Distresses in Bituminous Pavements

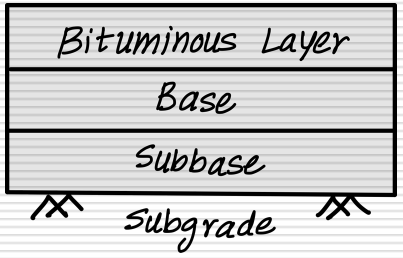
CE481A Project (Group 7)

Aman Kumar Singh (200100)
Apoorva Jha (200177)
Archana Meena (200180)
Chandan Singh Naruka (200290)
Chandramani Kumar (200292)

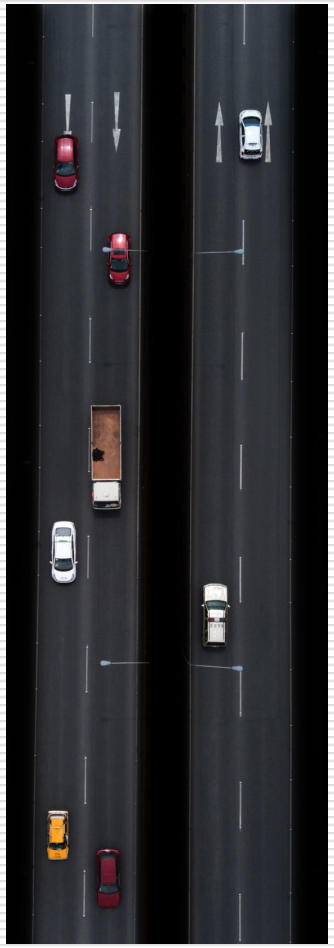
Dr. Prabin Kumar Ashish & Dr. Venkatesan Kanagaraj
Department of Civil Engineering
Indian Institute of Technology Kanpur

Bituminous Pavements

- Advantages
  - Better Riding Surface Quality
  - Flexibility
  - Cost-Effectiveness
- Disadvantages
  - High maintenance cost
  - Shorter Lifespan
  - Less stiffness



Typical c/s of a bit. pavement



Images Courtesy : ImagesBazaar

Distresses

- Deterioration or damage caused to the pavement by
  - Traffic Loads,
  - Environmental Conditions &
  - Material Properties
- In most cases, measured per unit area




Why are distresses important?

