Highway Laboratory

Introduction

- Laboratory testing of materials used for highway construction and maintenance is an essential part of highway engineering.
- The course includes testing procedures of soil, aggregates, asphalts and mix design procedures.
- At the beginning of the class, there will be a lecture on the experiment and thereafter the test is conducted.
- All students are required to collect the data and submit the data sheet for approval by the instructor.
- Necessary precautions should always be taken to avoid any possible hazards.
- One week after the completion of the test, each student should submit a written report. The report should consist of the following sections:
    - Cover Page
    - Aim, Apparatus and Procedures.
    - Experimental Data and Results.
    - Discussion and Conclusion.

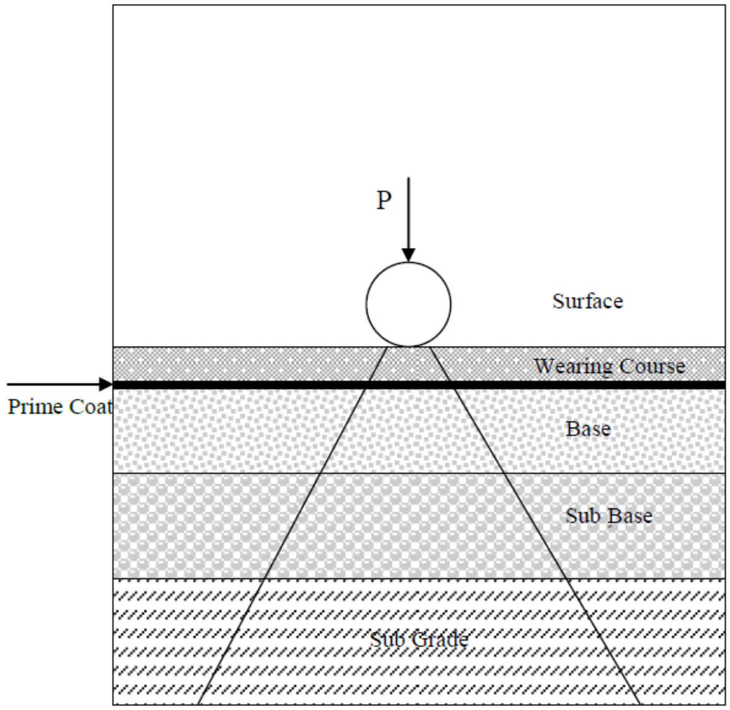

Figure 1: Cross section in a paved highway.

Purpose of material testing:

1. Suitability of materials.
2. Quality control and quality assurance.
3. Material characterization and development.

Highway Materials

1. Asphalt (bituminous materials)
   a. Asphalt cement
      - Asphalt cement is a dark brown to black, highly viscous, hydrocarbon.
      - Produced from petroleum distillation residue.
      - This distillation can occur naturally, resulting in asphalt lakes,
      - Alternatively, it occur in a petroleum refinery using crude oil.
      - Categorized as: semi solid and hot mix.

   b. Cutback asphalt
      - Cutback asphalt is a combination of asphalt cement and petroleum solvent.
      - Like emulsions, cutbacks are used because their viscosity is lower than that of neat asphalt.
      - Can be used in low temperature applications.
      - After a cutback is applied, the solvent evaporates away and only the asphalt cement is left.
      - Cutbacks are much less common today because the petroleum solvent is more expensive than water and can be an environmental concern.
      - Cutbacks are typically used as prime coats and tack coats.
      - Categorized as: rapid curing, medium curing, and slow curing.

   c. Emulsified asphalt
      - Emulsions have lower viscosities than neat (plain) asphalt
      - Can be used in low temperature applications.
      - After an emulsion is applied, the water evaporates away and only the asphalt cement is left.
      - Categorized as: rapid setting, medium setting, and slow setting.
      - Emulsions are often used as:
        - Prime coats and tack coats. Figure 2.
        - Fog seals. Slow setting. Figure 3.
        - Slurry seals. Used to fill existing pavement surface defects.
        - Bituminous surface treatments (BST). Figure 4 and Figure 5.

Figure 2: Poor tack coat (shown in the left half of the photo) vs. a good tack coat (shown in the right half of the photo). Notice the streaky coverage of the poor tack coat and the near complete coverage of the good tack coat.

Figure 3: Parking lot showing no treatment on the left side and a fog seal on the right side.

Figure 4: Freshly placed asphalt emulsion for a bituminous surface treatment; notice that the application rate is higher than that for a tack coat.

Figure 5: Chip seal rehabilitation over a BST.

