Prof. Zakaria Sir

CE 451

30/08/16 | Tue

Transportation Engineering II

Introduction | University
Department
Course - Highway materials & Mix Design

Rationale of the course / Question in CT 1

Materials for Road Construction

What is the rationale of this course (Highway materials & Mix design) ?

* Rationale - যৌক্তিকতা

এই course ছাড়া কাজ করা সম্ভব না।

⇒ Civil engineers plan, design, construct, maintain C.E. structures. In all phases of these works the material knowledge is very important. Without " " C.E. can not find the dimension of element of structure.

What are Civil Engg. structures ?

⇒ Anything manmade on the earth surface or underneath the earth surface is Civil Engg. structures.

⇒ Without f'_c and f_y structural elements এর dimension কেউ বলা যাবে না,

Materials for civil and highway constructions

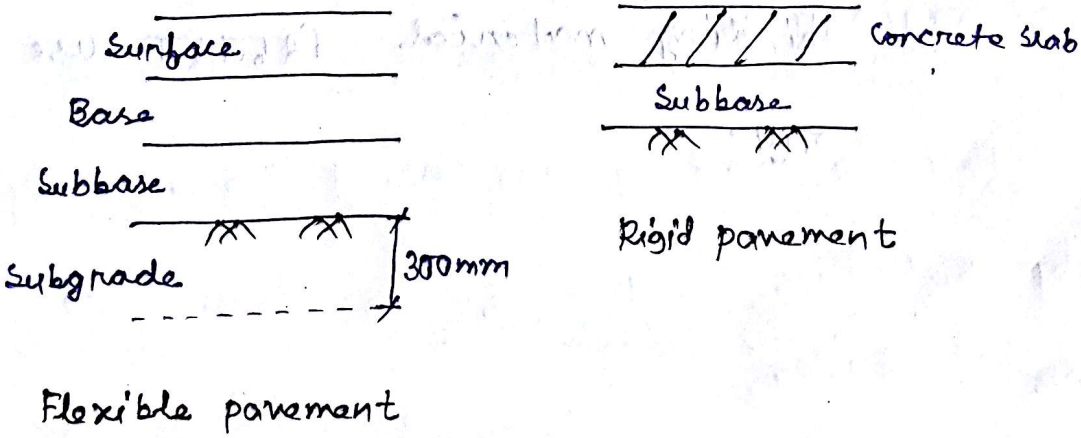
" " construction in developing countries

Definition of terms related to Tender Document

AGGREGATES :

* Def^n
* properties
* Tests
* Specifications

Materials for civil and highway construction :



Flexible pavement

Rigid pavement

* Subgrade - compacted earth surface

* Five Groups :

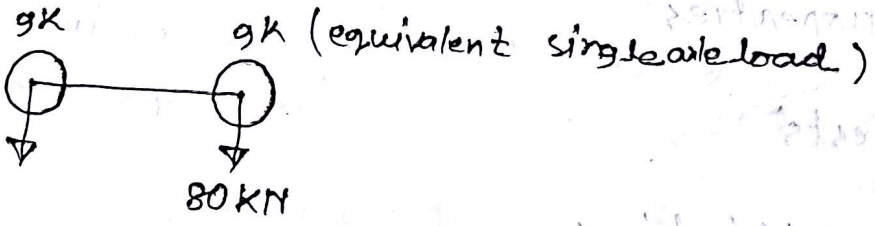
(1) Occupying main volume

(2) Binding

(3) Reinforcement

(4) Protection

(5) Decoration



ESAL → Equivalent Standard Axle load

* Gangoo - clay type material (China তে use হয়)
binding material হিসাবে use করা যায়

