Nepal Engineering Council Licensure Examination

ER. SAURAV SHRESTHA
MSC. IN TRANSPORTATION ENGINEERING
PULCHOWK CAMPUS

TRANSPORTATION ENGINEERING SYLLABUS OF NEC LICENSE EXAM

9. Transportation **(ACiE09)**

9.1 Highway planning and survey: Modes of transport, history of road development in Nepal; classification of roads; road survey; highway alignment and controlling factors; evaluating alternate alignments; Road Standards of Nepal. (ACiE0901)

9.2 Geometric design of highway: basic design control and criteria; elements of highway cross-section; highway curves; super elevation; average and ruling gradients; stopping sight distance; design considerations for horizontal and vertical alignments, extra widening, and set back distance; design of road drainage structures; design considerations for hill roads. (ACiE0902)

9.3 Highway materials: types of aggregates and tests on their gradation, strength, durability; binding materials and their tests; design of asphalt mixes; evaluation of subgrade soil. (ACiE0903)

9.4 Traffic engineering and safety: impact of human and vehicular characteristics on traffic planning; traffic operations and regulations; traffic control devices; traffic studies (volume, speed, O&D, traffic capacity, traffic flow characteristics, parking, accident, flow); road intersections (types, configurations, design); traffic lights; factors influencing night visibility, road safety measures. (ACiE0904)

9.5 Road pavement: different types of pavement; design methods for flexible and rigid pavements (DOR Guidelines); loads and other factors controlling pavement design; stress due to load, temperature. (ACiE0905)

9.6 Road construction & maintenance: activities, techniques, tools, equipment and plants used in road construction; preparation of road subgrade; field compaction control and soil stabilization; construction of asphalt concrete layers; construction procedure for penetration macadam, bituminous bound macadam and plain cement concrete pavements; road maintenance, repair and rehabilitation. (ACiE0906)

the spreading and compacting of key aggregates (intermediate aggregates)

- **Full Grout** – Bitumen Penetrates through the full depth
- **Semi-Grout** – Bitumen Penetrates through half depth
- Full grout in case of heavy rainfall area
- Semi grout in case of average rainfall and traffic
- **Full grout thickness** – 7.5 cm
- **Semi grout thickness** – 5 cm

macadam

- Uniform coverage is not ensured

y)

Grouted or Penetration Macadam

Procedure

1. **Preparation** and **intensive cleaning** of the existing surface by broom and air compressor.
2. **Spreading of coarse aggregate** as per the specified rate of application.
3. **Dry rolling** of the spread coarse aggregate at least with 10 ton roller.
4. **Spreading of bitumen** as per specified rate of application.
5. Spreading of **key aggregate** as per specified rate of application.
6. **Rolling of key aggregate** at least with 10 ton roller.
7. Application of **seal coat**.
8. Opening to traffic

Bituminous Bound Macadam

- A premix with coarser aggregate used in binder course or in base course with large void contents
- Open graded aggregates with high **void content** of **20-25%** with **large size aggregates**
- Stability is due to the **interlock** of the **aggregate particles and** the **frictional resistance**
- **Dense Bituminous Macadam** in **Binder course** generally has **less voids of 5 to 10%** contains dense graded aggregate

Bituminous Bound Macadam

Materials

Bitumen

- VG-10, VG – 30 or VG-40, quantity required for premix, 3.5 to 4.5 % by weight
- NO mix design procedure is available

Aggregate

- LAA – 40%
- AIV – 30%
- Flakiness Index (FI) – 25%
- Stripping Value – 25%

Materials

Aggregate Gradation

- For 75 mm thickness of BBM, 37.5 mm nominal size of aggregate is selected
- For 50 mm thickness 19 mm nominal size of aggregate is selected

Bituminous Bound Macadam

Construction Procedure

- Cleaning by brushing, sweeping and air compressor
- Depressed portions are filled up with precoated aggregates and rammed up
- **Tack coat** is applied prior to the application of premix
- **Hot mix method** is used for which is Hot mix plant is used
- Both the aggregate and bitumen are brought together which is heated for 140-160 C (bitumen) and aggregate (100-150 C)
- Mixing for 1 min till a homogenous mix is obtained

Bituminous Bound Macadam

- Through paver paving is done, and laying temp. should be in a range of 110-135 C
- Rolling is done by the **8-10** smooth wheeled or **vibratory roller** (rolling done till no impression is made in the pavement)
- Immediate rolling is done by the **pneumatic tyred roller**
- The finish rolling is done by **6-8 ton smooth wheel tandem roller**

Asphalt Concrete

Materials

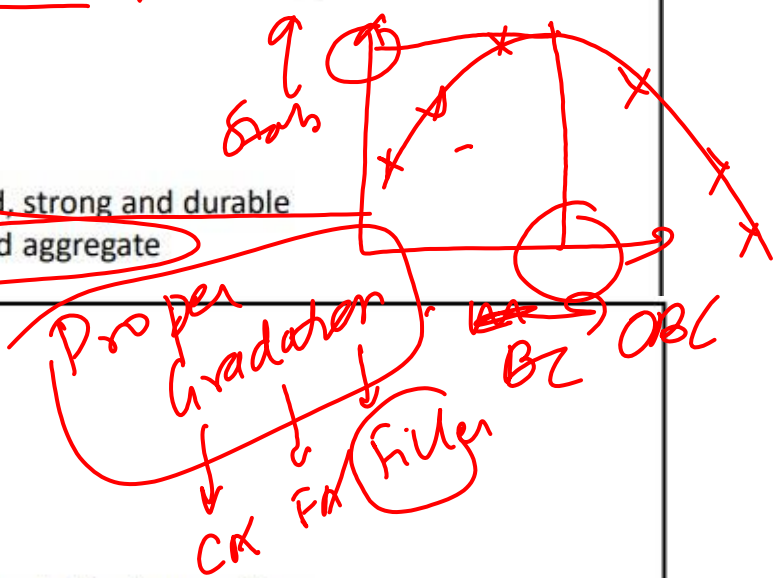
Bitumen

- VG-10, VG – 30 or VG-40, quantity required for premix. Has to design for OBC (Max. unit weight, design void content, max. stability)

Coarse Aggregate (Nominal size of 20 mm for 50 mm thick, or 13.3mm for 40-50 mm thick)

- LAA – 30%
- AIV – 30%
- Flakiness Index (FI) – 25%
- Stripping Value – 25%
- Soundness – 12%

- The aggregate should be clean, hard, strong and durable
- Requires appropriately proportioned aggregate



Asphalt Concrete

Materials

Fine Aggregate (<4.75mm)

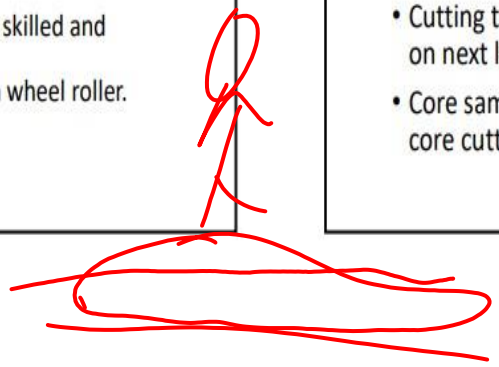
- Free from clay, silt ,organic and other deleterious matter
- Non plastic
- Should be made crushed rock of LAA not more than 30
- Soundness < 12%
- Sand equivalent >60

Filler Material(<0.075 mm)

- Lime stone, hydrated lime, OPC, fly ash or other non-plastic material
- 75% should pass through 75μ sieve

Asphalt Concrete

- Checking of temperature of mix before delivering, during laying and before compaction. The temperature difference should not be greater than 10°C in each activity.
- During the laying of the asphalt concrete mix, a good coordination between the equipment and labors is very important and shall be maintained.
- Checking the loose thickness manually.
- Follow up level corrections by skilled labors.
- Finishing the asphalt concrete layer before compaction by skilled and corrections at joints while laying on next lane.
- Initial compaction of the asphalt concrete layer by smooth wheel roller.