2. Aggregate and soil

Approximately 92 % - 96%of the volume of asphalt concrete is occupied by aggregates, thus, properties of aggregate can have a great influence on the quality of asphalt concrete. Categorized as fine and coarse aggregate:

- Aggregates manufactured by crushing waste materials.
- Natural sand (<4.75mm) and gravel (>4.75mm).
- Aggregates crushed from selected natural rock.
  a. Igneous Rocks (i.e. Basalt & granite).
  b. Metamorphic Rocks.
  c. Sedimentary Rocks (i.e. Limestone & sandstone).

Aggregate shape can be angular or round. Angular soil particle results in higher friction and round soil particle results in lower friction. See Figure 6.

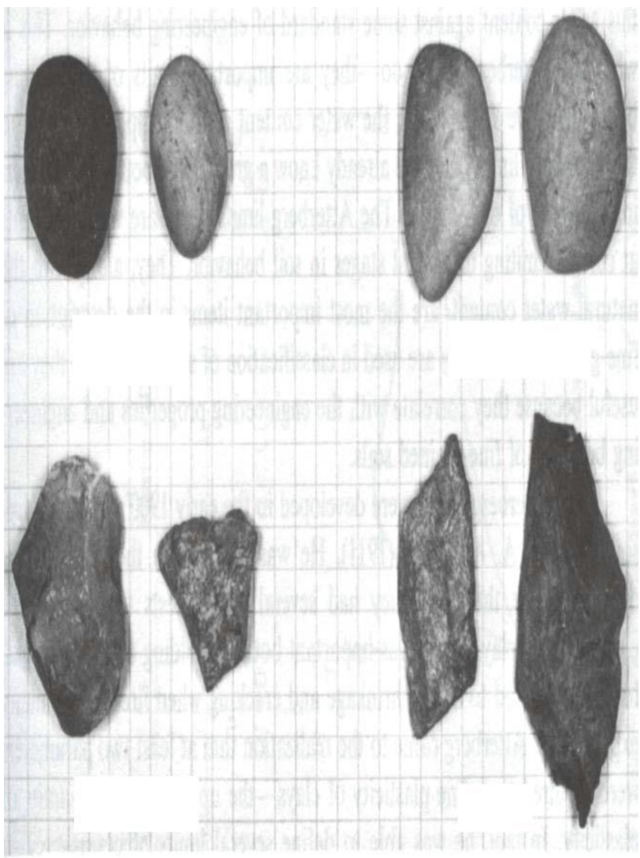

Figure 6: Angular and round particles

3. Additives:
  a. Portland cement.
  b. Lime.
  c. Anti-striping.

Sampling Method

1. Methods of taking representative field samples:

- Sampling from a Flowing Aggregate Stream (Bins or Belt Discharge):
  - At least three approximately equal increments.
  - Selected at random.
  - All the increments are mixed to form a field sample.

- Sampling from the conveyor belt:
  - At least three approximately equal increments.
  - Selected at random.
  - Stop the conveyor belt.
  - Insert two templates.
  - Scoop all material between the templates.
  - All the increments are mixed to form a field sample.

- Sampling from stockpiles or transportation units:
  - At least three approximately equal increments.
  - From the top third, at the mid-point, and at the bottom third.
  - A board shoved vertically into the pile just above the sampling point aids in preventing segregation.
  - For fine aggregate, the outer layer should be removed.
  - For fine aggregate, sampling tubes may be inserted into the pile at random locations to extract a minimum of five increments.
  - All the increments are mixed to form a field sample.

2. Methods of taking small samples out of field samples:
- Quartering.
- Splitting.

Sieve Analysis of Fine and Coarse Aggregates

- Aggregates sizes up to 50 mm is used in normal strength concrete.
- The size of aggregate influences the surface area and thus influence the amount of bitumen required to coat the surface of aggregates.
- Particle size distribution is called grading (sieve analysis).
- Grading controls packing density and therefore improves strength. See Figure 7.
- This method covers determination of the particle size distribution of coarse and fine aggregates.
    - Gradation Curve.
    - Nominal Maximum Size.
    - Maximum density line.