* Standard (What is Standard? Who uses standard?)
* Specification
* Test Method

• BS 812 ACV ≯ 30

- BS 812 → Standard
- ACV → Name of test
- 30 → Specification value

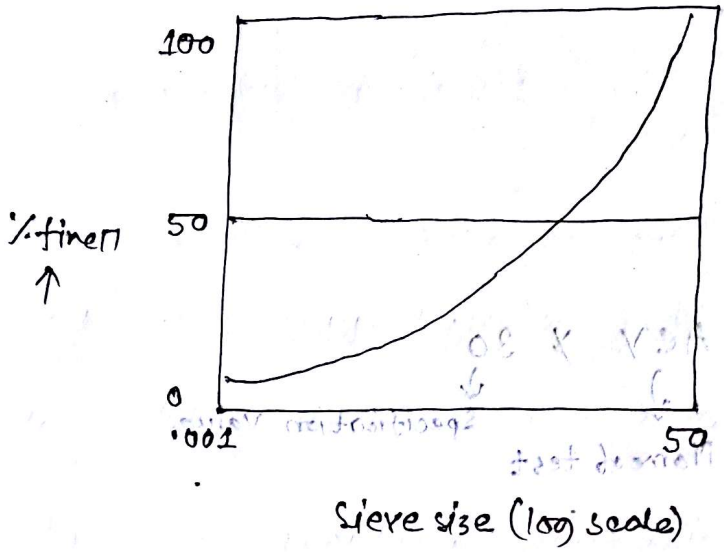
• BSTI – Bangladesh Standards and Testing Institution
• ASTM – American Society for Testing and Materials

* Pg 412 (15.8.1)
* Chapter 15 & 19 (Wright & Dixon)

What are the properties of aggregate?

Briefly state " " " " ? (1 or 2 statement লিখতে হবে)
(as particle size and gradation affects the stability of pavement layer)

What is the difference between grading and FM?



$$* FM = \frac{\Sigma \text{ total \% retained on } \#4, 8, 16, 30, 50, 100}{100}$$

⇒ Grading is the complete picture and FM represents the fineness and coarseness of aggregates.

For one grading, we will have only one FM but for 1 FM we can have more than one grading.

Blending of Aggs. | What is it?

Tests of Agg. | Strength tests | – ASTM
– BS
– Others

Specification of Aggs.

SAND

* Blending:
– It is the mixing of aggregates

- Why blending needed?
– We have to mix aggregates one, two or more in order to get a specified gradation for concrete or road aggs.

Where there is an agg. const., there is an agg. grading – Justify.

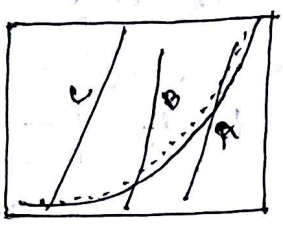
(1) What type of agg? (Brick/stone chips)

(2) Crushed/uncrushed? (What type of stone agg.?)

(3) What is the max^{m} size? – 25 mm

(4) What are the proportions of other size is?

- The answer is gradation in graphical or tabular form.



40% A
40% B
20% C

* Market থেকে agg. sample নেয়া gradation curve তৈরি করতে হবে। Then for particular job to get specified gradation mixing of the proportions of other aggs. is called Job mix formula.

* How is done?

⇒ Blending is done for 3 ways.

1. Equation method
2. Trial and error "
3. Graphical "

- Engineering Materials Aziz book example of Eqn Method

- Trial & error method (Chapter 19, Table 19-4, 19-5)

- Graphical " (ordinates from grading curve)

* Tests of Aggs.:

- ACV
- AIV } BS
- TFV

* Strength
  - hardness (not to be crushed under the wheel load)
  - toughness (to withstand the load under adverse load conditions and severce service condition)

- Strength means strong characteristics.

* % wear in L.A. Abrasion test = $\frac{\text{wt. passing \#12 sieve}}{5000} \times 100$
  ↓
  ASTM

যত বেশি হবে, তত agg. দুর্বল।

* Absorption test

- Very important for mixing concrete

* Durability test

- ability to retain strength properties under the action of severe weathering agents (rain, wind)

* Other tests

- Sheet 8 Table

* What are the typical strength values of brick agg.?

- Sheet 5
- Sheet 6 (Jamuna bridge) } only to see

* Specification of agg.

- Sheet 11 - Table 8-3

* What are the agg. test for Asphalt concrete for runway overlaid?

* Sand

- Properties
- Uses
- Bulking of sand

** Mix design should always be in weight basis.

* Why is sand necessary for any agg. construction ?

- Because without the percentage of sand. the gradation can't be complete. We can't fill the void without sand.

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④

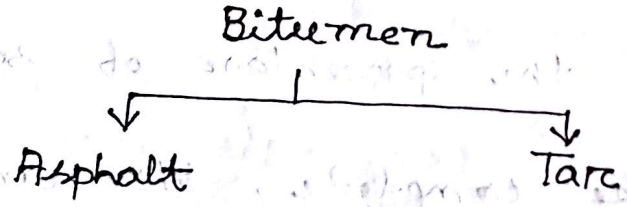
Bitumen / Asphalt (Sheet 12)

What is it?

Why is required?

How is produced?

What are the properties, tests and specs?



