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Q.1(A). Given Figure. 1 refers to which phenomena of the pavement conditions?

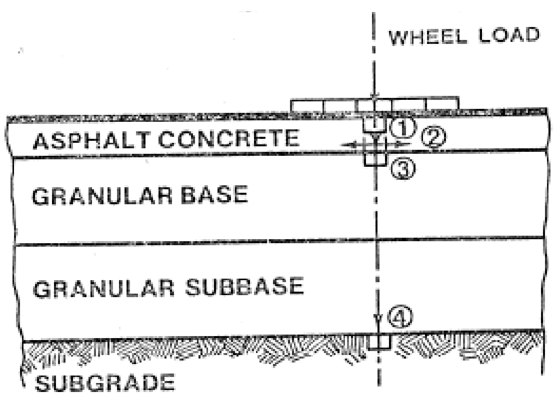
The given figure refers to Stresses and Strains phenomena of the pavement conditions. According to this phenomenon, the pavement directly under the load is under compression, while most of the surrounding is under very little stress.

Q.1(B). Find the phenomena and discus that phenomena / behavior for flexible pavement with granular base and stabilized base.

According to the Stresses and Strains phenomenon, the pavement directly under the load is under compression, while most of the surrounding is under very little stress.

The Stress/Strain phenomenon for Flexible pavement with Granular Base and Stabilized Base is explained below with help of diagrams to show the critical locations where Stresses and Strain occur once the pavement is under the wheel load.

1. **Stress – Strain phenomena for Flexible pavement with Granular Base:**

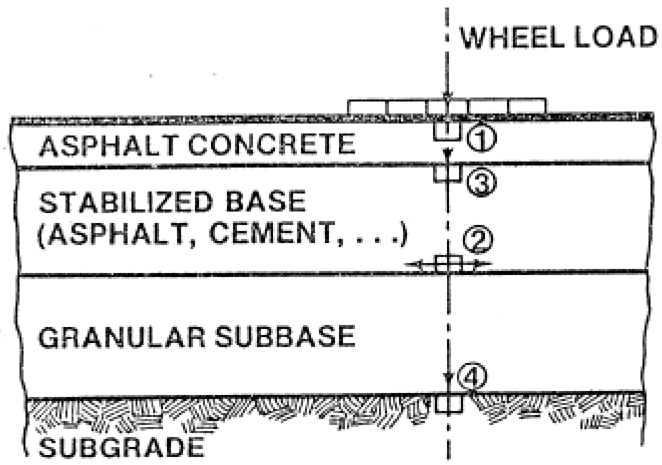


TYPICAL FLEXIBLE PAVEMENT
WITH GRANULAR BASE

The above figure is showing the critical Stress/Strain locations for Flexible pavement with Granular Base. According to above figure, below are the stresses/strains location mentioned in above figure.

1. Compressive Strain – Rutting
2. Tensile Strain – Fatigue or Alligator cracking
3. Compressive strain – Rutting
4. Compressive strain - Rutting, Depressions

2. Stress – Strain phenomena for Flexible pavement with Stabilized Base:



TYPICAL FLEXIBLE PAVEMENT
WITH STABILIZED BASE

The above figure is showing the critical Stress/Strain locations for Flexible pavement with Stabilized Base. According to above figure, below are the critical stresses/strains locations mentioned in above figure.

1. Compressive Strain – Rutting
2. Tensile Strain – Transverse Reflecting Cracking or Fatigue cracking
3. Compressive strain – Rutting
4. Compressive strain - Rutting, Depressions

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Q.2. 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.

The objectives of soil investigation are to determine the following.

- The geologic, seismologic, hydrological and other sub-surface conditions that influence selection of the project site.
- The characteristics of the foundation soils and rocks.
- Geotechnical conditions which influence project safety, design, and construction.
- Sources of construction materials.

