DEPARTMENT OF CIVIL ENGINEERING
Mid Assignment / Quiz (Spring 2020)

Subject: Pavement Material Engineering

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Q1: (a) Given figure.1 refers to which phenomena of the pavement conditions?
(b) Find the phenomena and discus the phenomena/ behavior for flexible pavement with granular base and stabilized base.

Ans.

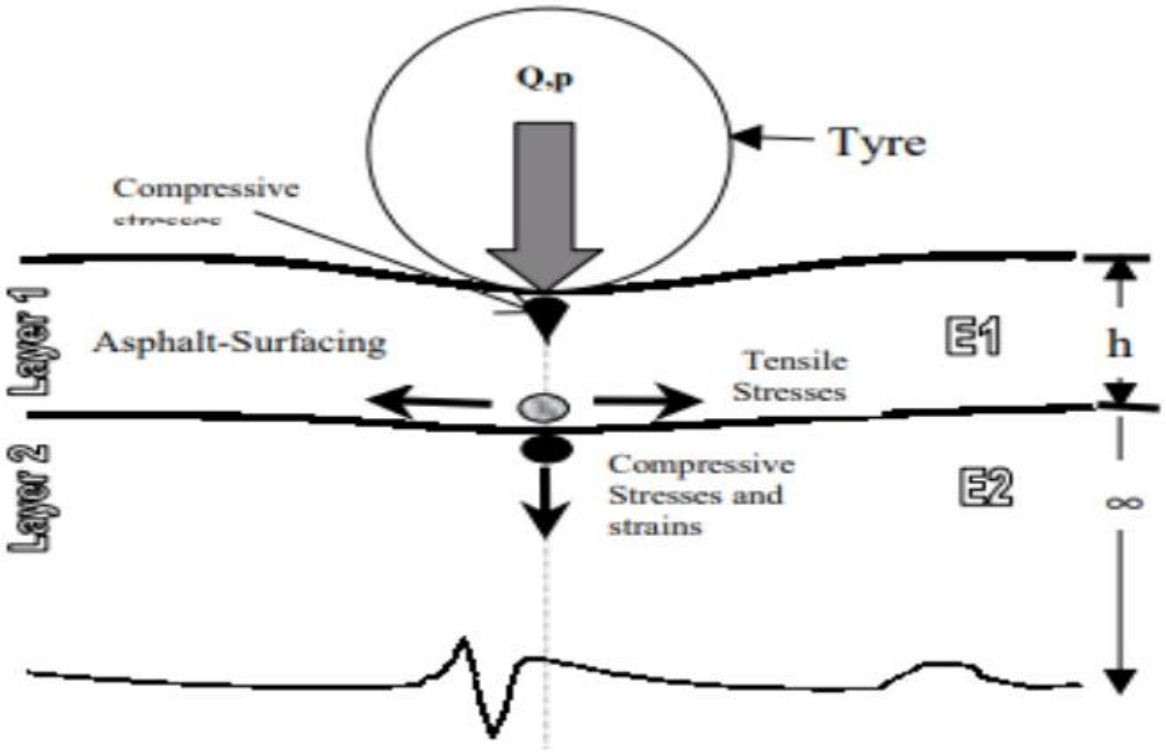
a) The phenomenon shown in the figure is the **stress and strain phenomenon**. In road the moving traffic load cause complex dynamic loading phenomenon and is considered as three effects….

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.

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.

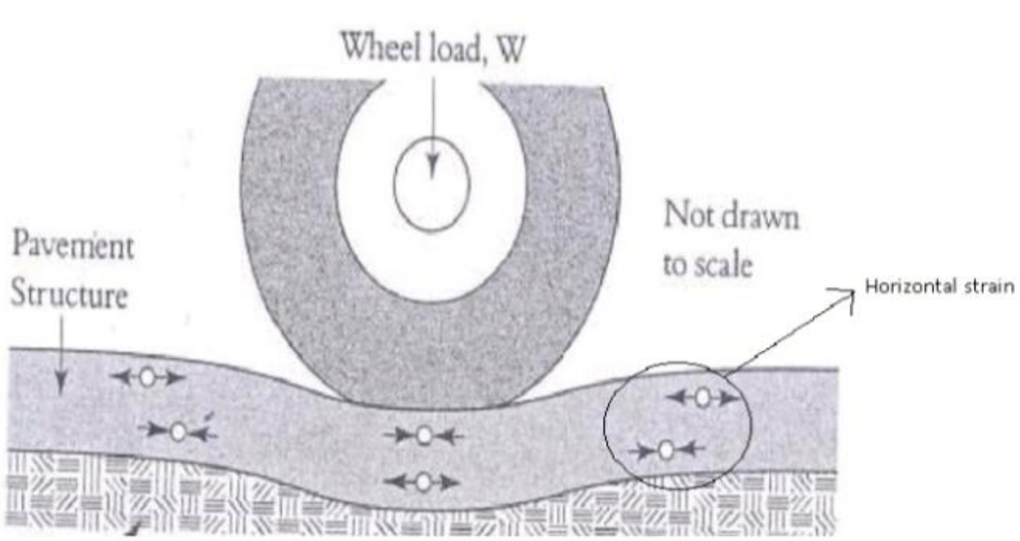
Horizontal load is the main cause of pavement interlayer shear stresses in areas where the vehicle accelerates, decelerates, brakes or turns such as toll gates, police check-points, airport runways experience interlayer slipping due to the effect of horizontal shear stress. This stress is not located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