* Sheet 14 - Introduction of Bitumen

* What is the chemistry of Bitumen?

⇒ 1) Aliphatic Chain
2) Aromatic unsaturated ring } Compound of C & H_2
3) " saturated "

* Why required?

⇒ Bitumen is the upper layer of flexible pavement. It is the binding material and gives flexibility of pavement.

* Tar is the byproduct from destructive distillation of coal or wood. Destructive distillation is done to produce gas

* Tar এর অনেক Adhisiveness থাকে but susceptible to temparature. Now Tar is obsolete.

Asphalt

- Natural
  - Rock asphalt
  - lake "
  - Gilsonite
- Artificial (From refining crude petroleum)

* What are the steps of refining Crude Petroleum?

- Chapter 15 – Fig

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Bitumen
- Types
- Grading
- Properties
- Tests
- Specifications

Refining process :

* Straight run asphalt from refinery
Air ⇓ Rectification
Air Blown Asphalt

⇒ Gasolene
Kerosene
Diesel
lub. oil

Solid (x)
(✓) Semi solid
(✓) liquid consistency

- Sheet 10 → Flowchart of refinery

* More refine करने पर liquid → semisolid → solid.

* Air Blown asphalt is mainly used for sealing pavement.

* Asphalt ⇒
  - Grasolene → RC cutback asphalt → RC 250, RC 800
  - Kerosene → MC " "
  - Diesel → SC " "

  } Cutback Asphalt

* We need liquid asphalt to mix with aggregates so that coating is everywhere in aggregates.

* Semi-solid + water ⇒ Emulsified Asphalt → Anionic, Cationic

What is the common properties of Bitumen?

→ Sheet 12 + 10 → General properties
↓ summary
common properties → same

15.9 (from book)

↳ Properties of aggregates

* Grading

- → Penetration Grade (from Pen. test)
- → Viscosity " (from Viscosity ")
- → Performance "
- → Modified Binders

15.7 → Classification of Bituminous materials

pg. 248 (3 tables)

↓

(1 must)

What are the desirable properties for satisfactory function of bitumen?

→ Sheet 10 (6)

Table 15.4 (Laboratory tests of bituminous materials)

5 Groups

- What are the consistency tests? (1 must)

" " " .....

What is viscosity of Bitumen?

Viscosity opposite to fluidity. It is the property which retards the flow

(Pg. 456)

What is temparature susceptibility?

- Sheet 14

  2nd page 1st parca

What is Penetration Index?

* Sheet 1 to 5 (CT) (Next Week)

Specifications

- SBS Modified Asphalt

{ Styrene Butadiene Styrene (Block) }

* Sheet 11 pg. 890

Requirements for Asphalt cement (5 specification)

What is the requirement / specification for Asphalt cement?

* Sheet 10 → 20.3 → Modified Binders (to 20.3.5)

(Not for CT)

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Emulsified Asphalt ⟹

Bitumen Quality for Road construction in Bangladesh

What is it?

Why required?

How is manufactured?

Section: 20.1.18 Pg. 462, Sheet #10

Pg. 427, Textbook - tests

Specifications, Sheet # 8

Asphalt overdry

What is it?

⇒ This is emulsion

↓

mixture of two immiscible materials

one is asphalt and other is water

Bitumen + Water

Oil + Water

Why required?

⇒ for road and airport construction

liquid asphalt

* Post straight run asphalt are in semi-solid consistency.

  * Asphalt Cement → Commercial name of penetration grade asphalt

* Portland cement → fly ash & pozzolanic material add
  ↓
  Portland composite cement (PCC)

* Apply heat to turn semi-solid asphalt into liquid → Hot mix asphalt

How is manufactured?

⇒ Cut the bitumen into small globules and mix with water.

* Emulsifier → an agent which creates charges
  ① Sodium$^+$ stearate$^-$ (Anionic)
  ② Cetyl trimethyl amonium$^+$ bromide$^-$ (cationic)

Where is used?

⇒ aggregate এর ~~সাথে~~ positive charge থাকলে

- Anionic → for road works

any aggregate when wet has (-)ve charge

- Cationic → for road work emulsion

What are the special test for emulsified asphalt?

⇒ from book.

Specification of emulsified asphalt

⇒ Sheet # 11 (8-20, Table 8.5)

What is the appropriate bitumen for road construction in Bd.? and how to achieve the qualities?

⇒ Sheet 14 (Climate.....)