Asphalt Concrete

- Follow up compaction by pneumatic roller. The rolling shall be continued until the voids measured in the completed layer are within the appropriate range.
- Average density after compaction shall not be less than 98 %. No individual density shall be below 95 % of the average of the laboratory specimens
- Cutting the edge of previously laid mix with edge cutter for laying mix on next lane. The edge cut should be perfectly vertical
- Core sample of the previously laid mix is taken out with the help of core cutter for further necessary laboratory tests

d. 4.5 m

63. In four lane single carriage way road, the design should be based on ……. of the total number of commercial vehicles in both directions.
    a. 75% (two lane)
    b. 50%
    c. 40%
    d. 60%

Type of Road	LDF
Single lane road	1
Two lane- Single Carriageway	0.5
Four lane- Single Carriageway	0.4
Dual Carriageway	0.75

Intermediate lane | LDF 0.75

4.5 Lateral Distribution of commercial traffic over the carriageway

Total traffic AADT (both way) is distributed over the whole carriageway for design of pavement. During the calculation of design traffic volume (total equivalent standard axle), realistic study should be done for the directional distribution of total traffic. In the absence of adequate and conclusive data for particular project, it is recommended that following distribution may be assumed for design.

a) **Single lane roads:** traffic tends to be more channelized on single lane roads than two-lane roads and to allow for this concentration of wheel load repetitions, the design should be based on total number of commercial vehicles in both direction.
b) Intermediate lane roads of width 5.5 m: Design traffic based on the 75 percent of the two-way commercial traffic.
c) **Two-lane two-way roads:** the design should be based on 50 percent of the total number of commercial vehicles in both directions.
d) **Four-lane single carriageway roads:** the design should be based on 40 percent of the total number of commercial vehicles in both directions.
e) **Dual carriageway roads:** The design of dual two lane carriageway roads should be based on 75 percent of the number of commercial vehicles in each direction. For dual three-lane carriageway and dual four lane carriageway, the distribution factor will be 60 percent and 45 percent respectively.

$$N = \frac{365 \times ((1+r)^n - 1)}{r} \times A \times D \times F$$

Where,

N = Cumulative number of standard axles to be catered during design period in terms of MSA.

A = Initial traffic in the year of completion of construction in terms of CVPD

D = Lane distribution factor

F = Vehicle damage factor (Either from the table or from the axle load survey)

n = Design life in years

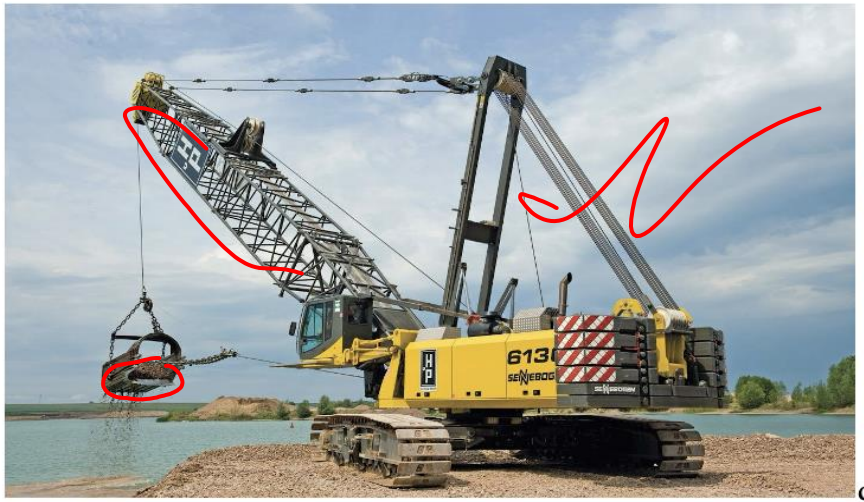
r = Annual growth rate of commercial vehicles

Flexible pavement	Rigid Pavement
The load is transferred from top to bottom by grain to grain contact.	The load is transferred through slab action
Low or negligible flexural strength.	High flexural strength.
Joints are absent.	Expansion and contraction joints are provided
Low initial cost but high maintenance cost.	High Initial cost but low maintenance cost.
It includes- Surface, base, sub-base, and subgrade layers.	It includes – Concrete slab, base course, and subgrade layers.
Deformation in the top layers is transferred to under- laid layers	Deformation is only in the top layer of the concrete slab.
More suitable for stage construction	Less Suitable for stage construction.
Very less effect of temperature stress.	Effected by temperature and frictional stresses.

71. A vehicle for transporting excavated material so designed to be capable for discharging
    a. Bull dozer
    b. Dumper
    c. Scraper
    d. Tractor

dumper

72. Among the following excavators, the most suitable excavator for dredging purposes will be
    a. Front shovel
    b. Back hoe
    c. Dragline
    d. Scraper



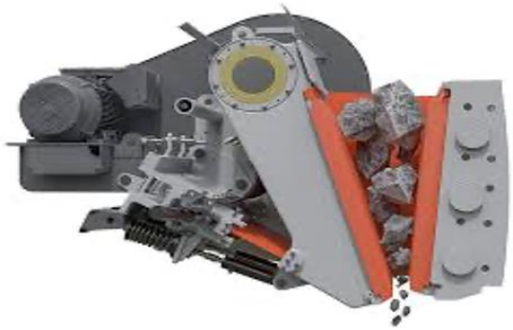
dragline

79. Downtime of an equipment is
    a. the time when equipment shall have to be returned to the owner due to expiry of its lease period
    b. the period of time when equipment is idle for want of work
    c. the period of time that the equipment fails to provide or perform its primary function
    d. the time when contractor has to do the down payment before taking equipment on rent

80. Vibrating compactor is ideally suited for
    a. Manual towing and compacting any type of soil with varying moisture content
    b. Compacting fly ash masses with any moisture content
    c. Compacting cohesion less granular material with any moisture content
    d. Compacting all fine grained materials having adequate moisture content

81. A process of transporting material from one place to another over a stationary structure in a continuous stream is known as
    a. Transporting
    b. Hauling
    c. Conveying
    d. Hoisting

96. Which of the following crushers is primarily used for shaping the aggregates?
    a. Jaw crusher
    b. Vertical shaft impactor
    c. Cone crusher
    d. Jaw crusher and cone crusher together



jaw crusher

97. Which of the following surfaces will give highest coefficient of friction while using crawler track tractors?
    a. Earth
    b. Ice
    c. Concrete
    d. Loose sand

98. A _____ is very useful equipment and it can be used for construction work like to clear the site of work, to make the land level, etc.
    a. Scraper
    b. Grader
    c. Excavator
    d. Bulldozer

105. A low viscosity liquid bituminous material applied to the existing pervious surface is
    a. Tack coat
    b. Prime coat
    c. Seal coat
    d. Bituminous surfacing

106. A high viscosity bituminous material applied to the relatively impervious surface such as existing bituminous pavement, concrete pavement, etc is
    a. Tack coat
    b. Prime coat
    c. Seal coat
    d. Bituminous surfacing

