Pavement Material Engineering

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Ms TRANSPORTATION

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Mid Assignment / Quiz (*Spring 2020)*

Subject: Pavement Material Engineering
Instructor: Engr. Shabir Ahmad
Semester: M.S (Civil Engineering)

Question. 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.

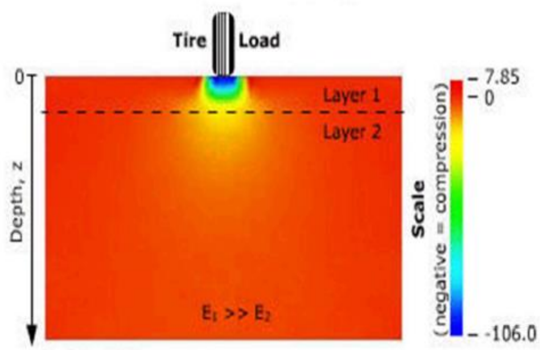


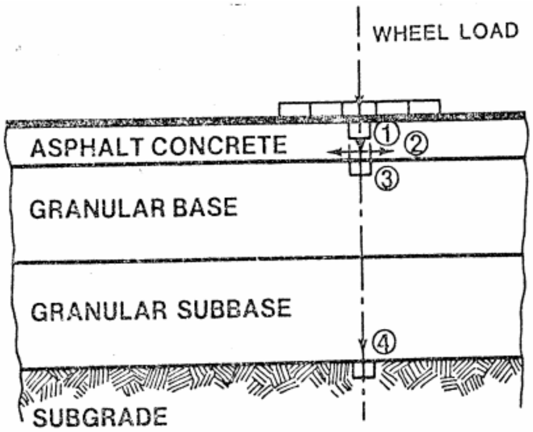
Figure. 1

Answer:

Part-1:

Stresses and strains (Finite Element Method)

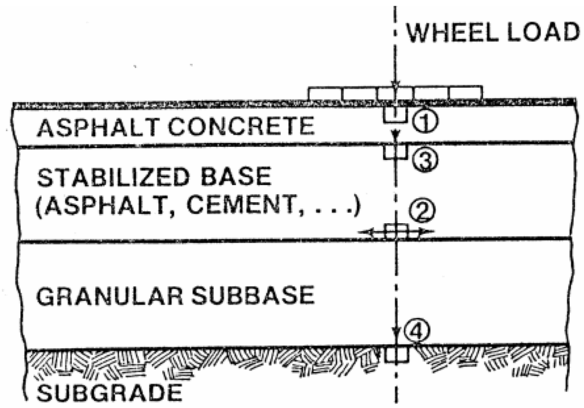
Part-2:



TYPICAL FLEXIBLE PAVEMENT WITH GRANULAR BASE

Figure 3-1.3. Typical Asphalt Pavement with a Granular Base Showi 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 Cracking
3. Compressive Strain - Rutting.
4. Compressive Strain - Rutting, Depressions.

<u>Question. No. 02.</u>

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.

<u>Answer:</u>

<u>Part-1:</u>

The following data is essential for the preparation of a good geo technical investigation report:

i. Details of the proposed structure.

ii. Site conditions, including geological and topographical features

iii. History of land use.

iv. Details of the adjacent structure(s).

v. Details of field investigations, including field testing and sampling.

vi. Laboratory test results.

A good soil investigation report should be prepared in the following standard format:

1. Introduction.
2. Objectives of the geotechnical investigations.
3. Details of the proposed structure.
4. Site conditions.
5. Field investigations.
6. Laboratory test results.
7. Soil profile.
8. Allowable bearing capacity.
9. Analysis and interpretation of the results.
10. Foundation alternatives.
11. Recommendations.
12. Limitations and uncertainties of soil exploration.
13. Annexure.

If the report is voluminous, it may be prepared in two volumes. Volume I is the main body of the report and contains the main text, summarized data sheets, location maps indicating the geographical location of the site, proposed structure, various field tests and sampling, soil profiles, etc. Volume II contains the supporting calculations pertinent to the data in Volume I, data of field, laboratory tests and investigations, etc.