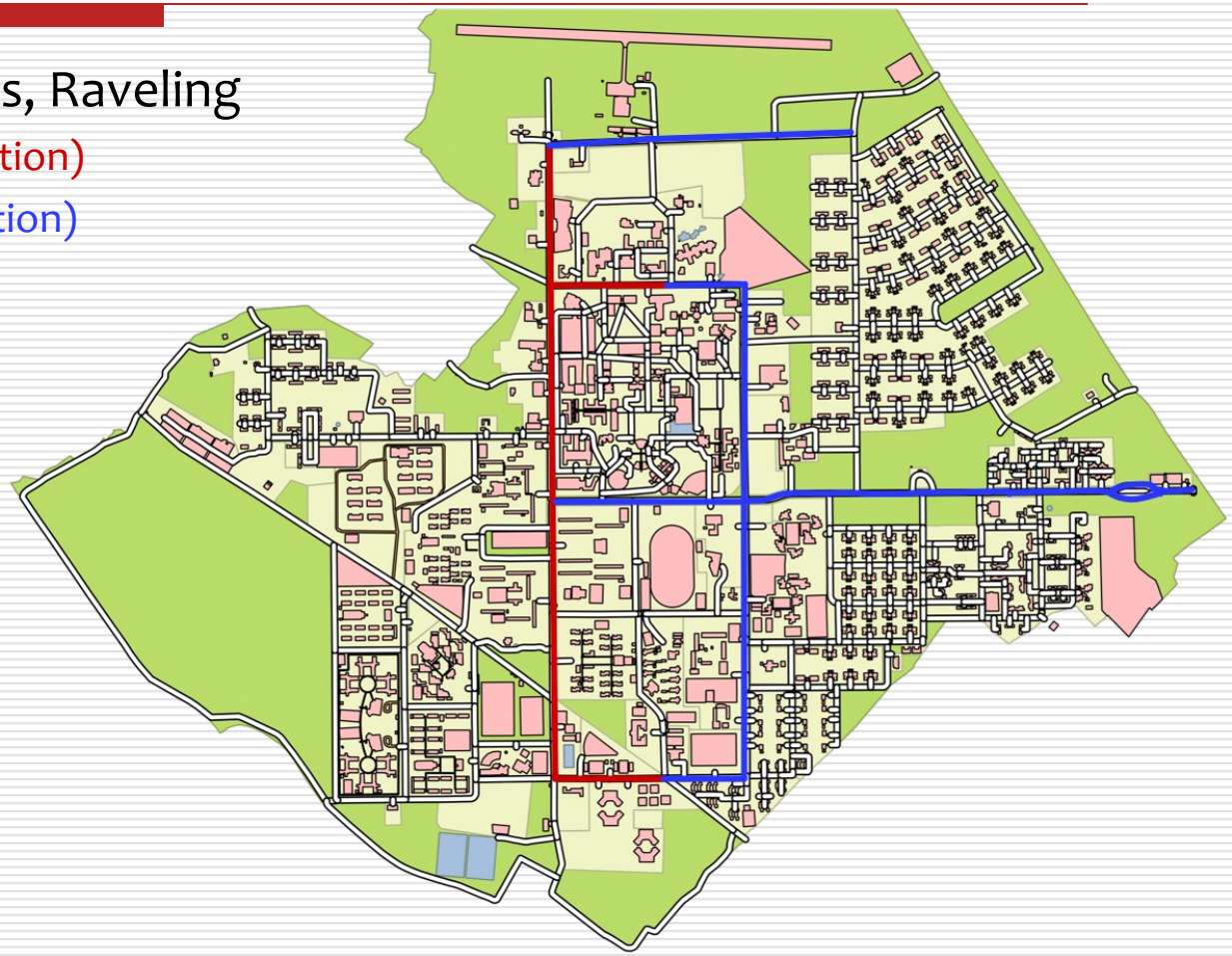
- *Economic Implications:*
  - Maintenance Costs ↑
  - Pavement Lifespan ↓
  - Vehicle Operating Costs ↑
- *Safety Concerns:*
  - Accidents and Injuries
  - Roadway Conditions
- *Environmental Impacts:*
  - Environmental Degradation
  - Increased Emissions
- *Operational Efficiency:*
  - Traffic Congestion
  - Transportation Delays

- *Regular maintenance vital for safety & longevity*

Images Courtesy : ImagesBazaar

Distresses in Campus

- Common Distresses: Fatigue, Rutting, Potholes, Raveling
  - More distressed bituminous pavements (Poor Condition)
  - Less distressed bituminous pavements (Good Condition)



Types of Distresses

- *Structural*
  - **Rutting**
  - **Fatigue**
  - **Potholes**
  - Thermal cracking
  - Longitudinal cracking
  - Transverse cracking
  - Reflection cracking
  - Corrugation
  - Depression
- *Functional*
  - Polished Aggregates
  - Raveling
  - Bleeding

Types of Distresses

Structural Distresses

- Impact structural integrity and load-bearing capacity
- Characteristics:
  - Often lead to cracks, rutting, and other damage
  - Can compromise the safety and durability of the road

Functional Distresses

- Impact the functionality and ride quality of the pavement
- Characteristics:
  - May not compromise load-bearing capacity

Rutting

- Permanent deformation along the maximum travelled wheel path
- Depends on
  - traffic repetitions,
  - construction materials,
  - densification,
  - and pavement temperature
- Occurs in areas with heavy traffic or frequent heavy vehicles

Rutting in Campus

Rutting observed along the road extending from e-shop to Hall 6, specifically in the vicinity of the Faculty Apartments

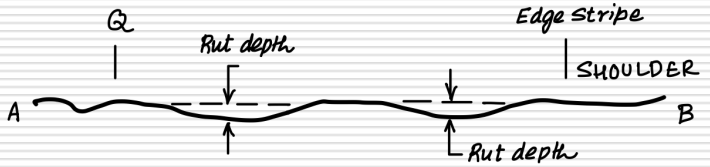
Rutting: How to measure?