General Procedure for soil Investigation is below:

1. **Desk Study:** All possible information about all candidate sites are gathered.
2. **Site Reconnaissance:** Site is visited to gather / Confirm initial data which have been gathered during desk study.
3. **Preliminary Investigations:** Include Preliminary Bore Holes and Preliminary Tests.
4. **Main Investigations:** Detailed Investigations, Insitu tests, and Laboratory tests.
5. **Geo-Technical Report:** All findings are presented, and Recommendation are made.

Q.2. Also elaborate the steps briefly in your own words.

Desk Study: Desk studies are an essential part of the site investigation process, irrespective of whether they have been developed or not. These reports are invaluable in assessing the requirements of a ground investigation not only from an environmental perspective, but also for geotechnical purposes. A well-executed desk study can help to formulate investigation work, targeting specific areas of contamination or geotechnical parameters, culminating in a cost effective and targeted investigation.

Site Reconnaissance: Site Reconnaissance included a site visit to the proposed site to find out its general topography and to find out the below information

- General Ground Slope
- Plain, Rolling, Hilly area
- Property in Proposed ROW
- Presence of Water Courses
- Soil Stratification from Deep Cuts
- Prospect Material Sources
- Any Local Problems (Floods, Cracks, Subsidence etc. etc.)

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Preliminary Investigations: Following works needs to be done under preliminary Investigations:

- General Geology of the Site
- History of the Site (Existing Reports, tests etc.)
- Pavement Details

Main Investigations: After site Reconnaissance and preliminary investigations, main investigations which included site works and laboratory works are conducted. Following are the main works which needs to be performed during main investigations.

Site works:

- Test Pits
- Boring/Drilling
- Sampling
- In-situ Density/Moisture
- Testing (SPT, CPT)

Laboratory works:

- Classification Tests (Sieve Analysis, Atterberg Limits)
- Strength
- Consolidation/Settlement/Expansion
- Resilient Modulus
- Permeability
- Chemical Testing

Geo-Technical Report: Geo-Technical report shall be comprehensive to provide all the information required to assess the sub-surface information and to reach some conclusion. At a minimum the following information are required to be included in the Geo-Technical report.

- Title page
- Table of Contents
- Objectives
- Testing Details
- Site Plan
- Bore logs
- Analysis of Test results
- Conclusions
- Recommendation
- Graphs

Q.3 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.

Please elaborate the Figure in your own words in detail.

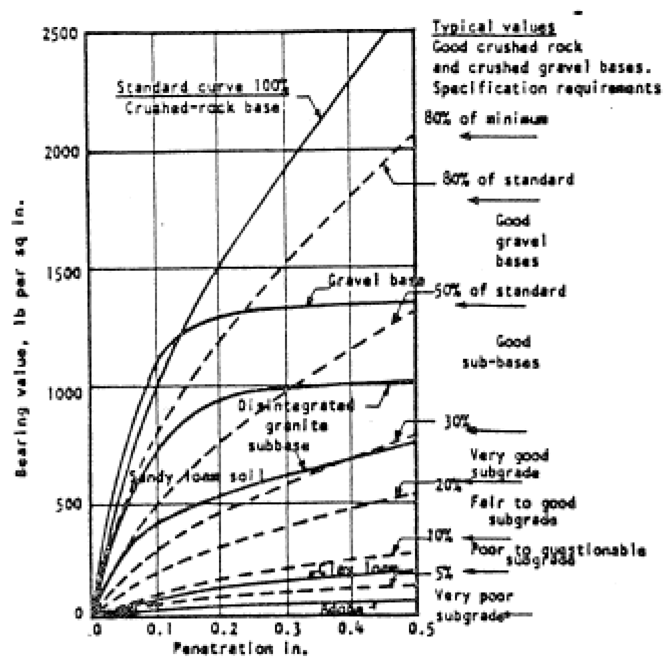


Figure 2-1.7. CBR Testing Procedure and Load-Penetration Curves for Typical Soils.

Definition of CBR: The California Bearing Ratio (CBR) test measures the resistance of the soil to penetration.