<u>Part-2:</u>

The various elements of the soil investigation report are briefly explained below:

1. Introduction:

This section indicates the client company and the project for which geotechnical investigations are carried out, its location, the name(s) of the case investigator(s), the main objective or context of the geotechnical investigations, and the reference to the work order by the client company.

2. Objectives of the Geotechnical Investigations:

This section gives the detailed objectives for which the geotechnical investigations are being carried out. If the case investigator feels that the scope is inadequate, the same should be clearly stated, which will become important when the soil or foundation is found to behave differently from the predictions of the report due to inadequate geotechnical investigations.

3. Details of the Proposed Structure:

This section gives the type and number of the proposed structure(s) in the site, along with the extent of its area. This also specifies the nature of the structure, that is, whether sensitive or non-sensitive, or light or heavy, and the nature of its use and possible loads and discharges that the underlying formation will be subjected to from the proposed structure. The location of the proposed structure should also be shown in the site plan.

4. Site Conditions:

This section gives the nature of the ground surface at the site, whether undulating or flat. If the ground is highly uneven, reference should be made to a relatively permanent datum from which the depth to various soil strata and the sampling are measured.

This section presents a brief account of the geology and morphology of the area, including the presence of a hill or valley water courses or ponds, and cultivated land within and outside the site. It also gives information about the land use history of the site, existence of any old structure or mines within or in the neighborhood of the site, and also any other observations or findings during field visit which is useful in deciding the design parameters. This section also provides a survey map showing the geographical location of the site and the proposed structure.

5. Field Investigations:

This section reports details of field investigations, including date of commencement and completion, as well as the type of exploratory methods adopted. The layout of the test pits and/or deep borings should be provided in relation to the plan of the proposed structure.

Details of field tests conducted, such as SPT, SCPT, DCPT, PLT, vane shear tests, or PMT, should be specified. Specific observations of site conditions, including color of soil, groundwater seepage, speed of progress at different depths during the boring operations, and field tests, should be clearly reported. The depth interval at which the field tests are conducted in each borehole should be specified.

The type of samplers used for collection of undisturbed soil samples, including the inside clearance, area ratio of the samplers, and the recovery ratio obtained, should be included. The degree of disturbance that occurred in collection of soil samples should be indicated, which is very important information, especially for sensitive soils. The method adopted for collection of rock core samples as well as the RQD should be included.

The details of the field tests conducted, if any, and their results with special remarks on their limitations and applications are presented in this section. If any nonstandard tests or equipment is specially devised for the investigations, the details of the equipment and the test procedure adopted should be described in the report.

The maximum depth of exploration in each borehole should be recorded. The reference datum from which the depth to various strata is recorded should be reported. The depth of GWT in each borehole should be recorded and included in the report.

Specific comments and observations of the case investigator on the overall performance and progress of the field investigations should be included in this section.

6. Laboratory Test Results:

This section presents the results of various laboratory tests conducted on undisturbed soil samples collected from the field. The date of collection of the samples and the date of test conduction are to be specified to indicate the time lag between the two and its possible effect on the test results. The method used for transportation and preservation of the soil samples and the method and tools used for recovery of soil specimens for each test are specified. For shear tests, drainage conditions such as UU, CU, or CD, with special reference to the range of confining pressure used, are indicated.

The laboratory test results may be presented in tabular forms, and it is desirable that the results on disturbed and undisturbed soil samples are separately presented or clearly marked.

Soil classification should be complete as per the IS – 1498-1970 code, and the properties used for classification should be clearly specified, for example, grain size distribution, index properties, SPT, SCPT, DCPT, or unconfined compressive strength (laboratory) or vane shear strength (laboratory/field), etc. All the test results should be used to carry out soil classification such as grain size analysis, consistency limits based on the plasticity chart, and field identification tests in addition to those mentioned above. The nomenclature and symbols used for soil classification should be clearly mentioned to avoid misinterpretation.