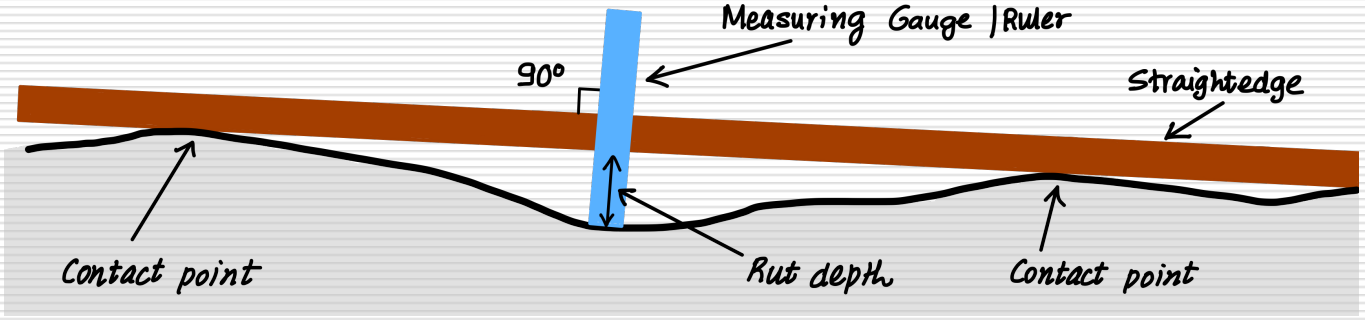
- Criterion: Critical rutting condition = Rut depth ≥ 20 mm along wheel paths
- Prediction: Estimate ESAL repetitions before reaching this condition

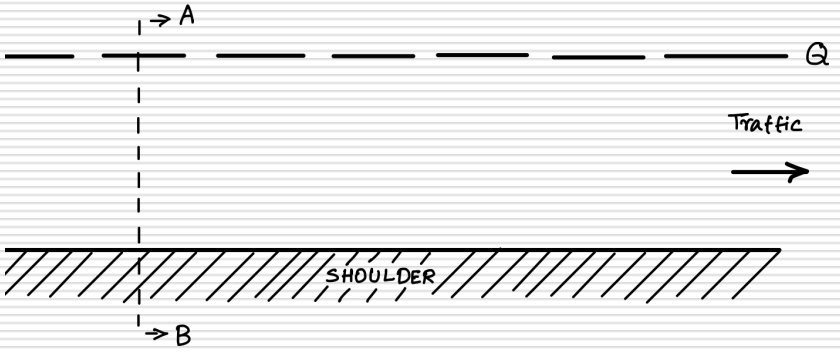
$$N_R = 4.1656 \times 10^{-08} [1/\varepsilon_v]^{4.5337} \quad \text{(for 80 \% reliability)}$$

$$N_R = 1.4100 \times 10^{-08} [1/\varepsilon_v]^{4.5337} \quad \text{(for 90 \% reliability)}$$

IRC 37: 2018





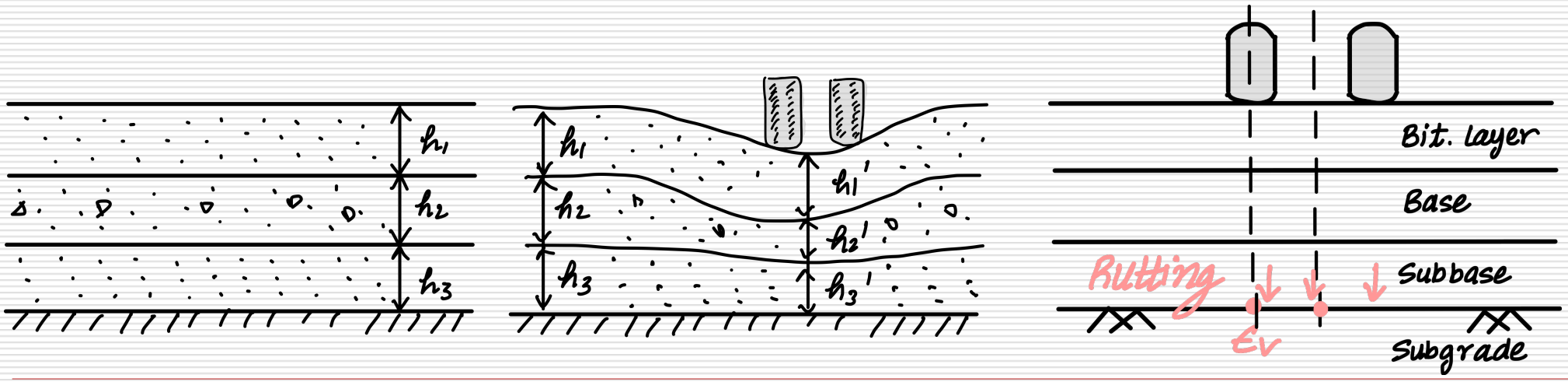


Rutting: Causes

- Heavy channelized traffic and overloading of vehicles
- Inadequate compaction of the mix at the surface or in the underlying bituminous courses
- Improper mix design
- Weak pavement due to poor subgrade