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Bituminous Mixes
- What is it?
- Why is required?
- Where is placed?
- How is done?
- What are the properties, design & spec.?
- What are the types?

* Cement concrete
  - BS method
  - ACI "

* Asphaltic / Bituminous concrete
  - Ch-19 text book
  - Marshall method
  - Hveem "

Bituminous mixes

⇒ It is a mixture of CA, FA & mineral filler
- CA → +4.75mm
- FA → −4.75mm
- mineral filler → −0.075mm

The material which is objectionable in CC that is a requirement in asphaltic concrete.

* Cement + water – gel

H-C-S gel (Hydrogen, Calcium & Silicate gel) } CC + Admixtures ↓ to improve quality

* Asphalt / Bitumen (liquid consistency) + ... rubber gum / Chemicals

* Why is required?

⇒ Bitumen is very unpleasant material. as we want to construct flexible pavement. Bitumen is a visco-elastic material provides the flexibility. Bitumen is needed for the upper layer of flexible pavement

* Where is placed?

⇒ upper layer of flexible pavement.

Sheet 13 - Bituminous mixes

* BDS 2002 - Classification of bricks according to BSTI

⇒ Low, Intermediate, High type

Types of bituminous mixes

- Prime coat → surface এর সিচে ১ম coat
- Tack coat → old road এর
- Seal " → FA দিয়ে seal করে চলা হয়
- SBST → Single Bituminous surface treatment
- DBST → popular in construction

- J. L. Mc Adam → Scottish Road - builder engineer
- Macadam is an aggregate construction.

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- Design of High type Bituminous Mixes
- Characteristics
- Fundamental properties
- Materials
- Requirements
- Steps for Mix design

1
2
3

· Step 3. Optimum Asphalt Content

Methods

General steps

* Sheet 15 & 16, Chapter – 19

High type → high cost, high supervision

→ high volume of traffic

Types of bituminous mixes (Sheet 16)

c. Int. type / Low type mixes :

- Mastic asphalt — SMA (Stone Mastic Asphalt)

* What are the characteristics of high type bituminous mixes ?

⇒ Chapter – 19 1st page 1st para (Italics)

Design of high type bituminous mixes

* What are the fundamentals ?

⇒ ① layer টা stable হতে হবে

② Durability

③ Skid resistance

④ Economy

Civil engineers know the technique to prepare economic mixes with required properties.

Scanned by CamScanner

* (b) voids are filled up with fine aggregate
in CA

and voids in FA are filled up with fines

So mix (b) is desirable.

* Requirements

* Design
  - ~~TO~~ thickness
  - material design

Steps for Mix design

- 19-14 → Determination of Job-mix formula
- Step 2 & 3 (19-14)

* Cement concrete ~~में~~ objectionable asphaltic concrete ~~में~~ must. (mineral fillers)

* N का value 0.5 हुआ → Dense graded parabolic curve

* N का value .45 हुआ → straight line

* Trial & Error Method (Table 19-3, 19-4, 19-5)
↓
Blending का final trial

• Step-3

- Methods

⊞ Marshall method of Mix design - Part II :

- General
- Preparation of test specimen
- Test procedure
- Interpolation of test data
- Preparation
- Trends and relations
- Criteria
- Determination of design asphalt content

Step-3 : Optimum Asphalt Content

2. General steps

- Determination of parameters at 4% Pa (air voids)
  (correction in sheet)

Preparation of Marshall specimen

% of asphalt (5 specimen করতে হবে)
4
4.5
5
5.5
6

What is the amount of asphalt at 5% bitumen of total mix where Aggregate 1200 gm?

$\Rightarrow 1200 + \frac{60}{.95}$

Testing of Marshall specimen : (Sheet এ আছে)

In Marshall method each compacted test specimen is subjected to following test :

- Bulk specific gravity determination
- Stability and Flow test
- Density and void analysis

Marshall stability & flow test

Density - voids analysis (formula book এ আছে)

Table : Marshall specimens after testing

⇒ 6 টা value দিয়ে 6টা graph draw করতে হবে, (dotted column)

⇒ প্রত্যেক graph এর abscissa column 1.

** Exam এ ছোট problem আসতে পারে (formula মুখস্থ রাখতে হবে)

- Asphalt কতটুকু void fill up করছে → VFA
- Standard sample এ convert করতে হবে → correlation ratio দেয়া আছে (Table 5.1)

⇒ Size বড় হলে ratio কম দিয়ে গুণ করতে হবে

Interpolation of Test data

Determination of OAC / DBC / OBC

• Step 1: Find asphalt content at median of % air voids [i.e at 4%] from asphalt content vs. air voids curve.