107. A very thin surface treatment which is applied as final step in construction of bituminous surface or on existing surface is
    a. Tack coat
    b. Prime coat
    c. Seal coat
    d. Bituminous surfacing

108. In bitumen bound macadam, the thickness of single layer is
    a. 20-30 mm
    b. 30-45 mm
    c. 50-100 mm
    d. 75-150 mm

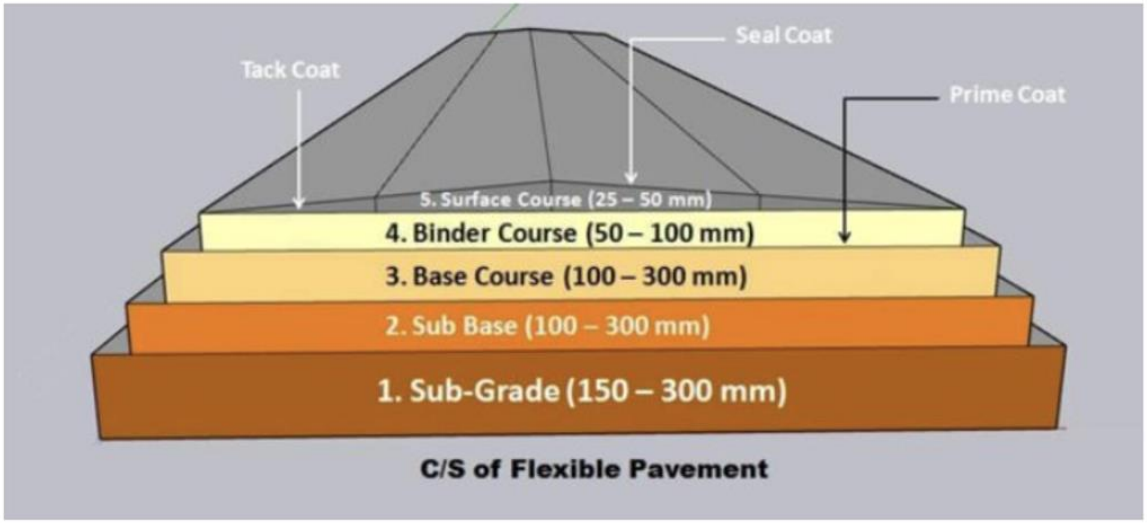
109. The thickness of bituminous carpet varies from
    a. 10-20 mm
    b. 20-25 mm
    c. 25-30 mm
    d. 30-50 mm

110. In the penetration macadam construction, the bitumen is
    a. Sprayed after the aggregates are spread and compacted
    b. Premixed with aggregates and then spread
    c. Sprayed before the aggregate are spread and compacted
    d. None of the above

111. The shear failure of soil sub grade may be attributed to …
    a. Inadequate stability
    b. Excessive stress
    c. Inadequate stability and excessive stress
    d. None of the mentioned

112. The stability of flexible pavement structure depends on
    a. Sub grade
    b. Degree of compaction
    c. Drainage system
    d. All of the mentioned

113. The bottom most layer of pavement is known as
    a. Wearing course
    b. Base coarse
    c. Sub-base course
    d. Sub-grade



Road maintenance and Repair

Measures intended to keep the pavement structure in serviceable condition as best as practicable and as long as possible is known as maintenance.

Types of Maintenance:

(1) Routine Maintenance
(2) Recurrent Maintenance
(3) Periodic Maintenance
(4) Emergency Maintenance

(1) Routine Maintenance:

- Routine maintenance is carried out daily at road, below road or above road.
- The works done in routine maintenance are grass cutting of shoulders, cleaning of road & drain, cleaning of sign post, pot holes repair of earthen and gravel road, etc

(2) Recurrent Maintenance:

- Recurrent maintenance is carried out at the interval of 6 months to 2 years.

The works done in routine maintenance are pot holes repair of bituminous road, painting of road marking & sign posts, repair of drainage , etc

3)Periodic Maintenance:

- It is carried out at the interval of 5 to 7 years.
- The works done in periodic maintenance are overlaying of road, Bio-Engineering, installation of cross drainage structures like culverts , etc.

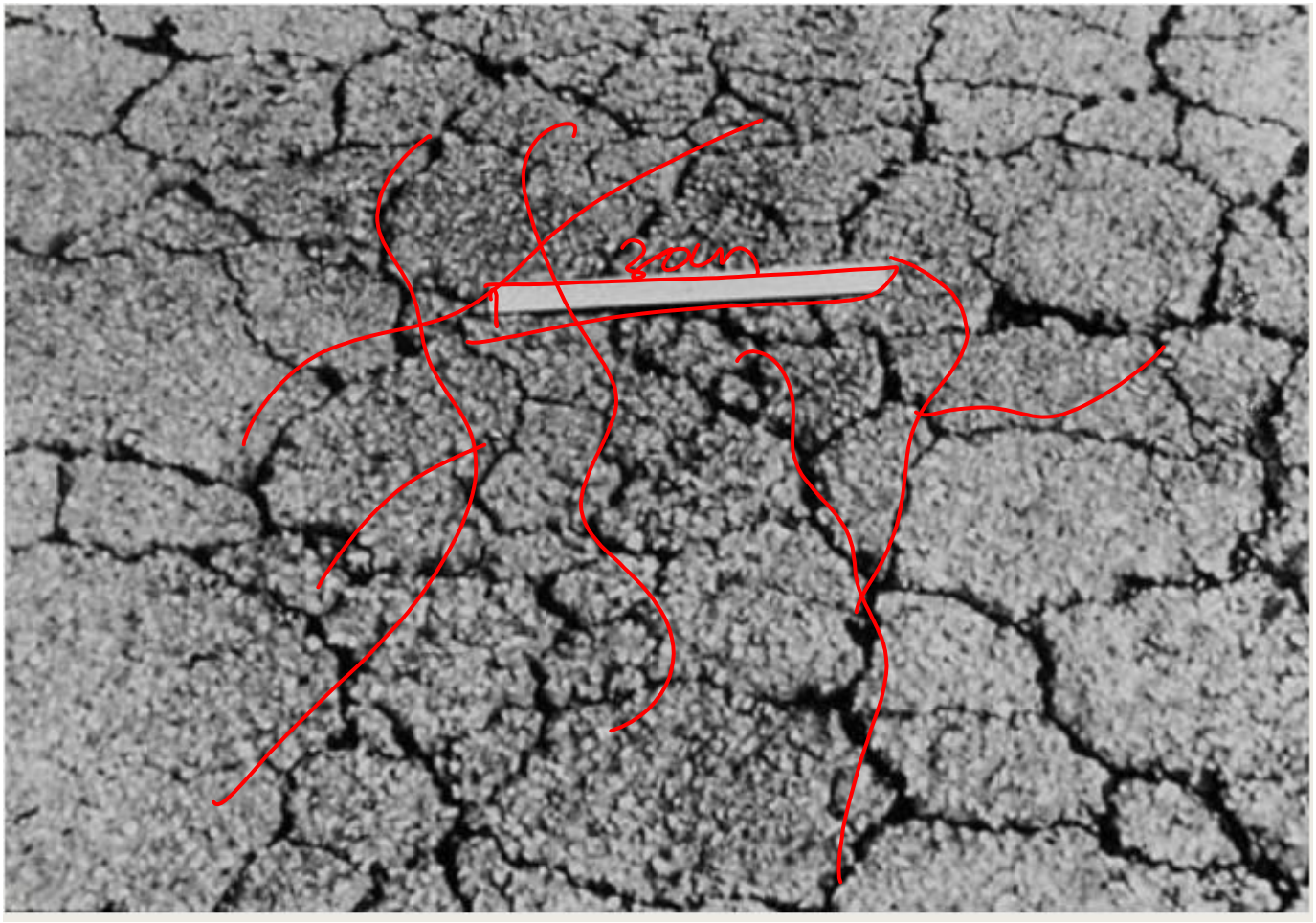
(4) Emergency Maintenance:

- It is also known as special maintenance.
- It is carried out in a emergency situations.

