Question 1)

i). Given Figure 1. Refers to which phenomena of the pavement condition?

It refers to Stress-Strain Behavior

ii). Phenomena and behavior for flexible pavement with granular base and stabilized base.

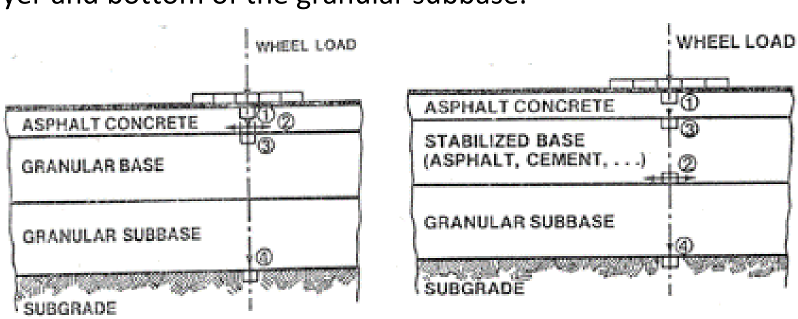
In order to analyze phenomena first we need to recognize the difference between granular base and stabilized base.

Granular Base: Aggregates used in granular base and subbase applications generally consist of sand and gravel, crushed stone or quarry rock, slag, or other hard, durable material of mineral origin. The granular base is typically dense graded, with the amount of fines limited to promote drainage.

Stabilized 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. In other words, additives are used to enhance the engineering properties of the soil. The treatment used can be mechanical, chemical or bituminous.

When the load is applied on the surface of the pavement with granular base it produce compressive strain on top of the asphaltic layer which leads to failure in rutting deformation and produces tensile strain at the bottom of asphaltic layer instigating fatigue or alligator cracking, while produces critical compressive strain on top of granular base layer and causes compressive strain on the bottom granular subbase.

While in stabilized base it when the load is transfer via tire the load is transmitted through lateral distribution of stress producing tensile strain on bottom of the stabilized base under load and compressive strain on top of the said layer. Moreover, it produces compressive strain on top of asphaltic layer and bottom of the granular subbase.



TYPICAL FLEXIBLE PAVEMENT WITH GRANULAR BASE

TYPICAL FLEXIBLE PAVEMENT WITH STABILIZED BASE

Question 2)

i) General Procedure of Soil Investigation

General Procedure of Soil Investigation:

1. **Desk Study:** All possible information about all candidate sites is gathered.
2. **Site Reconnaissance:** Site is visited to gather/confirm initial data.
3. **Preliminary Investigations:** Include prelims BHs and prelims tests
4. **Main Investigations:** Detail investigations: insitu tests, sampling, and Lab Test
5. **Geotechnical Report:** All findings are presented and Recommendations are made.

ii). Elaboration of the General Procedure for Soil Investigation.

Desk Study: The desk study ponder is work taken up earlier to commencing the work on location and the Ground Examination. It ought to be the primary stage of the Location Examination and is utilized to arrange the Ground Examination. The work includes investigating the location to pick up as much data as conceivable, both topographical and authentic. It makes a difference in minimizing mitigation risk, understanding of potential varieties in ground conditions, can lead to economical plan of engineering facilities, diminish chances of delays on location, and makes a difference in measuring and qualifying hazard.

Site Reconnaissance: The Site Reconnaissance is the walk over study of the site for soil investigation. Site reconnaissance is the first stage of site investigation. In this phase, visual review of the location is done and data around geological and topographical is highlighted. The study helps us finding the hydrology, slope instability, mining, and access. Moreover further information about the presence of drainage ditches and dumping yards are located, assessing ground water table and water bodies around the study area. Land slide and flood area are recorded. Geological maps are gathered and studied. Observing the stratification of soils and settlement cracks of the existing structures.

Preliminary Investigations: The main objective of preliminary exploration is to achieve probable situation of sub-soil conditions 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. The information collected is about engineering properties of soil compressive strength, soil composition, depth of the hard strata from ground level. It is preferred for light projects.

Main Investigations: Detailed exploration is favored for complex projects. Compare to minor projects this phase needs a bigger capital and is only preferable for big projects. In this phase various field tests area conducted such as in-situ vane shear test, plate load test, etc. To find exact value of the soil properties lab tests are also done.

Geotechnical Report: The last stage of the soil investigation is to prepare geotechnical report that contain. The report include introduction, scope of work, structure under study, detail of phase 2 and phase 3. Lab test performed and result. Ground water table information followed by recommendation and conclusion.