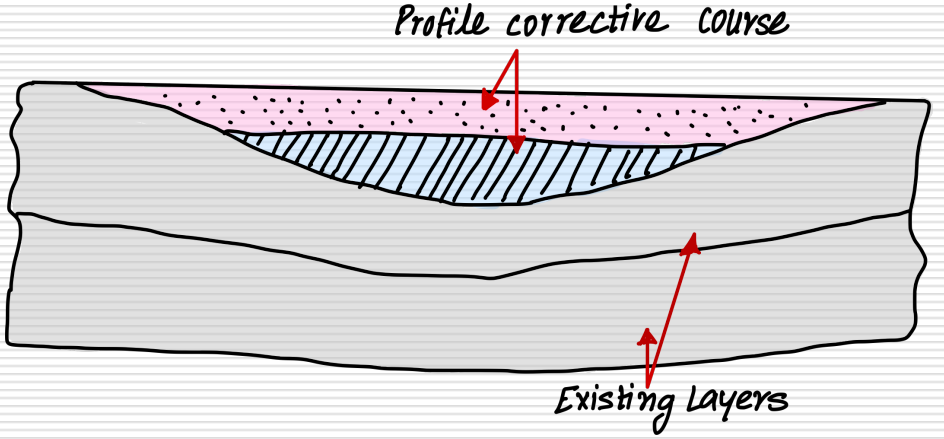
Rutting: Mechanism

- Manifestation of two different phenomena:
  - densification
  - deformation of various layers



Rutting: Countermeasures

- Apply tack coat
- Compact to desired levels
- Apply a profile corrective course
- Fill ruts with premix patching materials (asphalt binder)



Images Courtesy : Pavement Interactive

Fatigue

- ‘Fatigue’ of the bituminous materials
- Network of interconnected cracks
- Also known as Alligator Cracking
- Decreases pavement life
- Accelerates further deterioration

Fatigue in Campus

- Road from Kargil Heights to Hall 6
- Road from Hall 2 to Academic Gate 3
- Road from Hall 6 to E-Shop
- Near DoAA Canteen

Fatigue: How to measure?

- Criterion: Critical fatigue condition = Fatigue area ≥ 20 % out of paved surface
- Prediction: Estimate ESAL repetitions before reaching this condition

$$N_f = 1.6064 * C * 10^{-04} [1/\varepsilon_t]^{3.89} * [1/M_{Rm}]^{0.854} \text{ (for 80 \% reliability)}$$

$$N_f = 0.5161 * C * 10^{-04} [1/\varepsilon_t]^{3.89} * [1/M_{Rm}]^{0.854} \text{ (for 90 \% reliability)}$$

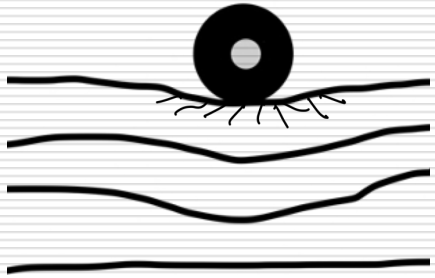
$$N = RF \left[\frac{(\frac{113000}{E^{0.804}} + 191)}{\varepsilon_t} \right]^{12} \quad \text{(for CTB)}$$

$$log_{10} N_{fi} = \frac{0.972 - (\sigma_t / M_{Rup})}{0.0825} \quad \text{(CFD analysis)}$$