Typical Flexible Pavement Failure

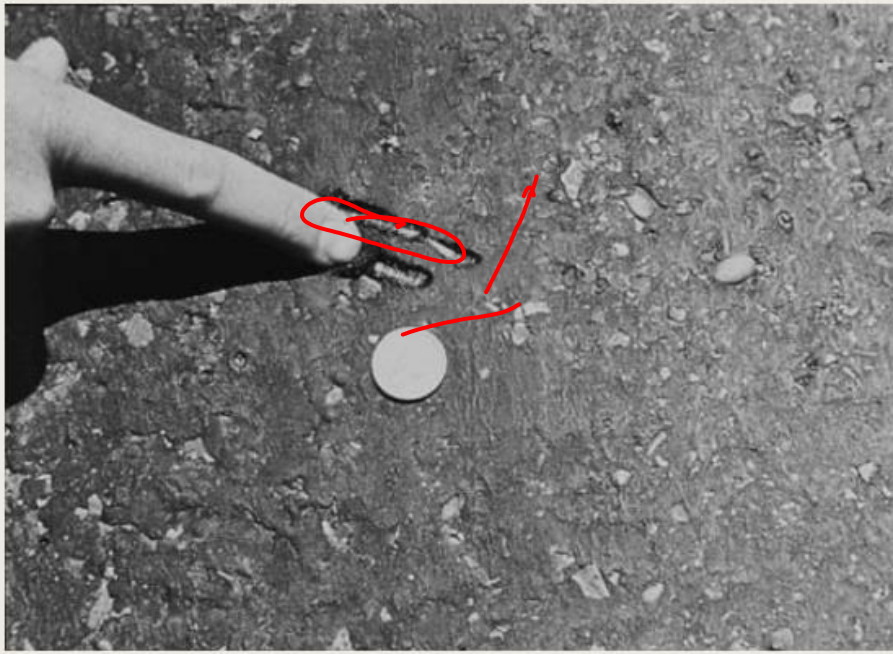
Alligator cracking (Fatigue)

- Alligator or fatigue cracking is a series of interconnecting cracks caused by fatigue failure of the asphalt concrete surface under repeated traffic loading.
- Cracking begins at the bottom of the asphalt surface, or stabilized base, where tensile stress and strain are highest under a wheel load.
- The cracks propagate to the surface initially as a series of parallel longitudinal cracks.


2cm

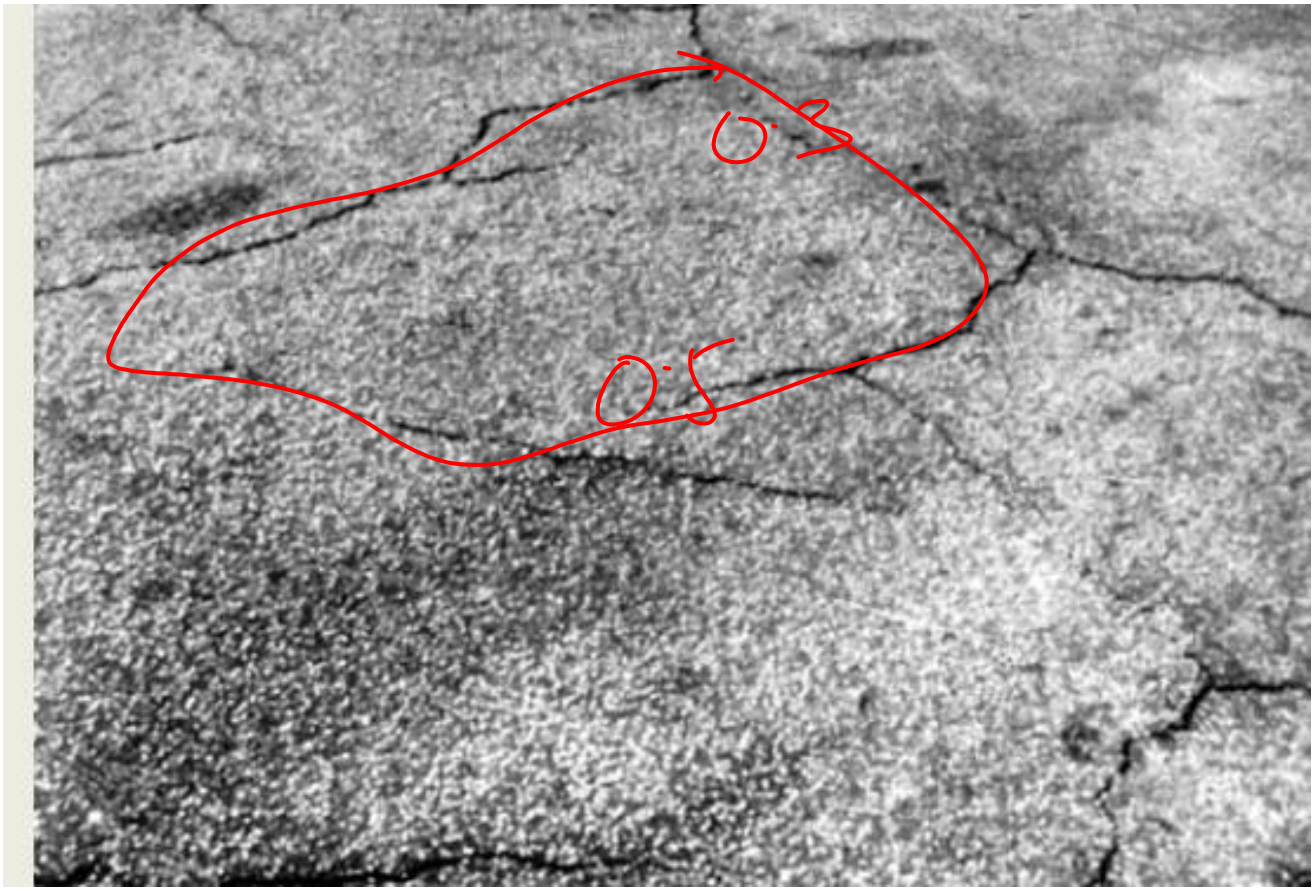
Bleeding

- Bleeding is a film of bituminous material on the pavement surface that creates a shiny, glasslike, reflecting surface that usually becomes quite sticky.
- Bleeding is caused by excessive amounts of asphaltic cement or tars in the mix, excess application of a bituminous sealant, or low air void content, or a combination thereof.
- It occurs when asphalt fills the voids of the mix during hot weather and then expands onto the pavement surface.
- Since the bleeding process in not reversible during cold weather, asphalt or tar will accumulate on the surface.

