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Answer (1):

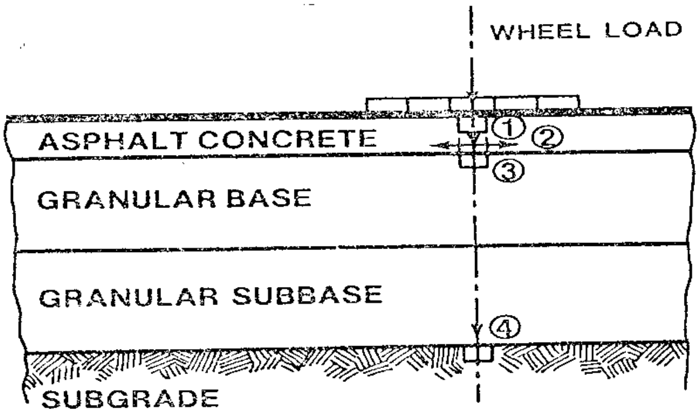
Part (1):

Figure 1 refers to stress strain phenomena. When a vertical load is applied on a pavement the pavement directly under the load is under the compression while the surrounding pavement is under very little stress. The closer the material to the surface the greater will be the stress caused by the wheel load. Stress at the top most layer is maximum which means that top material should be of good material. As obvious from the figure stress decreases with the depth as we proceed to sub grade so E1>>E2. The following stress and strain are produced.

a) The horizontal tensile strain at the bottom of bound layers.
b) The vertical compressive stress and strain in the upper part of unbound layers.
c) The vertical compressive stress and strain on the top of subgrade.

Part (2): Figure 1 refers to stress strain phenomena. When a vertical load is applied on a pavement the pavement directly under the load is under the compression while the surrounding pavement is under very little stress. The closer the material to the surface the greater will be stress caused by the wheel load.

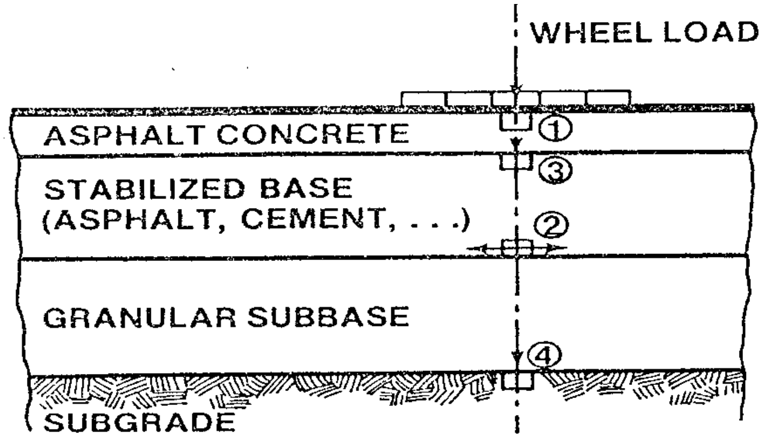
a) The horizontal tensile strain at the bottom of bound layers.
b) The vertical compressive stress and strain in the upper part of unbound layers.
c) The vertical compressive stress and strain on the top of subgrade.



TYPICAL FLEXIBLE PAVEMENT
WITH GRANULAR BASE

Figure 3-1.3. Typical Asphalt Pavement with a Granular Base Showin the Critical Stress/Strain Locations.

1. Compressive Strain - Rutting.
2. Tensile Strain - Fatigue or Alligator Cracking.
3. Compressive Strain - Rutting.
4. Compressive Strain - Rutting, Depressions.



TYPICAL FLEXIBLE PAVEMENT
WITH STABILIZED BASE

Figure 3-1.4. Typical Asphalt Pavement with a Stabilized Base Showing the Critical Stress/Strain Locations.

1. Compressive Strain - Rutting.
2. Tensile Strain - Transverse Reflective Cracking or Fatigue Crackin
3. Compressive Strain - Rutting.
4. Compressive Strain - Rutting, Depressions.

In these figures 2 typical cross section has been showed.

1) In first one vertical load is applied on typical flexible pavement with granular sub base.

4 points are shown on that figure.

Point 1 shows compressive strain which will cause rutting.

Point 2 shows tensile strain which will cause fatigue or alligator crakes.

Point 3 shows compressive strain which will cause rutting.

Point 4 shows compressive strain which will cause rutting and depressions.

2) In second one vertical load is applied on typical flexible pavement with stabilized base.

4 points are shown on that figure.

Point 1 shows compressive strain which will cause rutting.

Point 2 shows tensile strain which will cause traverse reflective cracking or fatigue cracking.

Point 3 shows compressive strain which will cause rutting.

Point 4 shows compressive strain which will cause rutting and depressions.

Answer (2):

Part (1)

Soils report may be required depending on type of structure, loads and location of the structure. The report gives understanding of earth conditions affecting road.

The following steps would be considered while investigating soil and preparing geo technical report.

