of disintegrated granite subcase which is that it is weaker at higher loads.

The summary of the graphic representation is that at the soil material up to 20% of the standard materials shows consistency in the graph progression, I.e. the week materials remain weaker till the full application of load, while if considered above the 20% we can see that the graphs loses their consistency I.e. the graph start a very steep progression or they are linear at the start but after some points they losses their consistency and almost get flattened at the end.

Q. No. (04)

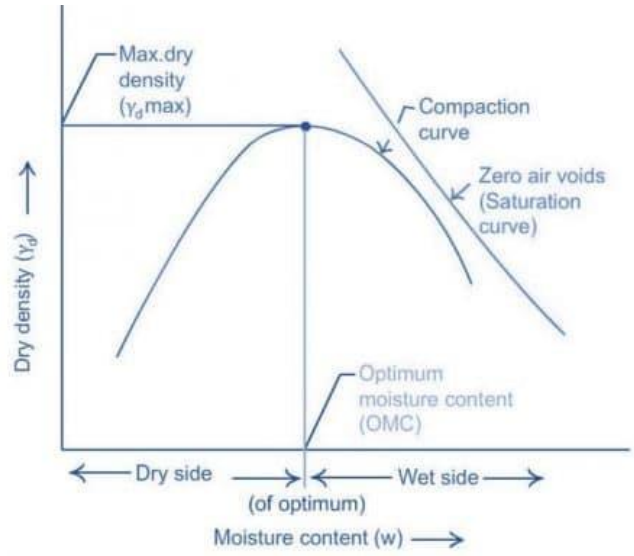
1. In the Figure given below what is Dry of optimum and Wet of optimum? Explain?

2. What are effects of compaction on Engineering properties of soil? Details.

Ans (1)

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).

So, if the amount of water added is less than the optimum moisture content then it is called as **dry of optimum compaction**. If the amount of water added is more than the optimum moisture content then it is called as **wet of optimum compaction**. Effects of compaction on engineering properties of the soil are briefly discussed below.



Ans (2):

Effects of Compaction on Soil Properties

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

1. Permeability
2. Compressibility
3. Shear strength
4. Soil structure
5. Swelling of soil
6. Shrinkage of soil
7. Pore water pressure
8. Stress-strain behavior of soil

1. 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.

2. 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.

3. 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.

Fig 2: Compaction of Soil using Sheep-foot Roller

4. 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.

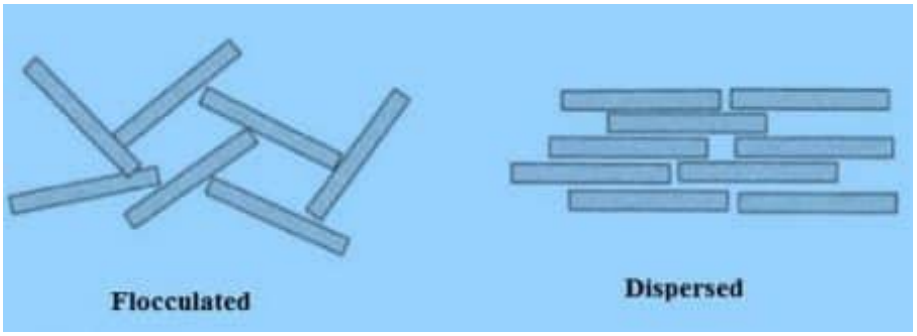


Fig 3: Effect of Compaction on Soil Structure

5. 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.

6. 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.

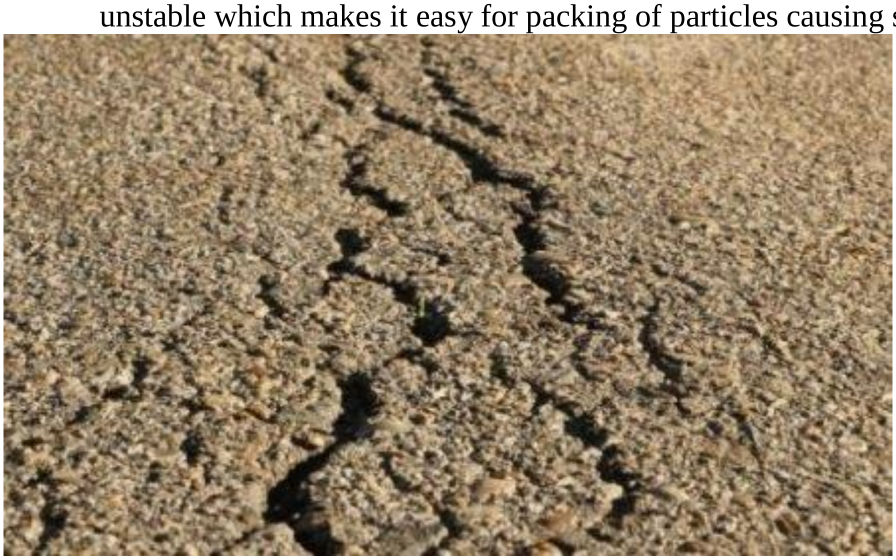


Fig 4: Shrinkage Cracks in Wet Compacted Soil

7. 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.

8. 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.

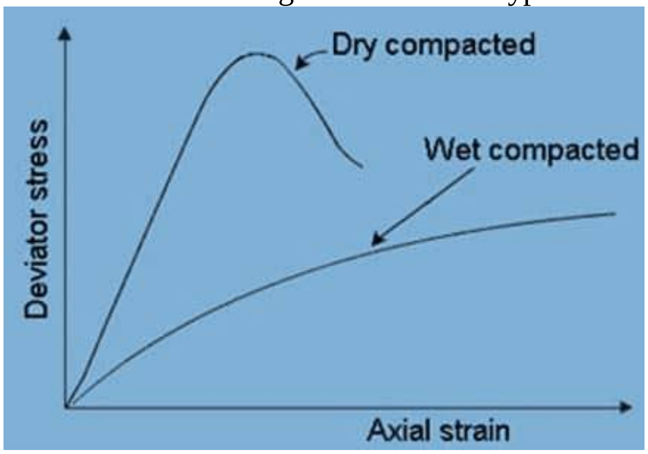


Fig 5: Stress – Strain Behavior of Compacted Soil

THE END