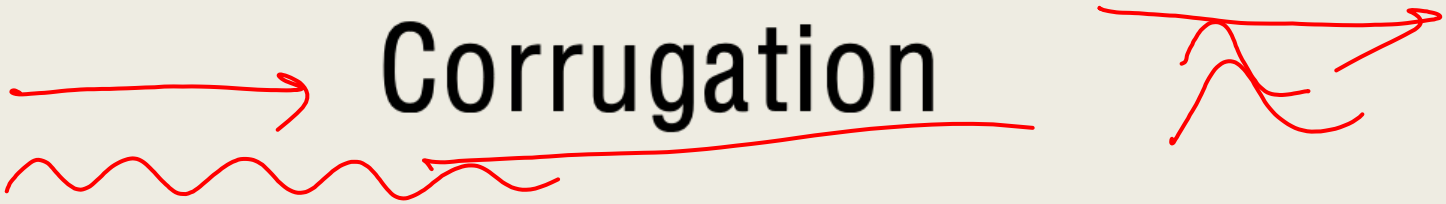


Block Cracking

- *Block cracks are interconnected cracks* that divide the pavement into approximately rectangular pieces.
- The blocks may range in size from approximately 0.3 by 0.3 m (1 by 1 ft) to 3 by 3 m (10 by 10 ft).
- Block cracking temperature cycling, which results in daily stress/strain cycling. It is not load-associated.
- Block cracking usually indicates that the asphalt has hardened significantly.
- Block cracking normally occurs over a large portion of the pavement area, but sometimes will occur only in non traffic areas.
- This type of distress differs from alligator cracking in that alligator cracks form smaller, many-sided pieces with sharp angles.
- Also, unlike block, alligator cracks are caused by repeated traffic loadings, and therefore, are found only in traffic areas, that is, wheel paths.

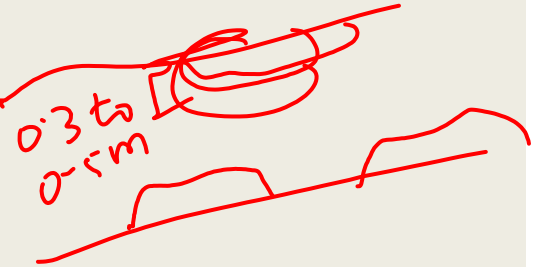


Corrugation

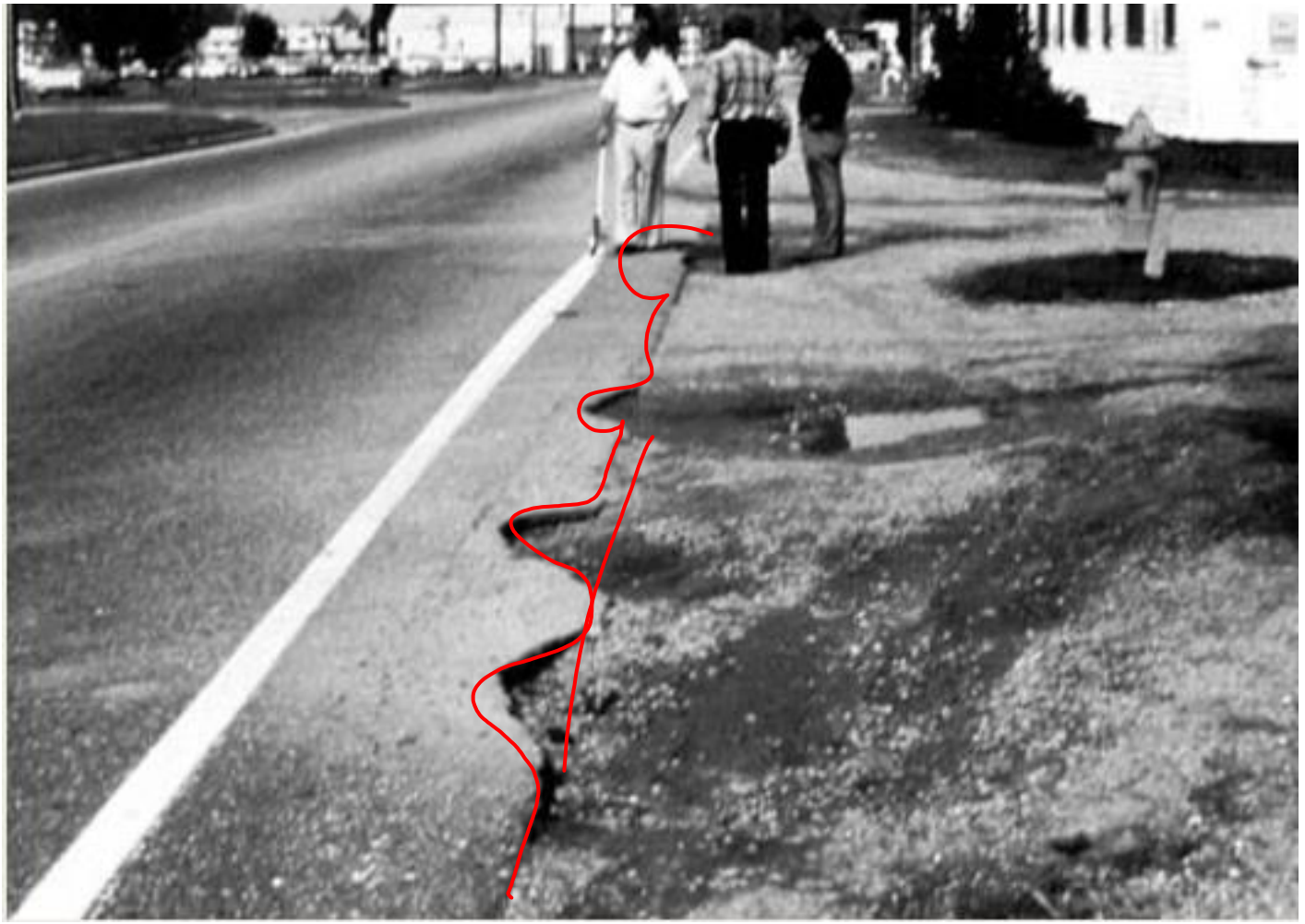


- Corrugation, also known as "washboarding", is a series of closely spaced ridges and valleys (ripples) occurring at fairly regular intervals, usually less than 3 m (10 ft) along the pavement.
- The ridges are perpendicular to the traffic direction.
- This type of distress usually is caused by traffic action combined with an unstable pavement surface or base.

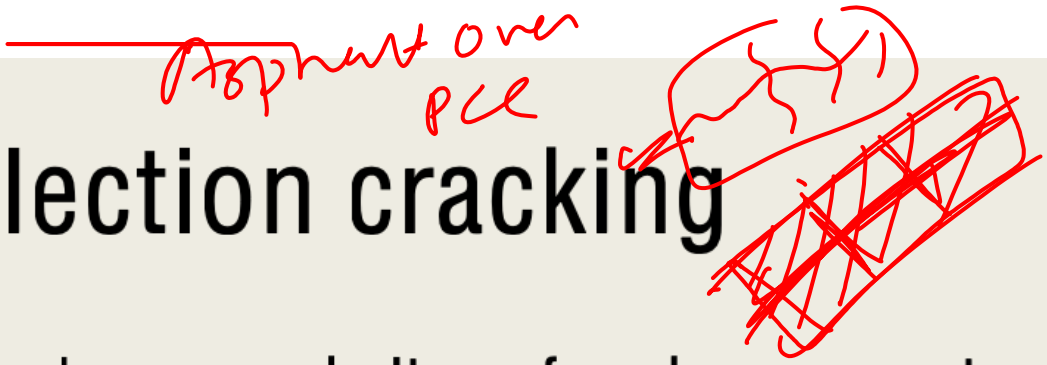
Edge Cracking



- Edge cracks are parallel to and usually within 0.3 to 0.5 m (1 to 1.5 ft) of the outer edge of the pavement.
- This distress is accelerated by traffic loading and can be caused by frost-weakened base or subgrade near the edge of the pavement.
- The area between the crack and pavement edge is classified as raveled if it is broken up sometimes to the extent that pieces are removed).