1) Desk study
2) Site reconnaissance
3) Preliminary Investigations
4) Main Investigations
5) Geochemical Report

Part (2)

Now discussing the above mentioned steps

1) Desk study:

   In desk study we gather all possible information which will be related to that assigned road project. Ideas are discussed about the current project and other projects that are present in that particular locality.

2) Site reconnaissance:

   Site reconnaissance is the 2nd stage of site investigation. In this stage visual inspection of the site is done and information about topographical and geological features of the site is collected. The general observations made in site reconnaissance are as follow:

   1) Presence of drainage ditches and dumping yards.
   2) Location of Ground water table.
   3) Presence of springs.
   4) High flood level marks on bridges.
   5) Presence of vegetation and nature of soil.
   6) Past records of landslides, floods, shrinkage cracks.
   7) Study of aerial photograph of sites.
   8) Observation of deep cuts to know about the stratification of soil.
   9) Observation of settlement cracks of existing structure.

3) Preliminary Investigations:

Preliminary investigation is carried out for small projects, light structure, highway, etc. the main objective of preliminary investigation is to obtain an approximate picture of sub-soil condition at low cost. It is also called general site exploration.

The soil sample is collected from experimental borings and shallow test pits and simple laboratory tests such as moisture content test, density, unconfined compressive strength test, etc. are conducted. Simple field tests such as penetration methods, sounding methods, geophysical methods are performed to get the relative density of soils, strength properties, etc.

The data collected about subsoil should be sufficient enough to design and build light structures. Following are some of the general information obtained through primary site exploration.

1. Approximates values of soil's compressive strength.
2. Position of the groundwater table.
3. Depth and extent of soil strata.
4. Soil composition.
5. Depth of hard stratum from ground level.
6. Engineering properties of soil (disturbed sample)

4) Main Investigations

Detailed exploration is preferred for complex projects, major engineering works, heavy structures like dams, bridges, high rise buildings, etc. A huge amount of capital is required for a detailed site exploration hence, it is not recommended for minor engineering works where the budget is limited. For such type of works, data collected through preliminary site exploration is enough.

In this stage, numerous field tests such as in-situ vane shear test, plate load test, etc. and laboratory tests such as permeability tests, compressive strength test on undistracted soil samples are conducted to get exact values of soil properties.

5) Geochemical Report:

After performing preliminary or detailed site exploration methods a report should be prepared. A sub-soil investigation or exploration report generally has the following sections :

1. Introduction
2. Scope of site investigation
3. Description of the proposed structure, purpose of site investigation
4. Site reconnaissance details
5. Site exploration details such as number, location and depth of boreholes, sampling details etc.
6. Methods performed in site exploration and their results.
7. Laboratory tests performed and their results.
8. Details of Groundwater table level and position.
9. Recommended improvement methods if needed.
10. Recommended types of foundations, structural details, etc.
11. Conclusion.

Answer (3)

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.
The figure shows the relationship between the bearing value and penetration value with respect to CBR value for quality of soil starting from 5% to 100%. The dotted line in the

graph shows the values of CBR for different soils. Solid line is showing standard value of CBR values.

From the figure it is obvious that

1) Adobe soil: o.5'' penetration in done by bearing load of 150lb/in2 (very poor sub grade).
2) Clay Loam: o.5'' penetration in done by bearing load of 200lb/in2 (poor to questionable sub grade). It shows little resistance to penetration.
3) Sandy loam soil: o.5'' penetration in done by bearing load of 510lb/in2 (fair to good sub grade). It is generally considered as fair to good sub grade.
4) Disintegrated granite sub base: o.5'' penetration in done by bearing load of 700lb/in2 (very good sub grade). It comes between 30% and 50% CBR values so it is considered as very good quality sub grade.
5) Gravel Bases: o.5'' penetration in done by bearing load of 1300lb/in2 (Good sub bases)
6) Crushed Rocks bases: o.5'' penetration in done by bearing load of 2100lb/in2. So they are considered as good quality materials.

Answer (4)

Optimum Moisture content:

The optimum moisture content is the moisture content at which soil attains maximum dry density.

There is standard value for measuring the optimum compaction of the soil.

DRY OF OPTIMUM:

If the amount of water added is less than the optimum moisture content then it is called as dry of optimum compaction**.** As the water increases the particles develops larger and larger water films around them and dry density increases with moisture content.

WET OF OPTIMUM:

If the amount of water added is more than the optimum moisture content then it is called as wet of optimum compaction**.**

The water content of a compacted soil is expressed with reference to the OMC. Thus, soils are said to be compacted dry of optimum or wet of optimum (i.e. on the dry side or wet side of OMC). The structure of a compacted soil is not similar on both sides even when the dry density is the same, and this difference has a strong influence on the engineering characteristics.
Soil Structure
For a given compactive effort, soils have a flocculated structure on the dry side (i.e. soil particles are oriented randomly), whereas they have a dispersed structure on the wet side (i.e. particles are more oriented in a parallel arrangement perpendicular to the direction of applied stress). This is due to the well-developed adsorbed water layer (water film) surrounding each particle on the wet side.

Part (2)

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 curve.

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 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 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.