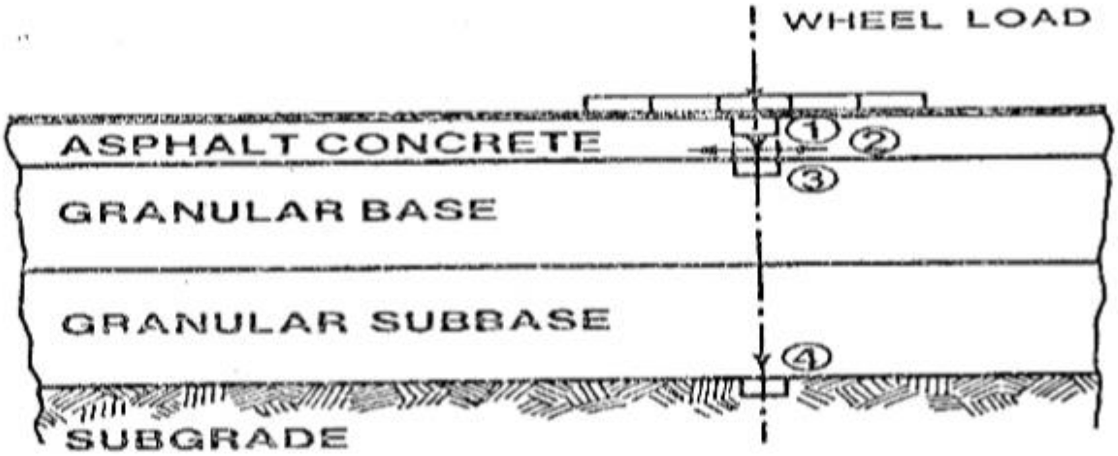
Horizontal strain also arises due to the screeching effect of the wheels of the accelerating car or due to the slipping effect of the braking/stopping vehicle.



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 *sub base* layer is to provide transitional load-bearing strata between the *pavement* layer, which directly receives the wheel loadings of vehicular traffic, and the underlying sub grade 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….

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.

Q2: Being a material design expert, If client department award you the consultancy for preparation of the geotechnical report for the upcoming road project.

a) Which steps (General procedure) you would consider while soil investigation and preparation of Geotechnical Report?

b) Also elaborate the steps briefly in your own words.

Ans:

a) There is Five General procedure steps involve which gave Below:

1. Desk Study
2. Site Reconnaissance
3. Preliminary ground investigations
4. Detailed ground Investigation
5. Geotechnical Report/ Monitoring

b) 1. <u>Desk study</u>

- The desk study is the first stage of the site investigation process which involves researching the site to gain as much information as possible, both geological and historical.
- A good starting point is to use Ordinance survey maps which allow the selection of the site by obtaining accurate grid reference through the maps.
- In addition to present maps, old maps are used to gain historical information such as former uses to the site; concealed mine workings; in filled ponds; old pits; disused quarries; changes in potential landslide areas, etc.

i. <u>Geological map</u>

Geological maps are probably most important source of information as these give and excellent indication of the sort of ground conditions like to be encountered.

ii. **<u>Aerial photography</u>**

Aerial photography is another extremely useful source of information on topography and ground conditions.

iii. <u>Records of previous investigation</u>

Records of previous investigation reports also helpful in a desk study. The many sources of site investigation data include previous company and public works department.