Joint reflection cracking



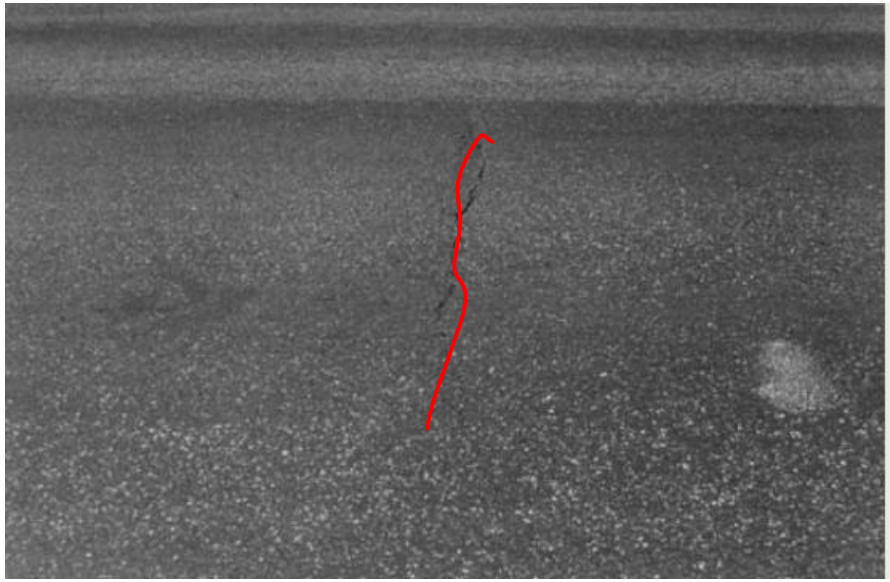
- This distress occurs only on asphalt surfaced pavements that have been laid over a PCC slab.
- It does not include reflection cracks from any other type of base, that is, cement- or lime-stabilized; these cracks are caused mainly by thermal- or moisture-induced movement of the PCC slab beneath the AC surface.
- This distress is not load-related; however, traffic loading may cause a breakdown of the AC surface near the crack.
- If the pavement is fragmented along a crack, the crack is said to be spalled.
- A knowledge of slab dimension beneath the AC surface will help to identify these distresses.

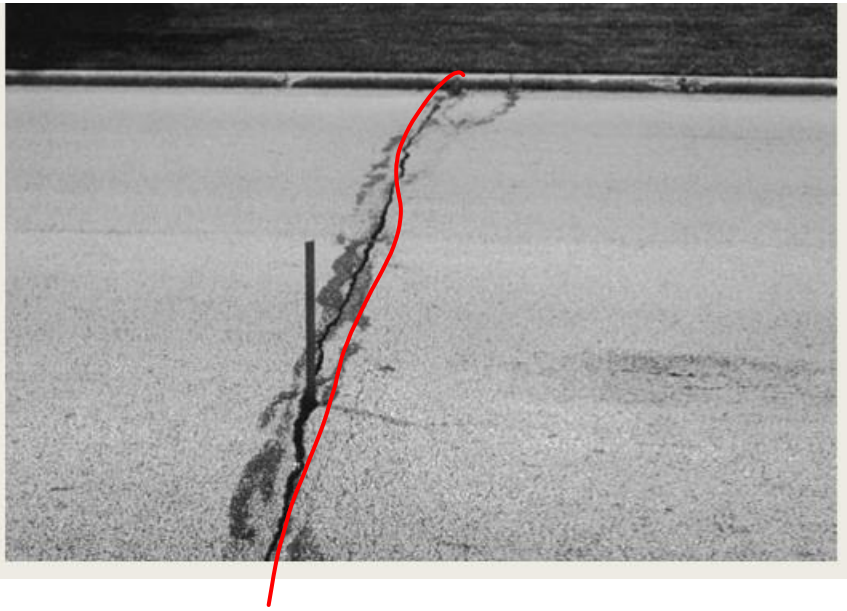
LONGITUDINAL AND TRANSVERSE CRACKING

(Non-PCC Slab Joint Reflective)

Longitudinal cracks are parallel to the pavement's centerline or laydown direction. They may be caused by:

- A poorly constructed paving lane joint.
- Shrinkage of the AC surface due to low temperatures or hardening of the asphalt, or daily temperature cycling, or both.
- A reflective crack caused by cracking beneath the surface course, including cracks in PCC slabs, but not PCC joints.
- Transverse cracks extend across the pavement at approximately right angles to the pavement centerline or direction of laydown.
- These types of cracks are not usually load-associated.





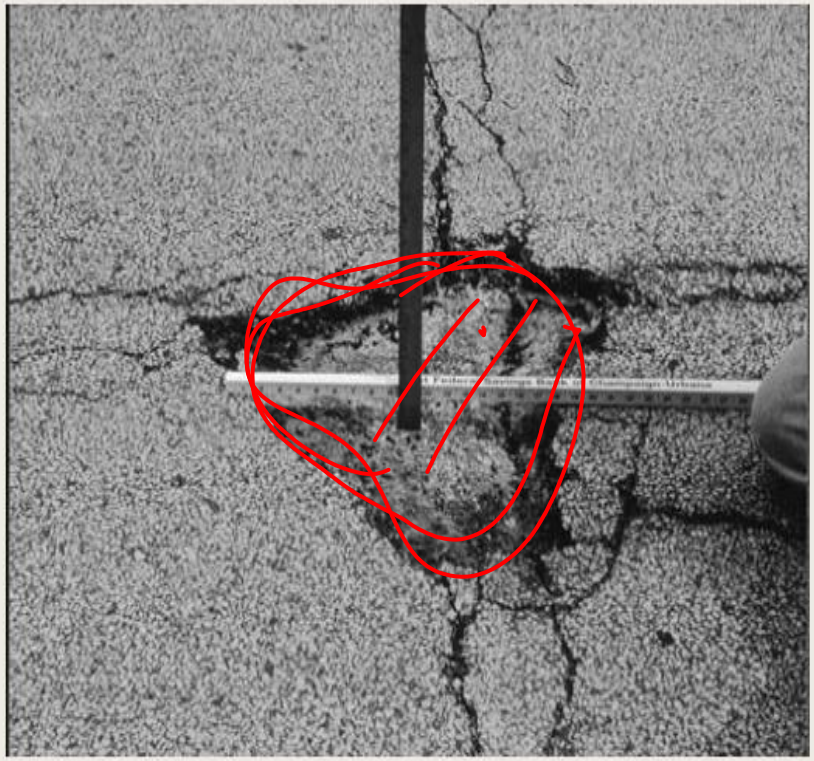
Potholes

- *Description—Potholes are small—usually less than* 750 mm (30 in.) in diameter—bowl-shaped depressions in the pavement surface.
- They generally have sharp edges and vertical sides near the top of the hole. When holes are created by high-severity alligator cracking, they should be identified as potholes, not as weathering.

Maximum Depth of Pothole	Average Diameter (mm) (in.) 100 to 200 mm (4 to 8 in.)	200 to 450 mm (8 to 18 in.)	450 to 750 mm (18 to 30 in.)
13 to ≤25 mm (½ to 1 in.)	L	L	M
>25 and ≤50 mm (1 to 2 in.)	L	M	H
>50 mm (2 in.)	M	M	H

Bump

Rut



Typical Rigid Pavement Failure

(1) Scaling of Cement Concrete:

- This is mainly due to deficiency in the mix or presence of chemical impurities.