[* Table 5.2: Marshall mix design criteria]

• Step 2: Find stability, flow, VMA, VFA at this asphalt content from respective curves

• Step 3:

• VMA → from table 5.3

* उक्त criteria satisfy गर्दछन् भने त्यो optimum asphalt content.

Evaluation and Adjustment of Mix design

⇒ General guidelines for adjusting trial mixes are :

. . . .

* Voids কোন অবস্থায় high / low হতে পারবে না কারণ 4% দিয়েই তার check করেছি ।

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- Hveem method of mix design.
- General
- Outline of method
- Approximate asphalt content by CKE [Centrifuge Kerosene Equivalent]
- Preparation of test specimen

* Ques: Compare Marshall & Hveem method of mix design regarding ..... (test, design criteria etc and general বলা যাবেনা এর topic discuss করতে হবে

⇒ Marshall method এ cutback asphalt নাই।

7 Stages 19.1.10 (Book)

* major difference - Hveem method ২ approximate asphalt content determine করি by CKE method

% Asphalt
4
4.5
5
5.5
6

⇒ It is observed that optimum asphalt content is around 5%, so 5% এর 2টা বেশি and 2টা কম নিয়ে specimen prepare করি - from experience of Marshall.

⇒ From material property, find approximate asphalt content. then 2টা বেশি and কম নিয়ে Specimen বানাব; (Hveem method)

Stage D: Determination of Approximate asphalt content

- Table 19.8 → Calculation of surface area
- Pg 547 → CKE definition (To determine ......)

  * always percentage is on the dry wt.

$$\left(\frac{102-101}{100} \times 100 = 1\% \right)$$

- Fig 19-5 (for determining K_f)
- Fig 19-6 (for determining K_c)
- Fig 19.7 (correction to K_f)

  * $K_m = K_f +$ corr. to K_f

- Fig 19.8 (computing oil ratio)

  ↓

  2 cases

- for bitumen type to be used

  ↓

  from fig 19.9

* viscosity এর বেশি material এর আগু হবে।

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Hveem method of mix design :

- Preparation of test specimen
- Testing
- Analysis
- Determination of OAC

Test schedule

Mixing of the ingredients

* এখানে মিশ্রণের পর curing করতে হবে, but marshall method curing করি না।

Compaction of the mixture

* Mechanical kneading compactor Marshall method ব্যবহার। (Fig from book)

Tests on the Hveem specimen

Stabilometer test

- If bitumen passes ductility test, then no need to do cohesion meter test.
- Fig 6.12, 6.13 – Hveem stabilometer

Bulk Density determination

- Fig 6.14

Swell test

Hveem Design criteria

Fig 6.11

- Table 6.2 – Hveem mix design criteria

Design asphalt content

⇒ যেটার % asphalt বের, তারই flushing or bleeding হয়,

• M.S.F → maximu surface flushing

** 5 & 5.5% দুইটাতেই 4% air void পাবে তাহলে design asphalt content হবে 5.5% (max টা হবে)

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Superpave Mix Design

Salient Features

Selection of Asphalt binder (pg. 553)

Selection of Aggs. (Pg. 556)

Selection of design agg. structure (pg. 558)

Design asphalt binder (pg 559)

Evaluation of Moisture sensitivity (pg. 559)

* Superpave → Superior Performing Pavement

* Classification of Bituminous materials

all types - Grades of bitumen
Straight run asphalt - semisolid

• Ch-15 - Grades of asphalt (15.7.1)
  - → Penetration grade
  - → Viscosity " (1.2)
  - → Performance "

- Ch-19 - Pg. 553 (last paragraph)

- Table 19-9 — Test parameters

- Cox's Bazar Asphalt — surface course

  PG 64-22

  ↓ max^{m} 64°c ↓ min^{m} −22°c

- The performance of bitumen at 64°c & −22°c.

* Table 19-10 — Equipment for superpave binder test
↓ (লাগবে)

- Table 19-11

* Selection of design asphalt binder content - Pg 559
↓ (6 steps)

- Evaluation of moisture sensitivity

* Special mix — 13 টা আছে (Sheet 1, বইএ নাই)

- Stone Matrix Asphalt (SMA)
  - SMA (Stone Mastic Asphalt) [British/India]
- Rich mix
- Hot inplace recycling
- Cold mixes