Gradation types include (See Figure 8):

1. Well graded (dense graded).
2. Poorly graded (uniform).
3. Gap graded.
4. Open graded (stone matrix).

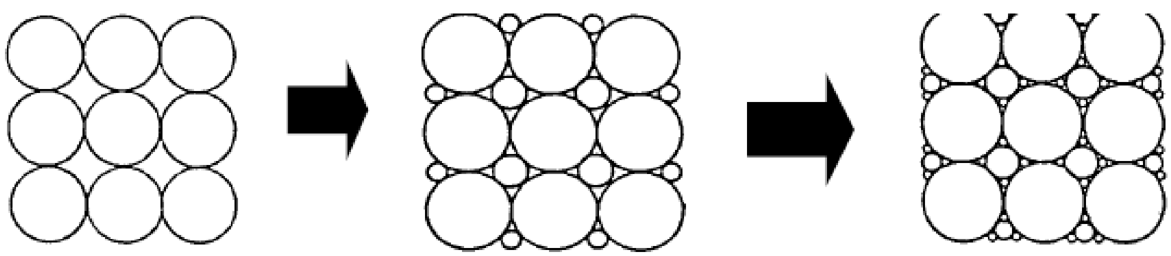

Figure 7: Effect of particle size and grading on packing density

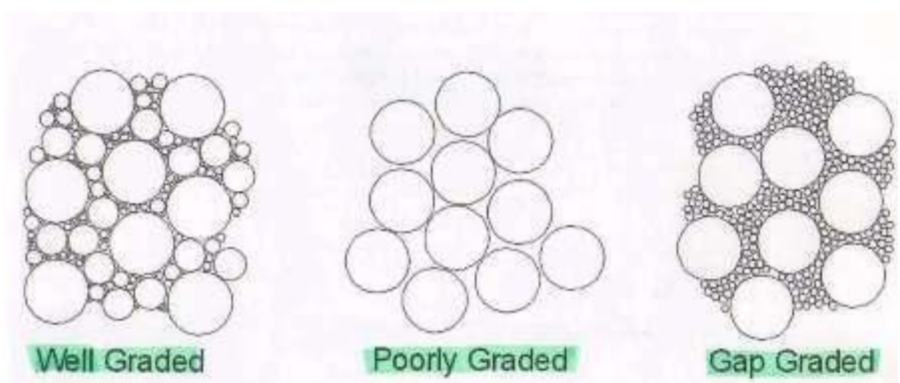

Figure 8: Different gradations of aggregate