Soil Profile:

Soil stratification at each borehole, based on the color of the drilling fluid and soil fragments and observation of the soil samples as well as on the analysis of field and laboratory tests, is reported in this section. The depth to the top of each stratum and the thickness of each stratum for each borehole should be specified.

The nomenclature of soil strata used in the report should be in accordance with the IS –1498-1970 Indian Standard Code of Practice for classification of soils with or without local names (with the local names provided within parentheses).

The depth to the top of soft and hard rock should be reported in this section, along with the degree of weathering. The soil and rock profile should be presented in the form of a bore log for each borehole and enclosed as an annexure. The variation in the soil or rock profile across adjacent bore logs or test pits is brought out and the logs are presented such that they join the profiles at various borehole locations.

Comparing the soil strata at different depths in various boreholes, the nature of variation in the soil strata across the length and breadth of the site, with special reference to the built-up area, should be commented upon. The depth up to which the soil characteristics or strata that would have a significant effect on the strength and stability of the structure and a bearing on the selection and design of foundation for the structure should be clearly remarked.

8. Allowable Bearing Capacity:

Using the laboratory test results, the safe bearing capacity of the soil at various depths should be computed based on the shear failure criterion as per IS – 6403-1981. The allowable bearing capacity should be carefully decided considering all the pertinent factors such as the settlement criterion as per IS – 6403-1981; field test results; site conditions; water table; long- and short-term conditions etc. The permissible settlement for which the safe settlement pressure is calculated should be specified. A model calculation showing the computation of safe bearing capacity and safe settlement pressure is to be included for future reference.

9. Analysis and Interpretation of Results:

The results obtained from the field investigations, laboratory testing, and safe bearing capacity (SBC) computation as well as specific observations during the field investigations are thoroughly reviewed in this section vis-a-vis the soil classification based on the laboratory tests and field observations. The general characteristics of the soil and the nature and extent of their variation over the site should be conclusively described. The anticipated design and construction problems and the influence of soil characteristics (such as shear strength, compressibility, swelling, and GWT) and seepage should be brought out in this section.

10. Foundation Alternatives:

The nature and magnitude of the loads from various portions of the proposed structure, the soil profile, and the soil characteristics at different depths, should be used as guidelines in working on suitable foundation alternatives for the structure and in taking a judicious decision based on the strength, economic, and long-term stability considerations.

Expected settlements of the structure under different foundation alternatives should also be computed and presented. Model calculations should be shown for all computations made in the report. Possible problems that may be encountered during construction are also brought out based on the analysis of results. When more than one type of foundation are to be recommended owing to their relative merits from conflicting criteria, the same should be clearly mentioned, indicating the personal choice of the case investigator, leaving the ultimate decision to the client.

11. Recommendations:

This is the most important section of the geotechnical investigation report and points made here need to be clear, precise, and free from error and ambiguity.

The recommendations should, among other things, include the following:

i. The recommended type of foundation for different parts of the structure.

ii. The depth from the existing ground surface where the foundation is to be located.

iii. Allowable bearing pressure and other soil characteristics to be used in the design of foundation, including the minimum width for which the allowable bearing pressure is applicable.

iv. Specific guidelines on whether the excavated soil can be used for refilling, and if not, suitable alternate materials within the vicinity of the site.

v. Suitable ground improvement techniques, wherever required and where the suggested bearing capacity is based on the improved ground conditions. In the case of expansive soils, special foundation techniques to be used to ensure long-term stability of the structure.

vi. Suitable time for commencement and completion of the foundation and the structure from compressibility, shear strength, and seepage considerations.

vii. Where the GWT is likely to be at or near the ground surface, specific caution to the client for close supervision and quality control during construction.

viii. In an area where soil erosion conditions are high or where the terrain is highly uneven, recommendations for special measures to prevent loss of overburden.

ix. Where non-conventional foundations are suggested, inclusion of the design and construction procedure of such foundations.

x. Anticipated problems during construction of the structure and special measures to be adopted to facilitate rapid and hassle-free construction.