A piston with an end area of 3 square inches is pressed into a six-inch diameter, five-inch tail soil specimen in a steel compaction mold at a standard rate of 0.05 inches per minute. The load required to force the piston into the soil is measured at given penetration intervals. The resulting penetrations are compared to the penetration recorded for a standard, well-graded crushed stone to get the bearing ratio as a percentage of the standard.

Because this test is arbitrary in nature, it has many limitations.

An advantage is the relatively simple equipment needed and the large amount of historical data available for correlating results with field performance.

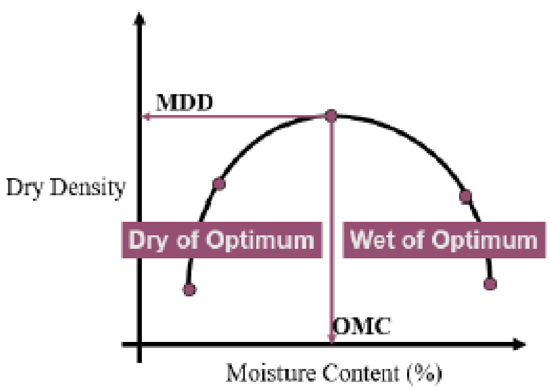
A disadvantage is that the test method is very sensitive to the method of specimen preparation.

There have been significant modifications to the original CBR method to improve its applicability.

As defined in above paragraph, CBR is the determination of soil resistance to penetration. The more the resistance is, the more the material will sustain the wheel load. The above diagram (fig. 2.1.7) is showing the resistance of soil against penetration. If the CBR value of a given soil is less than 5%, then it resistance to penetration will be very low and it will be a very poor sub-grade material. If the CBR value of a given soil is between 5% - 10%, then it will be a poor to questionable sub-grade material. Similarly, if the CBR value for a give soil is between 10% - 20% and 20% - 30% then it will be a fair to good and Very good subgrade material respectively.

Similarly, if the CBR value of a given soil is between 30% - 50%, then it will be a very good sub-base material. Finally, if the CBR value of a given soil is between 50% - 80%, its resistance to penetration will be very high and then it will be considering a very good material for Base course.

Q.4 In the Figure given below what is Dry of optimum and Wet of optimum? Explain?



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.

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).

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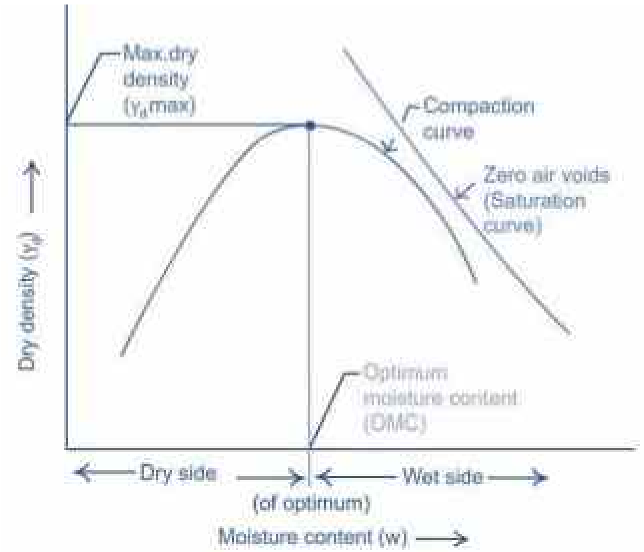

Fig 1: Compaction Curve

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**.

Dry of optimum: When the soil is drier than the optimum compaction of the soil, then it is called dry of compaction or Dry of optimum. These soils need more compaction and the soils are always flocculated,

Wet of optimum: When the soil is wetter than the optimum compaction of the soil, then it is called wet of compaction or Wet of optimum. These soils need lesser water supply and compaction and the fabric becomes more oriented or dispersed.

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

Effects of compaction on engineering properties of the soil are briefly discussed below.

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.

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.

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. 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 types of soils have low elastic modulus.