2. **<u>The site reconnaissance phase of site investigation</u>**

- This site investigation is done through a site visit or walk-over survey.
- Important evidences to look for are site lay out, surface condition, climate and hazards water levels, etc.
- Generally the desk study and reconnaissance is aimed the feasibility study of the being planned.
- If the desk study shows that the site is feasible for the structure, then preliminary investigation should follows.

3. **<u>Preliminary investigation</u>**

- Preliminary investigation is aimed at predicting the geological structures, soil profiles and the position of ground water table by geophysical method or by making a few boreholes.
- The investigation should give information on the existence on ground structures that may need closer examination. For example,
  1. The extent of disturbed strata.
  2. The location and extend of natural cavities and mine working.
  3. Fractures and river crossings or alluvial areas that may have buried soft material or pet, their liability to cause subsidence, surface movements or instability.
  4. Information on suitability of soil for fills work, ground water condition and the possibility of flooding should be provided at this stage.

4. **Detailed investigation**

- At this stage, the extent of the test, number and depth of boreholes, selection of appropriate equipment for field testing and the choice of laboratory testing are made.
- Soil exploration consists of three steps:
  1. Boring and in-situ testing
  2. Sampling
  3. Laboratory testing

5. **Geotechnical report/Monitoring**

- Monitoring in during construction and maintenance period is required whether expectations of the proceeding investigation have been realized.
- No one can ensure that the soil parameters used for design is the most representative of the soil conditions at the site unless the response is obtained.
- Field observation can help for easily diagnosis and redemption of any problem that might be encountered during construction.
- Among the measurement made during the monitoring stage are the settlement, displacement, and deformation, inclination, and pore water pressure.

Q3: The below figure 1-2.7refers to the CBR results showing penetration of the piston in X- axis and bearing value axis. At y- axis right side of the graph, it shows ranges in percentage from 5% to 100% referring to different of the subgrade (any material) quality in reference to CBR test.

a) please elaborate the figure in your own words in detail.

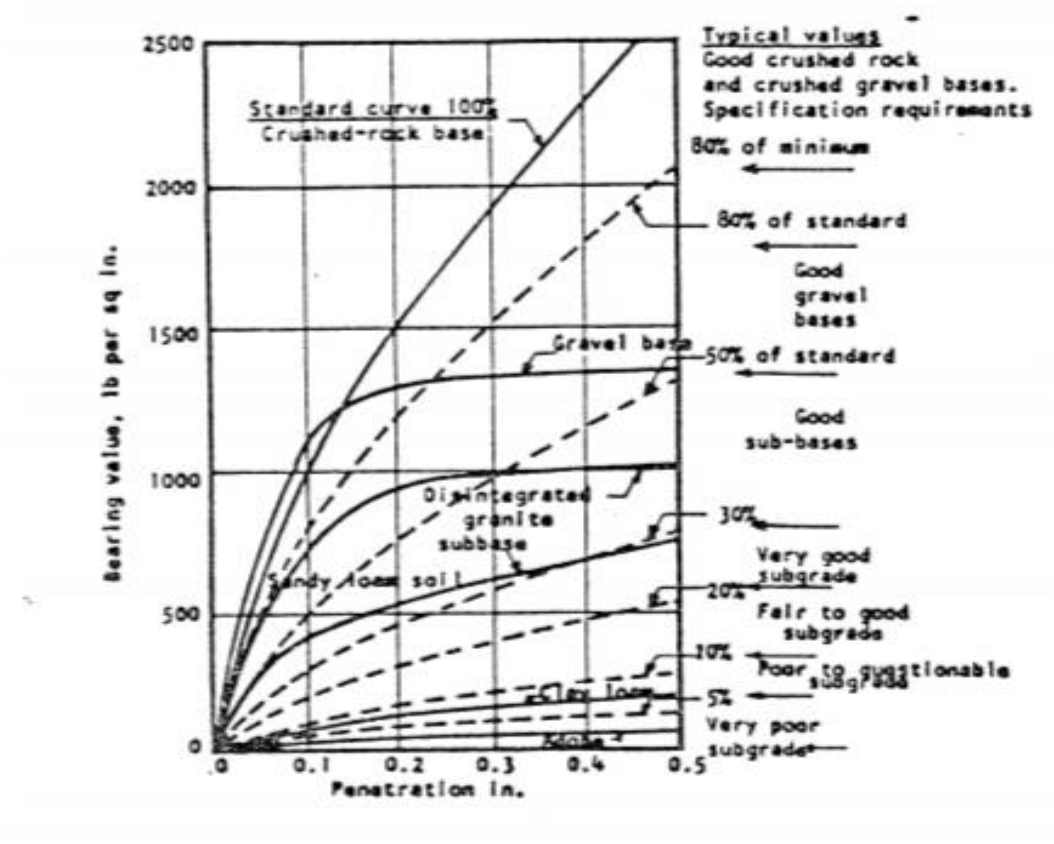


Figure 2-1.7. CBR Testing Procedure and Load-Penetration Curves for Typical Soils.