12. Limitations and Uncertainties of Soil Exploration:

This section clearly specifies the limitations and uncertainties of the soil exploration due to possible inadequate budget, inadequate scope and/or objectives of the soil exploration, or difficult or variable soil or site conditions. Specific recommendation of the case investigator for further investigation/exploration to address the cited limitations should be specified.

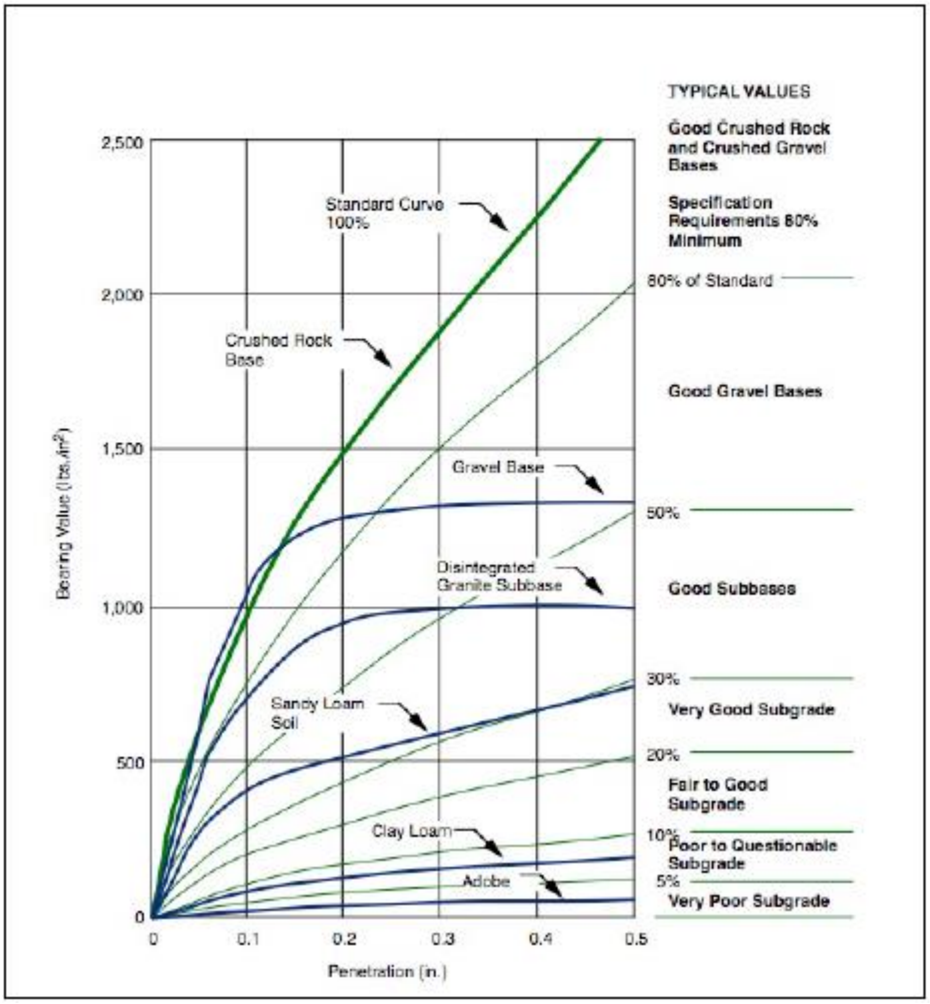
13. Annexure:

All the data related to the geotechnical investigation cited in the report as well as the supporting calculations, maps, drawings, and photographs are enclosed in the annexure in a logical sequential order, with clear reference number as cited in the report.

Question. No. 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.