IRC 37: 2018

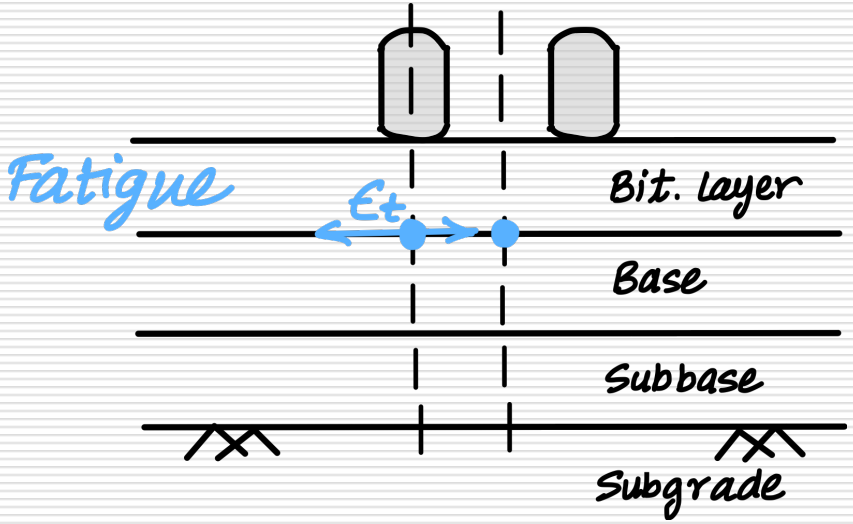
Fatigue: Causes

- Overloading by heavy commercial vehicles
- Inadequate pavement thickness / structural design
- Faster propagation due to freeze-thaw cycles, saturation and temperature fluctuations
- Stripping of surface course resulting in reduced thickness
- Cumulative fatigue damage



Fatigue: Mechanism

- Tensile stresses induced on bottom of bit. layer due to repetitive loading
- Initiation of microcracks
- Growth of micro cracks
- Propagate to the surface



Fatigue: Countermeasures

- Crack sealing by bitumen emulsions
- Crack sealing by rubberized and modified bitumen
- Milling and surface recycling
- Use of good quality binder materials

Images Courtesy : Maxwell Products
https://maxwellproducts.com/solutions/GAP-Mastic-Crack-Repair/

Potholes

- Bowl-shaped holes on bituminous pavement
- Minimum Diameter:

  (*FHA Distress Identification Manual*)
  - Circular potholes: ≥ 150 mm
  - Irregular potholes: Should fit a 150-mm circle
- Makes pavement accident prone

Potholes in Campus

Pothole on road in front of campus e-shop

Pothole near the BSBE building, close to academic gate 3

Pothole in front of Hall-2

Pothole in front of Hall-1

Potholes: How to measure?

- Pothole depth is the maximum depth below pavement surface
- Severity Levels:
  - Low: < 25 mm deep
  - Moderate: 25 to 50 mm deep
  - High: > 50 mm deep

