HIGHWAY ENGINEERING
SAB2832

Highway Drainage & Maintenance

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Highway Drainage & Maintenance by Che Ros Ismail (fka, UTM)
Highway Drainage & Maintenance

- Highway Drainage System
- Highway Maintenance
- Pavement Rehabilitation
- Visual Assessment of Flexible Pavement Surface Conditions
Highway Drainage System

• Adequate & proper road drainage is VERY, VERY, VERY IMPORTANT! Both for the safety of road users and pavement construction and maintenance
  1. User safety – accumulated water caused hydroplaning, splash and spray
  2. Pavement - reduce sub-grade strength, hydraulic pressure from passing traffic, binder stripping, slope stability

• Two types of drainage:
  1. Sub-surface drainage – cut/fill area, high water table
  2. Surface drainage – rain, snow, run-off water
Sub-surface Drainage System

- Provided within the pavement to lower the water table, intercept seepage from cut or sidehill, and drain out seepage water from pavement structure, drainage during and after construction.
- If inadequate – premature destruction of pavement (high pore pressure, frost action), slope failure (increase stress, reduce shear strength).
- Usually installed on expressway and trunk road.
- Three major sources of underground water:
  1. Natural ground water (WT) – seasonal
  2. Capillary action – move upward through underlying soil strata, particle size dependent
  3. Seepage – permeated through slope, pavement, road shoulder
Sub-surface Drainage System

- **Types of sub-surface drainage system:**
  1. *Longitudinal* – filtered perforated pipe along road shoulder
  2. *Transverse* – if longitudinal not adequate
  3. *Interceptor pipe* – cut area, pipe at toe
  4. *Horizontal* – inserted into cut/fill slope
  5. *Drainage blanket* – high coefficient layer
  6. *Porous sub-base* – percolated water carried out to side drain, cover entire road formation
SOURCE OF GROUND WATER

Compacted subgrade

Through permeable surface

Infiltration into verges and shoulders

From verge (suction)

Vapour movements

From water-table (suction)

Seepage from high ground

Water-table

Upward movement of water-table
LONGITUDINAL & TRANSVERSE DRAIN
INTERCEPTOR PIPE

Tanah telap air

Resipan

Tanah tidak telap air

Salir bawah tanah
Drainage blanket
Surface Drainage System

- Road surface need to be free of standing water to ensure safety
- To intercept surface and watershed run-off into designed channel for discharge into river or natural waterways

Types of surface drainage system:
1. Transverse slope/crown – facilitate removal of surface water
2. Side drain – alongside of highway to collect water from pavement surface, subsurface and ROW
3. Longitudinal slope – optional, help expedite water flow
4. Interceptor drain – at top of cut area to prevent water from flowing onto pavement, erosion, discharge into paved spillway/outfall
5. Curb, Gutter and Scupper drain – drainage, embankment erosion, and encroachment (urban)
6. Culvert – under pavement, carry water across road
7. Bridge – across river or waterway, part of a road
Camber, interceptor, collector, side
Curb, Gutter & Scupper

Rajah 3.24 Saliran permukaan - erong salir dan gergeluk
Rajah 3.25 Keratan rentas jalan – kedudukan pembetung
Maintenance

- Pavement maintenance is required to keep road network in satisfactory conditions to ensure safety and low road user costs
- Federal roads maintenance – privatization?
- Consist of (component based):
  1. *Resurface and patching*
  2. *Shoulder maintenance and grass cutting*
  3. *Repair and stabilized slope*
  4. *Clean, repair, reconstruct culvert, bridge, and drains*
  5. *Maintenance of road furniture and markings*
- Does not includes widening and structural strengthening
Maintenance

- Maintenance activities (frequency based):
  1. **Routine** – not subject to detailed planning, performed throughout the year, usually small scale/simple, can be carried out on a regular basis (grass cutting, patching, shoulder, drainage, signage, landscaping, routine inspection)
  2. **Periodic** – carried after once in a few years, normally large scale, require specialized equipment and skilled manpower, costly and need proper identification and planning (preventive maintenance, resurface, road marking)
  3. **Emergency works** – need to be dealt without delay, non-planned, have immediate effect on serviceability of the road
- **Routine and periodic maintenance** needed to maintain acceptable safety level and to avoid costly repair
Maintenance - Patch
Maintenance - Shoulder
Maintenance - Slope
Maintenance – Furniture, Landscape
Pavement Rehabilitation

• Various techniques, selection depends heavily on engineering judgment but other factors such as cost, construction feasibility and effect on road users should be considered as well.