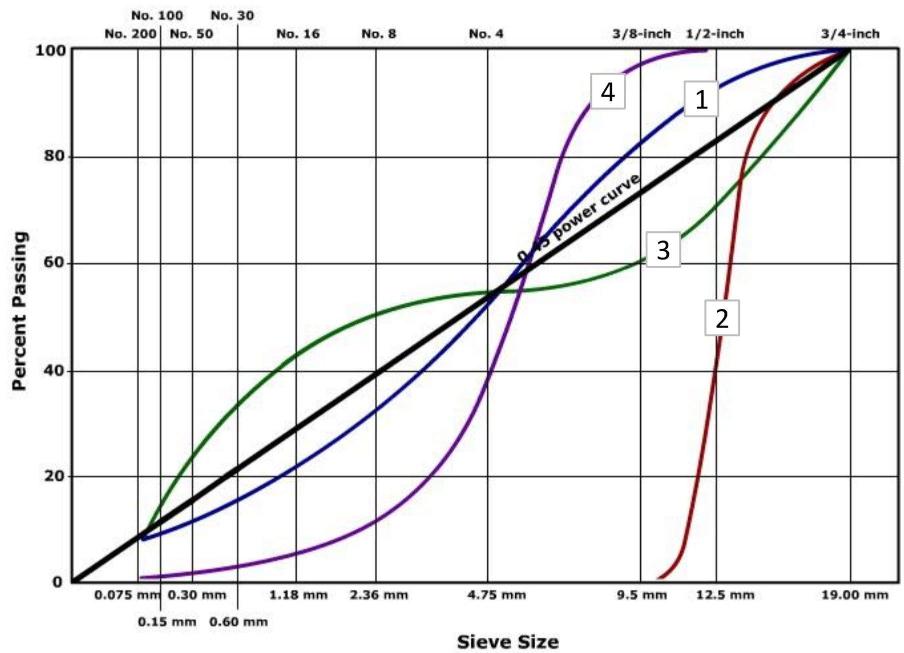

Figure 9: Gradation curve

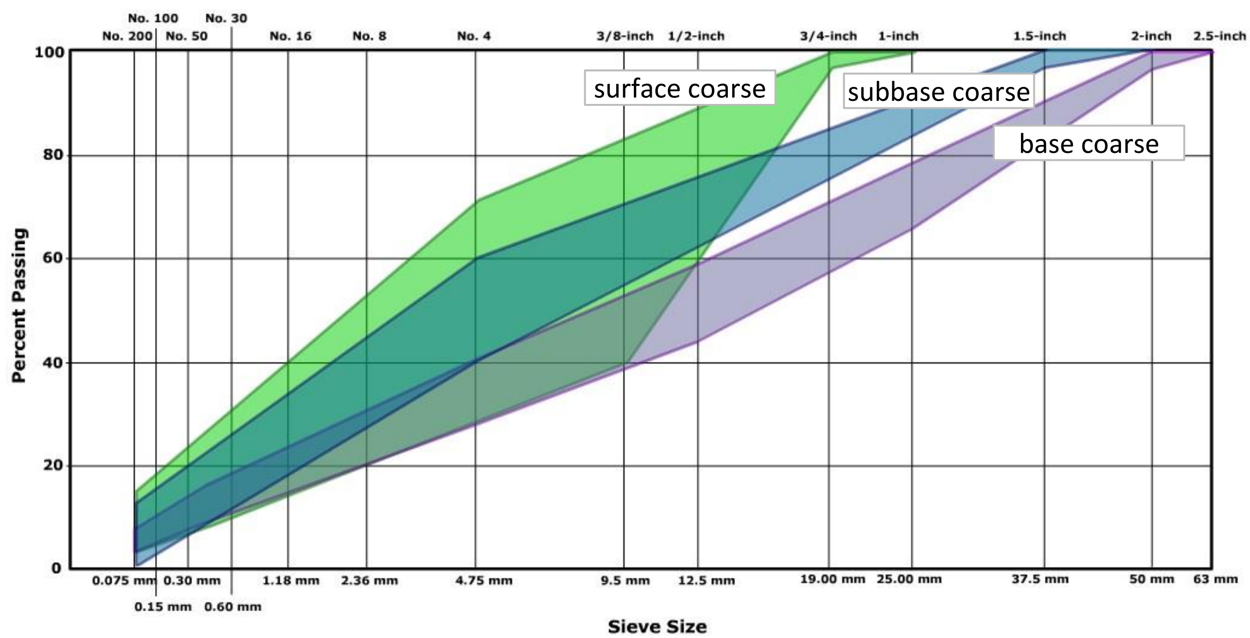

Figure 10: Gradation uses

Nominal maximum size (NMS): see Figure 11

1. NMS : 25.4
2. NMS : 39

NMS: is the next sieve size larger than the sieve that retain at least 10%.

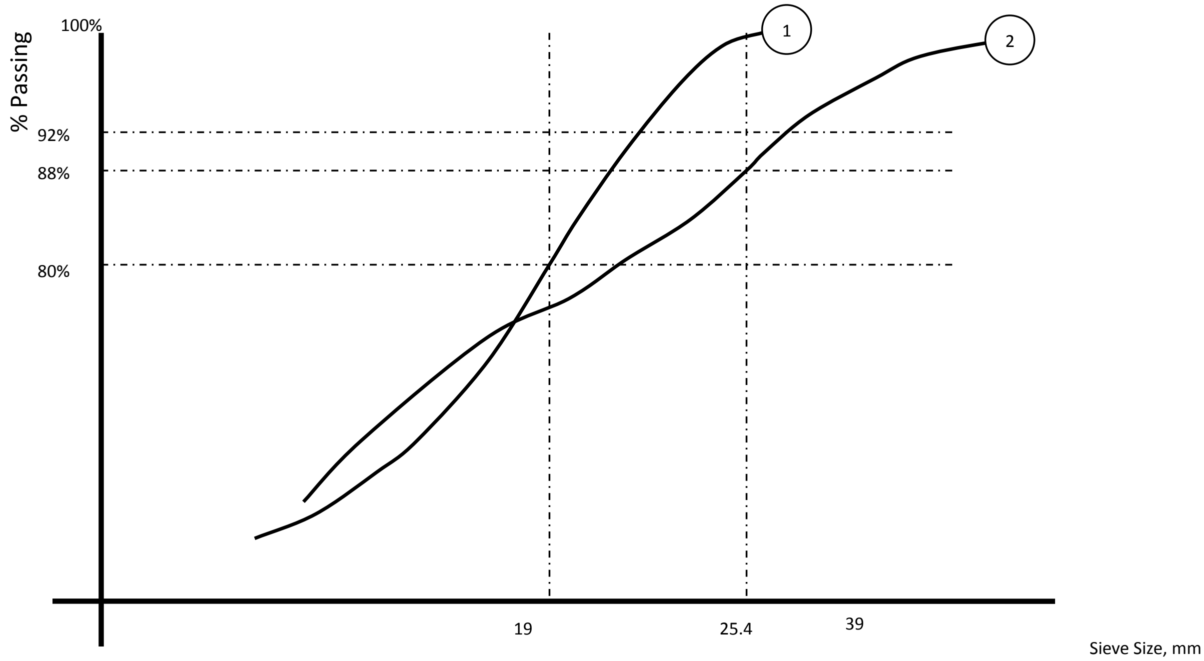

Figure 11: Nominal maximum size