Ans. Soil for civil engineering purposes. It was first developed by California State Highway Department and is used in the field as an arbitrary strength test which is considered to stress soils and replicate wheel load. The CBR test forms part of the site investigation and used to determine the thickness of materials needed for the proposed road construction.

How is a CBR Test performed?

The CBR test is performed by measuring the sample with a plunger of standard area. The measured pressure is then divided by the pressure required to achieve an equal penetration on a standard crushed rock material. The harder the surface, the higher the CBR value. Typically, a value of 2% equates to clay, while some sands may have a value of between 80-100% (maximum). The CBR test is carried out on soils with a maximum particle size of 20mm. (Note: For material greater than 20mm please see plate Bearing Tests). The technique involves driving a small cylindrical plunger (approx 50mm) into the ground at a uniform rate, using a four wheel drive vehicle as the reaction load to provide the force. Tests are normally carried out at surface level or at depths of between 500-1000mm in 20-30m intervals along the proposed construction centerline. A minimum of three tests are usually carried out at each site. On a typically site, and assuming surfaces are prepared, up to 8-10 tests can be carried out in a day, by a single operator, with provisional results available on site.

The abscissa of the given graph shows values of the penetration of the plunger in inches while the ordinate gives values of the bearing in pound per square inch. The bold live in the graph is representing the standard curve having a value of 100%.

Starting from the bottom, the first line shows a very poor sub grade as the penetration value of it has reached its maximum value of 0.5 inch by applying a very small fraction of load. It is 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 125lb/inch. It is also referred as poor to questionable sub grade.

The adjacent curve to the clay loam is the one which hold 10% of the standard penetration and is designated as fair to goo sub grade. There is not much difference between it and the 5% curve. The curve representing 20% of standard bearing values is designated as very good sub grade. The difference between this and the predecisive graphs is that its slope is bit increase in bearing capacity.

The 3rd bold curve which indicates disintegrated granite sub base have a linear start up to approximately 77lb/in, after that the graph slopes started decreasing and they got flat which shows that the material I good at handling the lighter stresses but weaker at higher points. The graph in the initial stages if interpolated would have reached up to 70% of the standard strength but it declined after 700lb/inch.

The 4th bold curve which indicates the gravel base is same as the standard graph up to 1300lb/inch stress but than a rapid declamation is observed and then reached to the point of 50% of the standard strength. The graph also shows the behavior of gravel base same as that of disintegrated granite sub base which is that it is not strong at higher loads.

Q4. (a) In the figure given below what is dry of optimum and wet of optimum? Explain?

(b) What are effects of compaction on engineering properties of soil? Details.

Ans.

(a) Optimum

Moisture content refers to the water content of a compacted soil. OMC of a soil is also called the compacted **dry of optimum or wet of optimum** on the dry side or wet side of OMC, respectively. This difference has a strong influence on the engineering characteristics of the soil.

- **Optimum Moisture content**

  Optimum moisture content refers to the water content of a compacted soil. OMC of a soil is also called the compacted dry of optimum or wet of optimum on the dry side or wet side of OMC, respectively. The structure of a compacted soil is not similar on both sides even when the dry density is the same.

  Why does the earth have optimum temperature condition?

  Earth has the optimum temperature condition because there is proper distance of the earth from the sun. The distance is not too far from the sun or not too close to the sun. so the sun rays can come to the earth's surface in a proper manner. Also the atmosphere of the earth plays important of the earth. Some sun rays are effects from the earth's surface se some portion of the heat can reach to the earth and the rest of the heat reflects back to the atmosphere.

- **Maximum Dry Density and Optimum Moisture Content of Soil**

  The determination of maximum dry density and optimum moisture content of the soil is a measure of compaction level of soil. This can be measure by mainly two methods;

  1. Standard Proctor Compaction Test
  2. Modified Proctor Compaction Test

  Both the tests help to determine the optimum moisture content that is required for soil to attain maximum compaction i.e. maximum dry density for performing construction.