Question 3)

Please elaborate the Figure in your own words in detail.

The CBR test measure the resistance of the soil to penetration. A piston with an end area of 3in2 is pressed into a 6-in diameter, 5-in tall soil specimen in a steel compaction mold at a standard rate of .05 per min. The load require to force the piston into the soil is measured at given penetration intervals. The resulting penetrations are plotted to obtain a load-penetration curve. The value of the unit load corresponding to a 0.1 in penetration is determined and compared with a standard value of 1,000 lb for a high quality crushed stone. The CBR may then be expressed as

CBR (%) = Unit Load at 0.1 in PEN x 100/1000

CBR curves for a wide range of soils are showed in figure 2-1.7. CBR value at each penetration can be read directly without computation. The same diagram can be used for small forces and low CBR values.

The CBR value obtained from a test is the force read from the test curve at a given penetration expressed as a percentage of the force corresponding to the same penetration on the standard curve. Curve representing a range of CBR values is included in a Figure. The standard force-penetration curve corresponding to a CBR value of **100%** is shown by the heavy curvy in figure The CBR value of 5 % or less corresponding to the bearing value of 200 lb per sq means that the specimen are fine grained soils with high compressibility that is fine sand and silty soil, elastic silts, inorganic clays of high plasticity, fat clays and organic clays of medium to high plasticity. The CBR value less than 5% should not be used for any layer of the pavement. The figure relates CBR less than 5% to a very poor subgrade.

The load penetration curve with CBR values between **10% and 5%** deems the subgrade as poor to questionable. The reason being a fine grained soils with low to medium compressibility. Such material could be used for embankment or subgrade if it is not less 5% and 7% respectively.

The CBR value corresponds to 600 lb/sq in bearing value with penetration values ranges for 0 to 0.5 in shows the CBR value of 20%. The CBR value between **20% and 10%** comes in a fair to good subgrade. This can also be fine grained soil with low to medium compressibility like inorganic silt and very fine sands, rock flour, silty or clayey fine sands with slight plasticity, clays of low to medium plasticity, sandy clays, silty clays low plasticity clays, organic silts and organic silt clays of low plasticity.

CBR value for **20% to 30%** shows the soil is very good for subgrade.

30% to 50% good subase. with poorly graded gravel and gravel sand mixtures, with little or no fines, or gravel with fines, very silty gravel clayer gravel, poorly graded gravel sand clay mixtures.

50 to 80% good gravel bases represents gravel and gravelly soils with well graded gravel and gravel sand mixtures with little or no fines that are excellent binder.

Question 4)

i). In the Figure given what is Dry of Optimum and Wet of Optimum? Explain.

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. Two of the most important variable of soil properties is density and its moisture content. The graph shows that starting at low water contents as the water content increases, the particles become denser reaching the maximum value of density and beyond this point the density curve starts to decrease. So when the soil is drier than the optimum compaction of the soil it is deemed as dry of optimum and needs more compaction. In the case the Dry of optimum water content the air voids are continuous, resulting in rapid dissipation of pore-air pressures. At the point where the density starts to fall off the soil particles are replaces with water and becomes wetter and completely saturated by compaction. This blocks air voids, producing high pore-water pressures and consolidation becomes major problem. This phase is called the Wet of Optimum.

ii) What are the effects of compaction on engineering properties of soil? Details.

The engineering properties of the soil changes when compacted and behaves differently. The engineering properties that is effected of compaction are as follow:

1. Permeability: 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: In case of soil samples initially saturated and having same void ratio, it has been found that in low pressure range a wet side compacted soil is more compressible than a dry side compacted soil, and vice versa in high pressure range.

3. Pore Pressure: In undrained shear test conducted on saturated samples of clay it has been found that lower pore pressures develop at low strains when the sample is compacted dry of optimum, compared to the case when the sample is compacted wet of optimum. But at high strains in both types of samples the development of pore pressure is same for same density and water content.

4. Stress Strain Relationship: Samples compacted dry of optimum produce much steeper stress-strain curves with peaks at low strains, whereas samples compacted wet of optimum, having the same density, produce much flatter stress-strain curves with increase in stress even at high strains.

5. Shrinkage and swelling: At same density a soil compacted dry of optimum shrinks appreciably less than that of compacted wet of optimum. Also the sol compacted dry of optimum exhibits greater swelling characteristics than samples of the same density compacted wet of optimum.