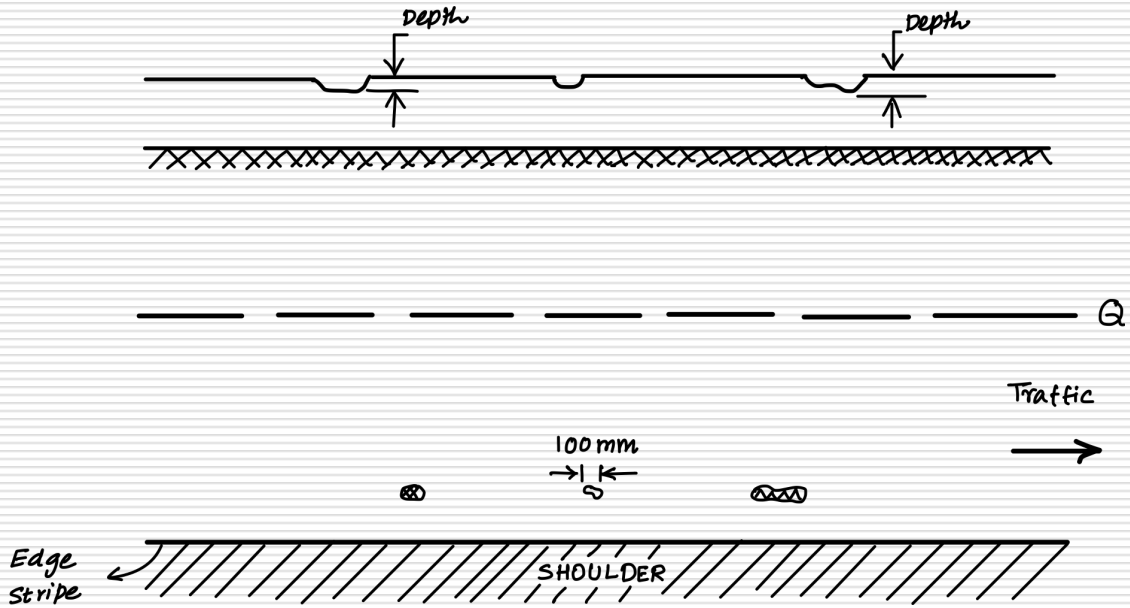
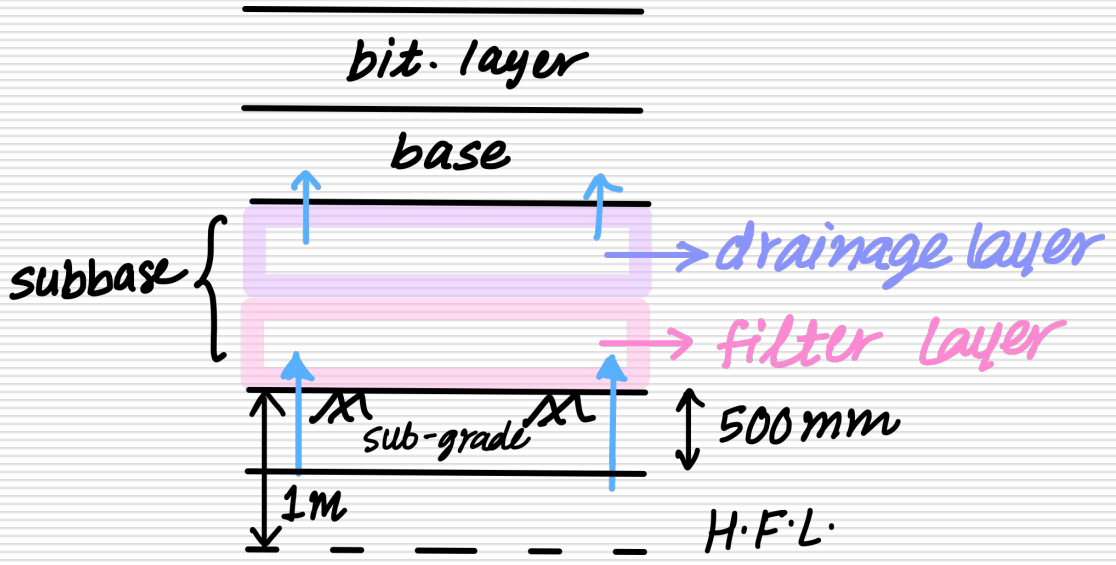


Image Courtesy: Bill Mouland & MobileWorxs

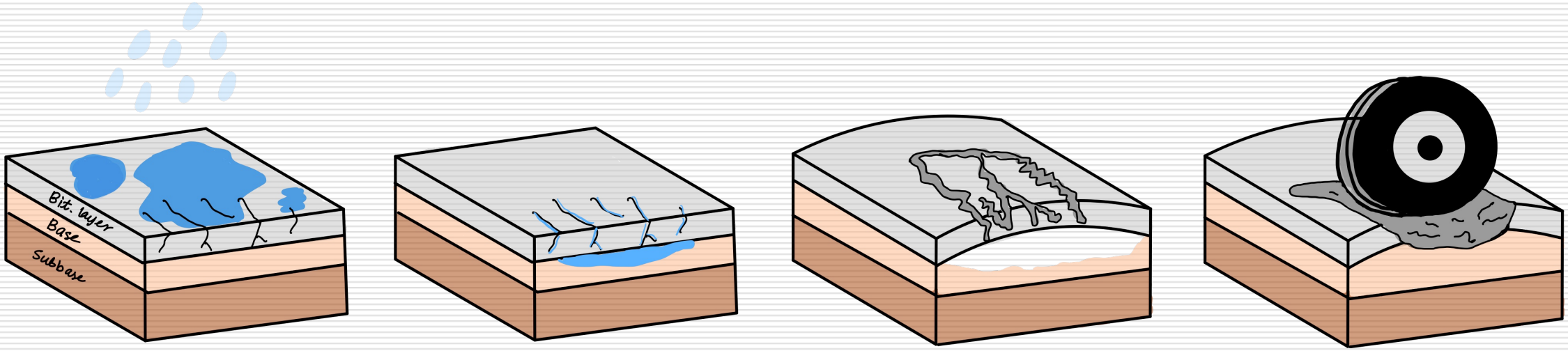
Potholes: Causes

- Weakening of bitumen-aggregate bonds
  - Inadequate construction quality control
  - Ingress of water and subsequent damage
  - Error in calculation of HFL / No calculation