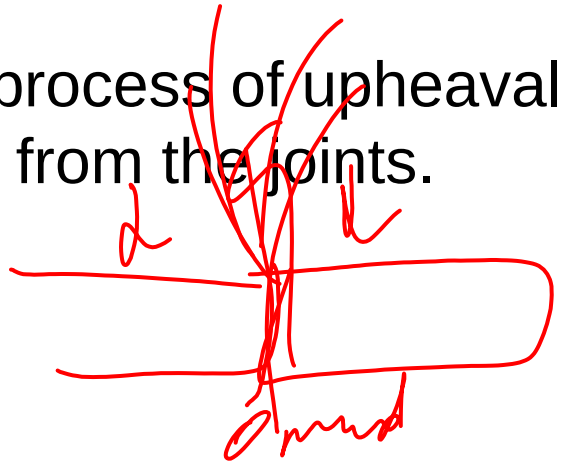
(2) Shrinkage Cracks:

- During the curing operation of cement concrete pavements immediately after the construction these cracks develop both in longitudinal and lateral direction.

(3) Spalling of Joints : It is the dislocation of the joints

(4) Warping Cracks: It is the failure at edge and corner of the pavement due to difference in temperature.

(5) Mud Pumping: It is the process of upheaval of mud below the pavement from the joints.



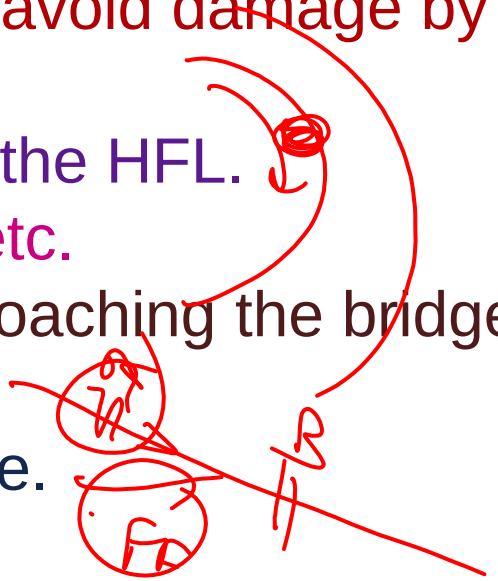
Bridge and types of bridge

A Bridge is a Structure Providing Passage Over an Obstacle without Closing the Way Beneath.

- The Required Passage may be for a Road, a Railway, Pedestrians, a Canal or a Pipeline.
- The Obstacle to be Crossed may be a River, a Road, a Railway, Body of Water or a Valley.

Characteristics of an Ideal Bridge

- Axis of the bridge and the direction of river flow should be **perpendicular** to each other as far as possible.
- Line of the bridge should not present any **serious deviation** from
the line of the approach roads at either end.
- Adequate width for the present as well as for the **anticipated future traffic**.
- **Firm foundations** to a sufficient depth to avoid damage by floods.
- **Provide head-room** for clearance above the HFL.
- Provide for services of sewerage, water, etc.
- Similar road surface for the roadway approaching the bridge on either ends and over the bridge.
- **Economical** both in cost and maintenance.



Classification of Bridges

1. According to Functions

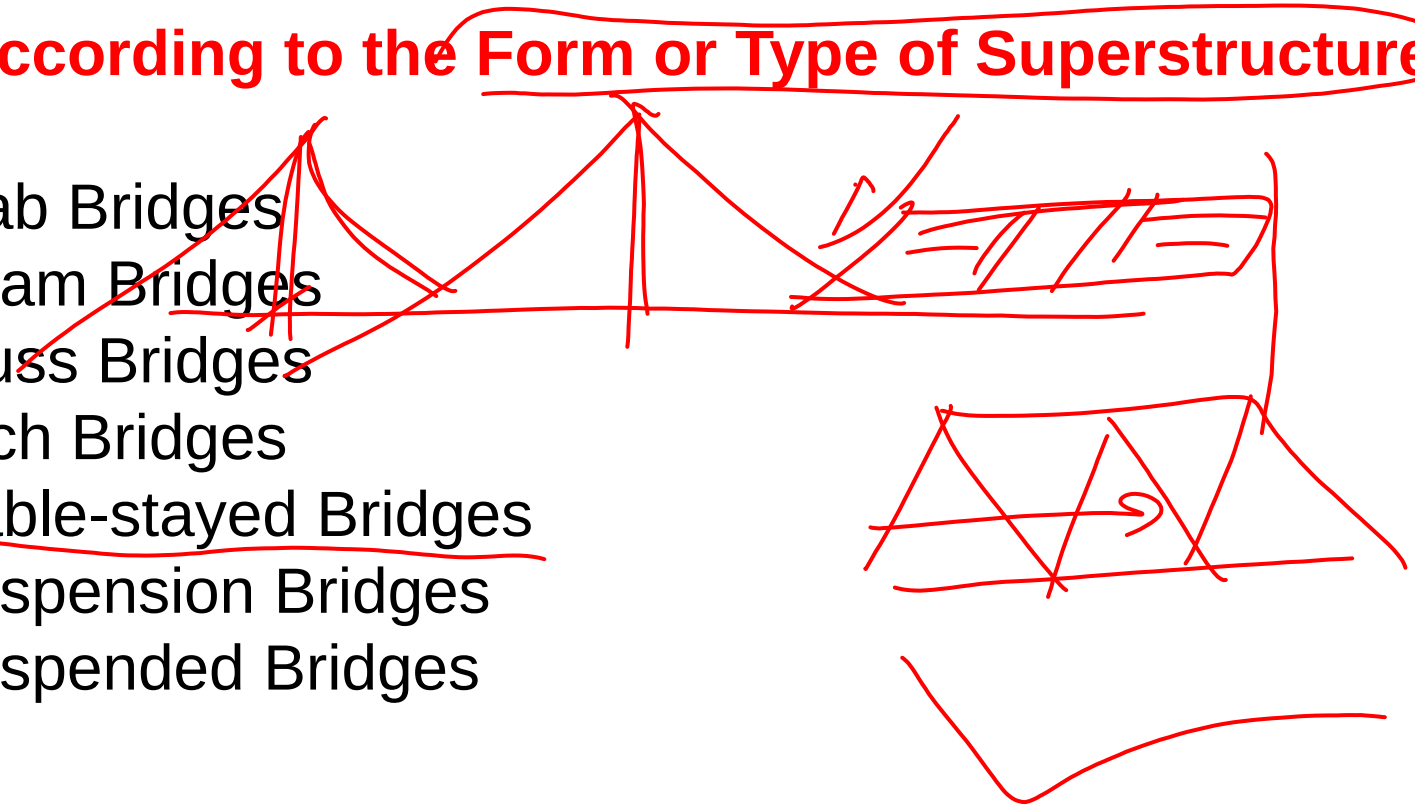
- Aqueduct (Canal Over a River)
- Viaduct (Road or Railway Over a Valley)
- Pedestrian Bridges
- Highway Bridges
- Railway Bridges
- Pipeline Bridges

According to the Materials of Construction of Superstructure

- Timber Bridges
- Masonry Bridges
- Iron Bridges
- Steel Bridges
- R.C.C. Bridges
- Pre stressed Concrete Bridges
- Composite Bridges
- Aluminum Bridges