• Rehabilitation methods:

1. Restoration
2. Resurfacing
3. Recycling
4. Reconstruction
**Restoration**

- When distress such as cracking and polishing.
- Restoration will – repair existing distress, reduces roughness rate and slow down pavement deterioration.
- **Restoration techniques:**
  1. *Rejuvenating* – spray on aged surface
  2. *Crack sealing* – fill crack with slurry, or bitumen + sand blotting
  3. *Cut and patch* – hot or cold patch mix
  4. *Thin bituminous overlay* – slurry seal, surface dressing, thin hot mix
Rehab - Cracksealing
Resurfacing

- When pavement have severe and extensive structural damage - structural improvement required
- Most popular in Malaysia
- Involved placement of fresh material – improves riding quality, enhance structural strength
- Need to properly design the overlay thickness to achieve design life
- Using thick asphalt overlay – with or w/o prior granular overlay (pre-treatment required)
Rehab – Resurfacing
Recycling

- Use of old pavement material to correct raveling, bleeding and improve skid resistance
- **Types of recycling:**
  1. *Hot recycling* – repair surface crack, road base still sound, use heat to soften surface
  2. *Cold recycling* – milling defected surface and reuse with addition of stabilizer, rejuvenator or bitumen
  3. *Base recycling* – road base fail, use stabilized old surface material as base, lay new surfacing
Rehab – Hot Recycling
Rehab – Cold Recycling
Reconstruction

- Removal and rebuilding of all or part of pavement using fresh material (current practice recycle) and new construction specification
- Pavement failed severely where deterioration has been allowed to occur w/o maintenance, or inadequate sub-surface drainage

- **Types of reconstruction:**
  1. *Hot recycling with overlay*
  2. *Cold recycling with overlay*
  3. *Construction/improvement of sub-surface drainage*
Visual Assessment of Pavement Surface Conditions

- Assessment of pavement surface conditions used by highway agencies to:
  1. Measure the ability of pavement to continue to provide service to public
  2. Determine deficiencies and inadequacies of pavement
  3. Determine remedial measures to be taken and its fiscal needs
  4. Planning and programming of pavement maintenance and/or rehabilitation
Types of distress in flexible pavement:

1. **Cracks**
2. **Surface deformation**
3. **Surface defects**
4. **Patches**
5. **Potholes**
6. **Edge defects**
Pavement Cracks

- Cracks – fissures resulting from partial or complete fractures of the pavement surface
- Variety of patterns from isolated to interconnected over entire surface
- Detrimental effects of cracks:
  1. Loss of water proofing
  2. Loss of load spreading ability
  3. Pumping and loss of fines from road base
  4. Loss of riding quality
  5. Loss of appearance
Pavement Cracks

- Possible causes of cracks – Depression, Fatigue life of surfacing exceeded, Age embrittlement of surfacing, Reflection cracks from underlying layers, Shrinkage, Poor construction joint
- Probable treatments – cut and patch, reconstruction, replace surfacing, crushed aggregate overlay, crack sealing, improve drainage and shoulder, widen pavement, strengthen shoulder, overlay with stiffer mix
- **Types of cracks** – longitudinal, transverse, block, crocodile, edge, crescent shape
Va - Cracks

mem anjang  melintang  pinggir

ROAD

blok  buaya  bulan sabit
Surface Deformations

- Deformation takes place when surface undergo changes from its original profile (due to traffic, environment, inadequate control during construction)
- Influences riding quality and may reflect structural inadequacies, may lead to cracks
- Possible causes – inadequate thickness, poor compaction, unstable premix, base or sub-base, volume change, settlement, lack of bond between bituminous layers, start-stop
- Probable treatments – overlay or reconstruction, replace/recycle with stiffer mix, base/sub-base strengthening, improve subsoil drainage, shoulder improvement
- Major types – rutting, corrugation, shoving, depression
Va - Surface Deformation
Surface Defects

- Surface defects cover loss of surfacing materials and surface micro/macro texture
- Have significant influence on serviceability, safety (skid resistance and maneuverability), and riding quality. If not corrected may lead to loss of pavement structural integrity
- Possible causes – excessive/lack of binder content, excessive/lack of coating, paving over flushed surface, poor adhesion between aggregate and binder, inadequate compaction, low PSV, seepage of water through surface, adhesion of binder to vehicle tyres
- Probable treatments – apply hot sand, thin bituminous overlay, use stiffer mix, mill and re-lay upper layer, replace WC, reconstruction of weak layers
- **Major types** – bleeding, polishing, raveling, delamination
Va - Surface Defects
Patch & Pothole

- **Patch** – repaired section where a portion of pavement has been removed and replaced
- Extend and frequency as indicator of structural adequacy
- Defects can occur within a patch or patch higher/lower than pavement surface
- Pothole – bowl shape cavity in the pavement from loss of WC and BC
- Produced when traffic breaches small pieces of pavement allowing water to enter > disintegrate, collected water accelerates disintegration
- Possible causes – loss of surface, moisture entry tru cracks, load associated base disintegration
- Probable treatments – cut and patch, base reconstruction
Va - Patch & Pothole
Edge defects

- Occur along interface of pavement and shoulder, most significant if shoulder unsealed
- Detrimental effects – reduction of pavement width, loss of riding quality and maybe loss of control, channeling water erodes shoulder, entry of water into base
- Possible causes – inadequate width/edge support, poor alignment, edge drop-off, loss of adhesion to base, shoulder material of low resistance to abrasion and erosion, resurface pavement w/o resurface shoulder
- Probable treatments – widening, re-alignment, strengthen and leveled shoulder, cut and patch, replace shoulder material
- Types of edge defects – edge drop-offs, edge breaks
VA - Edge defects