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

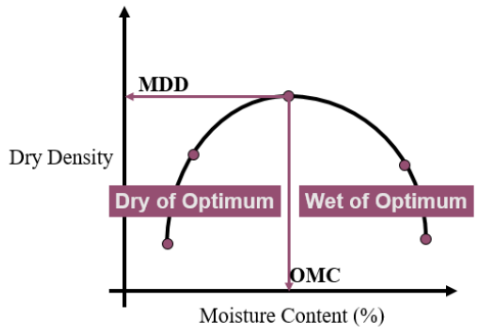


Answer:

Figure (from Porter's paper [1942]) shows typical bearing values (psi) versus penetration (in.) for various materials ranging from "very poor subgrade" (CBR up to 5) to "good crushed rock bases" (CBR of 100). The CBRs are in terms of percentages since the bearing value is divided by 1,000 psi (0.1 penetration) or 1,500 psi (0.2 in. penetration) which represents the bearing value of a crushed rock material (refer to "standard curve 100%" in Figure).

Question. No. 4:

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**



<u>Answer:</u>

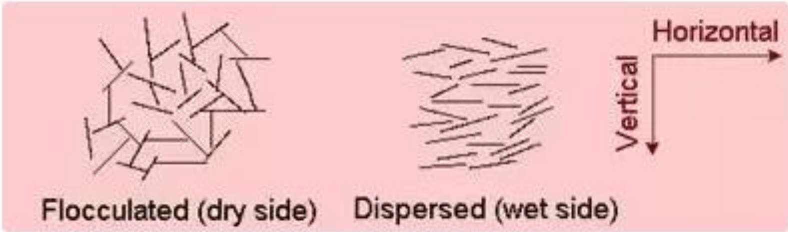
Optimum Moisture Content refers to the **water content of a compacted soil.** OMC of a soil is also called the compacted dry of optimum or wet of optimum on the dry side or wet side of OMC, respectively.

- When the soil is drier than the optimum compaction of the soil, then it is called **dry of compaction**. These soil need more compaction.
- When the soil is wetter than the optimum compaction of the soil, then it is called **wet of compaction**. These soil need lesser water supply and 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.



Swelling

Due to a higher water deficiency and partially developed water films in the dry side, when given access to water, the soil will soak in much more water and then swell more. Shrinkage

During drying, soils compacted in the wet side tend to show more shrinkage than those compacted in the dry side. In the wet side, the more orderly orientation of particles allows them to pack more efficiently.

Construction Pore Water Pressure

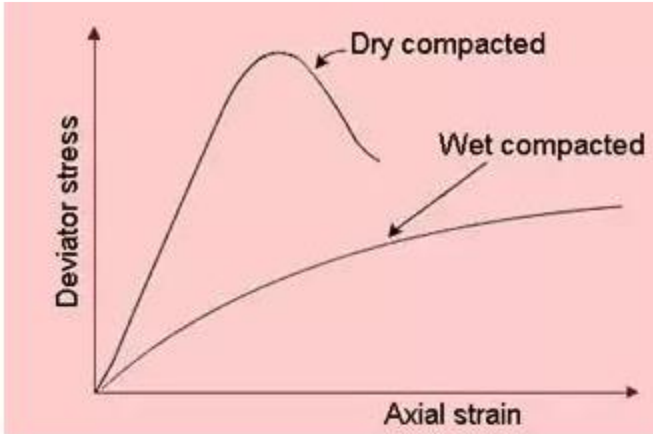
The compaction of man-made deposits proceeds layer by layer, and pore water pressures are induced in the previous layers. Soils compacted wet of optimum will have higher pore water pressures compared to soils compacted dry of optimum, which have initially negative pore water pressure.

Permeability

The randomly oriented soil in the dry side exhibits the same permeability in all directions, whereas the dispersed soil in the wet side is more permeable along particle orientation than across particle orientation.

Compressibility

At low applied stresses, the dry compacted soil is less compressible on account of its truss-like arrangement of particles whereas the wet compacted soil is more compressible.



The stress-strain curve of the dry compacted soil rises to a peak and drops down when the flocculated structure collapses. At high applied stresses, the initially flocculated and the initially dispersed soil samples will have similar structures, and they exhibit similar compressibility and strength.