Potholes: Mechanism

- Water infiltration, through cracks weakens pavement layers
- Freeze-thaw cycles in colder climates cause water to expand leading to cracks



Potholes: Countermeasures

- Repairment by patchwork
- Use of high-quality asphalt materials
- Adequate drainage systems design

Image Courtesy: Tarmac
https://tarmac.com/products/asphalt/ultipatch-pothole/

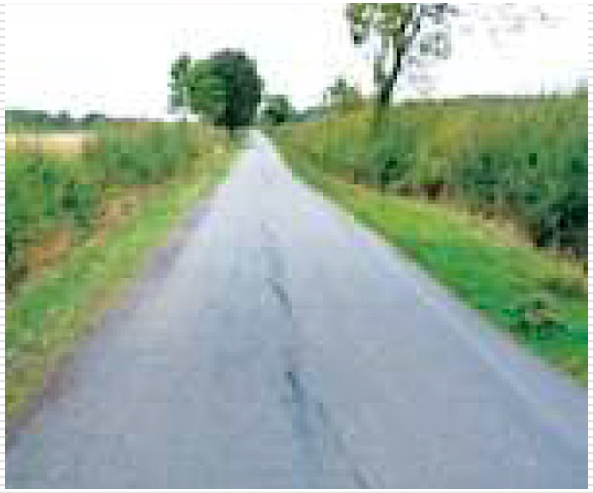
Thermal Cracking

- Gradual wearing of top surface
- Causes:
  - Temperature fluctuations
  - Different α of pavement materials
- Effects:
  - Reduced pavement life
  - Moisture infiltration, leading to further damage
- Countermeasures:
  - Proper Mix Design
  - Regular Maintenance

Image Courtesy: Behzad Behnia et al., 2018

Longitudinal Cracking

- Cracks parallel to the centerline or along the road
- Causes:
  - Alternate wetting and drying beneath the shoulder surface
- Effects:
  - Potential Alligator Cracking Source
  - Moisture infiltration, leading to further damage
  - Reduced ride quality
- Countermeasures:
  - Crack sealing using GGRB (Low/Medium severity)
  - Fresh overlay (High severity)



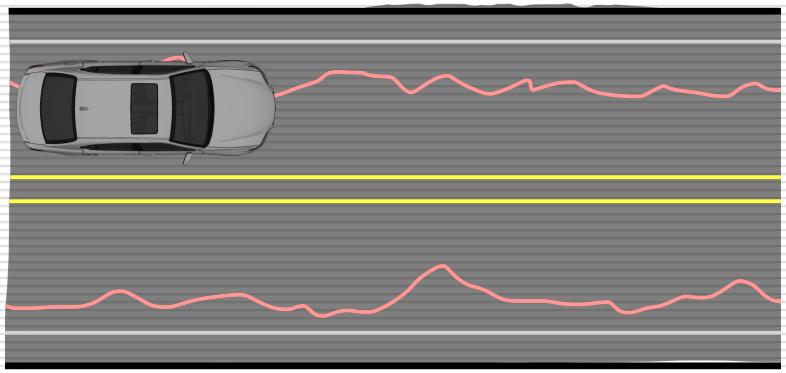


Image Courtesy: IRC 82

Transverse Cracking

- Interconnected cracks forming series of large blocks perpendicular to the road's direction
- Causes:
  - Structural failure of CTB
  - Shrinkage of bituminous mix
- Effects:
  - Moisture infiltration, leading to further damage
  - Reduced pavement integrity
- Countermeasures:
  - Treatment using slurry seal or rubberized bitumen