- **Effect of Compaction on Soil Properties**

  compaction is the process of expulsion of air from the voids present in the soil. In the construction field, it is an important process as it improves the engineering properties of soil to a great magnitude. Effects of compaction on different properties of the soil are explained in this article.

  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 curves, 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**.

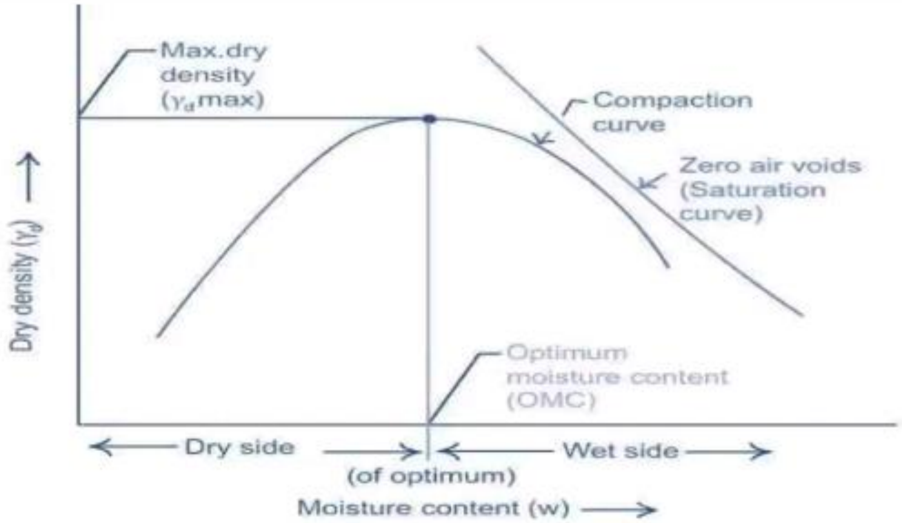


Fig 1: Compaction Curve

(b) Effect of Compaction on Properties of Soil

When a soil is compacted, it changes its engineering properties and there by behaves differently. Some of the engineering properties which changes on application of compactive effort is briefly described below;

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

1. Permeability

- Compaction reduces the void present in the soil hence permeability also reduces.
- At a particular density, for the same soil sample, permeability is more for soil which are compacted to dry of optimum than those compacted to wet of optimum.
- The effect of compaction is to decrease the permeability. In the case of fine grained soils it has been found that for the same dry density soil compacted wet of optimum will be less permeable than that of compacted dry 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 of optimum.

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

4. **Soil Structure**
   - Soil 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.

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.

7. **Pour Water Pressure**
   - Pour water pressure is high for that soil whose water content is high. Hence, soils compacted to wet of optimum compaction will exhibit more pore water pressure than soil compacted dry 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 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.

(P.T.O)

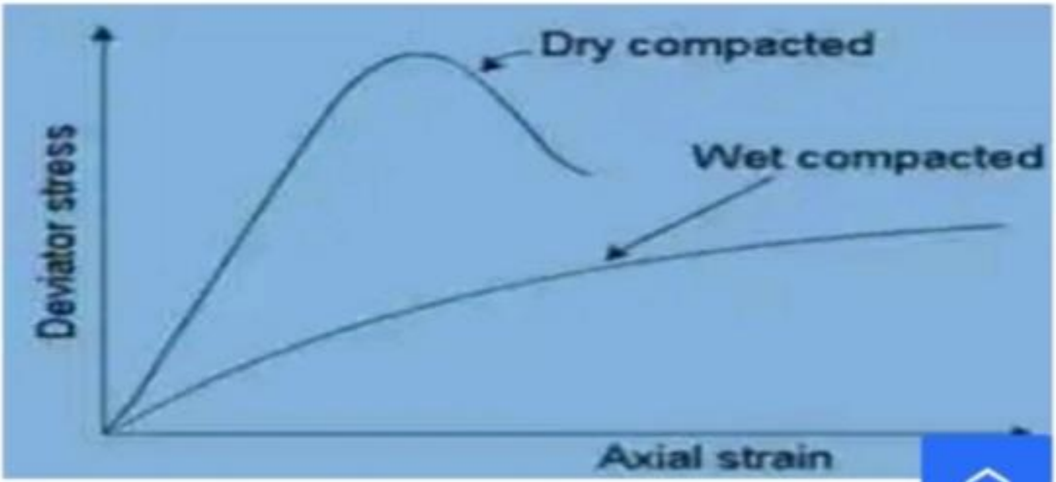


Fig 5: Stress – Strain Behavior of