3. According to the Form or Type of Superstructure

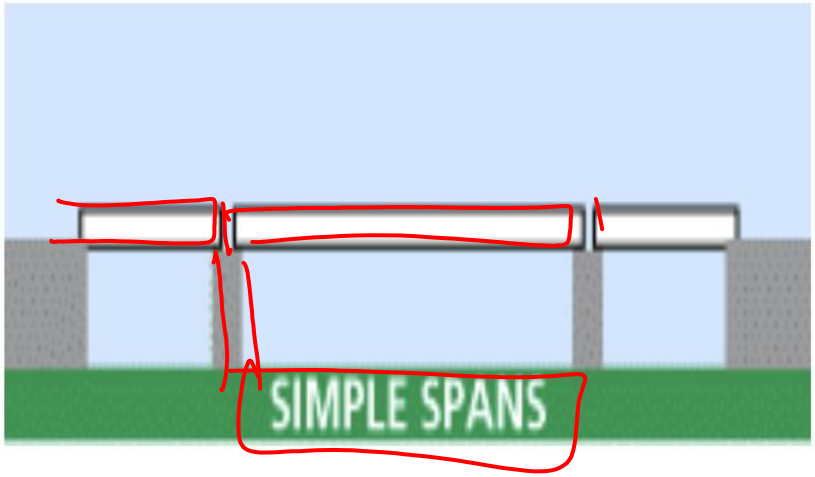
- Slab Bridges
- Beam Bridges
- Truss Bridges
- Arch Bridges
- Cable-stayed Bridges
- Suspension Bridges
- Suspended Bridges

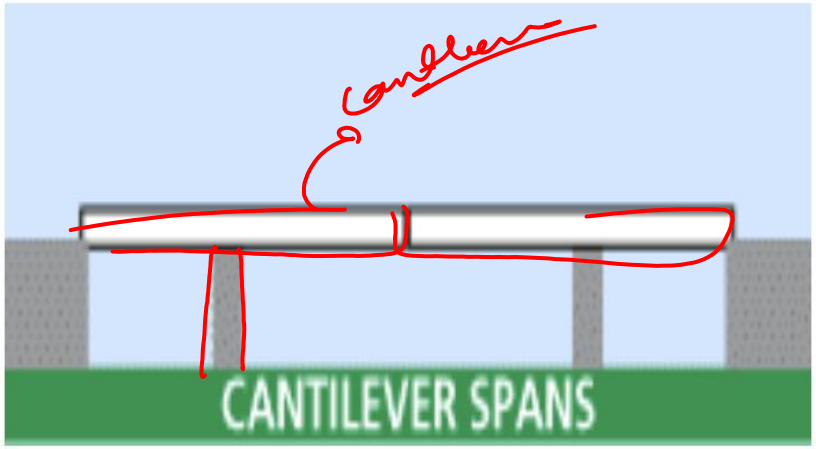


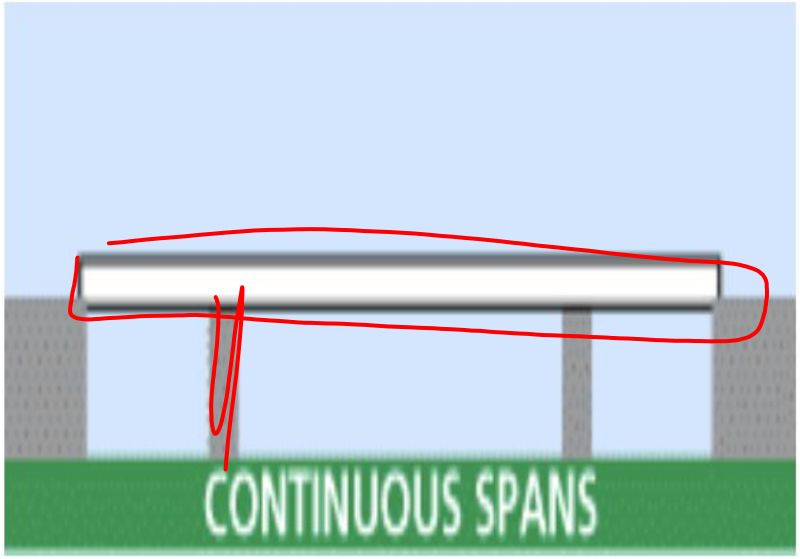
4. According to the Inner-Span Relations

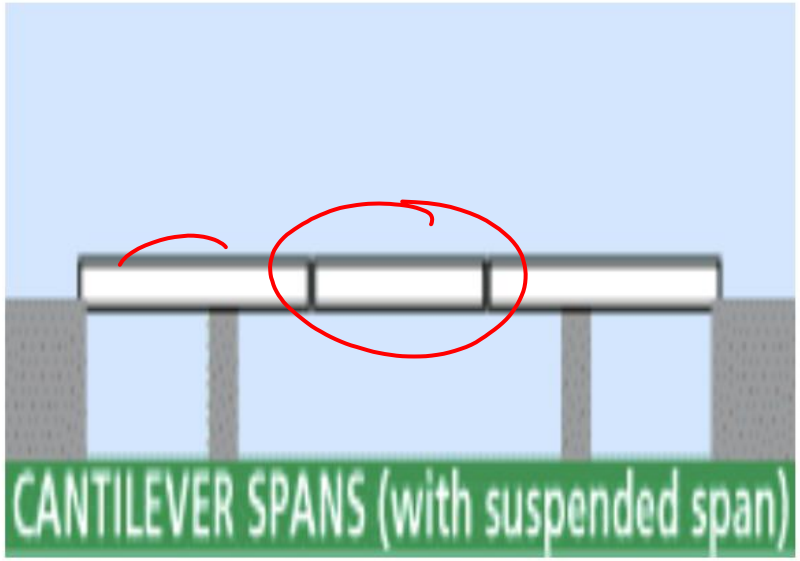
- Simple Bridges
- Continuous Bridges or
- Cantilever Bridges

General Span Types



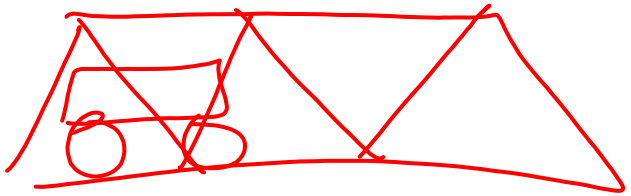


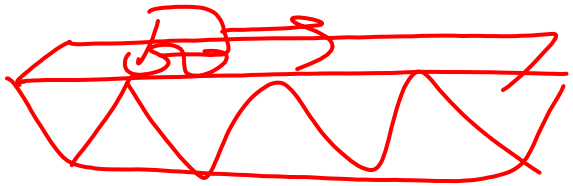


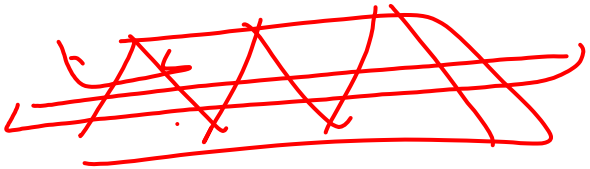


5. According to the Position of Bridge Floor Relative to the Superstructure

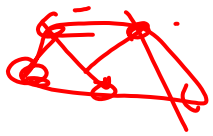
- Deck Bridges
- Through Bridges
- Half-through Bridges







6. According to the Method of Connections of the Different Parts of the Superstructure, particularly to the steel construction



- Pin-connected Bridges
- Riveted Bridges
- Welded Bridges

According to the Length of bridge (NRS 2045)

i. Culverts	... Upto 6 metres length
ii. Minor Bridges	... More than 6 metres and upto 20 metres length
iii. Medium Bridges	... Above 20 metres length, span lengths less than 20 metres.
iv. Major Bridges	... Bridges with span lengths greater than 20 metres.

Main Parts of a Bridge Structure

- Substructure
- Superstructure