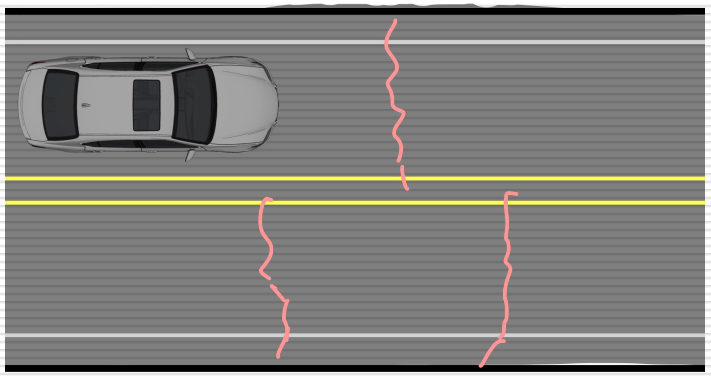


Image Courtesy: IRC 82

Reflection Cracking

- Propagation of cracks formed in CTB layer to the bit. layer
- Causes:
  - Construction vehicle
  - Thermal and moisture changes in CTB
- Effects:
  - Early-stage damage of pavement
  - Moisture infiltration, leading to further damage
- Countermeasures:
  - Aggregate inter layer (100mm)
  - SAMI (thin and polymeric)

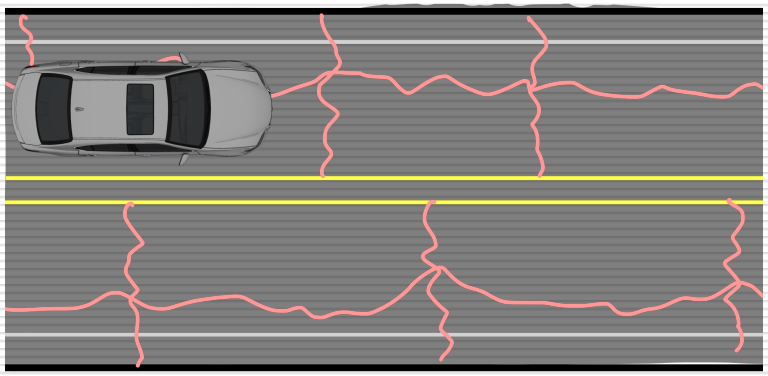


Image Courtesy: IRC 82

Corrugation

- Undulations due to plastic deformation of top bituminous surface
- Causes:
  - Lack of stability of asphalt mixtures in warm weather
  - Increased horizontal force during vehicle start or stop
- Effects:
  - Discomfort during driving
- Countermeasures:
  - Apply a new surfacing layer
  - Thoroughly roll the treated area for compaction
- In Campus:
  - Road in front of Hall 2

Depression

- Localized area where the pavement sinks relative to the finished surface
- Causes:
  - Differential settlement of subgrade
  - Inappropriate mix design
- Effects:
  - Water accumulation and further damage
  - Affects riding quality
- Countermeasures:
  - Filling with premix aggregates followed by compaction
- In Campus:
  - Road from Kargil heights to H6 near KV School

Polished Aggregates

- Smoothening of pavement surface
- Causes:
  - Repetitive passage of traffic
  - Less abrasive strength of aggregates
- Effects:
  - Lower Skid Resistance
- Countermeasures:
  - Replacement of top course with angular aggregate
  - Applying a skid-resistant slurry seal or overlay
- In Campus:
  - Road from Kargil heights to Hall 6

Raveling

- Gradual wearing of top surface
- Causes:
  - Weathering of bitumen
  - Aging of pavement
- Effects:
  - Faster Deterioration
  - Contributes to Pothole formation
- Countermeasures:
  - Coat of slurry seal
- In Campus:
  - Road in front of MT, Technopark, Hall 2

Bleeding

- Upward movement of excess asphalt/bituminous binder
- Causes:
  - Heavy tack coats
  - High Temperature
- Effects:
  - Decreased ride quality
  - Lead to low skid resistance
- Countermeasures:
  - Proper Mix Design
  - Sand blotting




Images Courtesy : Pavement Interactive, Lawson et. al 2007
& Indiana 2022 Pavement Inspection

References

- *Code of Practice for Maintenance of Bituminous Surfaces of Highways*, IRC:82-1982, The Indian Roads Congress, New Delhi, 1982.
- *AASHTO Guide for Design of Pavement Structures*, American Association of State Highway Officials, Washington, D.C., 1993.
- *Distress Identification Manual for The Long-Term Pavement Performance Program*, Federal Highway Administration Research and Technology, 2014.
- *A. Das and P. Chakroborty, Principles of Transportation Engineering*, Prentice Hall India Pvt., Limited, 2017.
- *Guidelines for the Design of Flexible Pavements*, IRC:37-2018, The Indian Roads Congress, New Delhi, 2018.

Thank You!