Course content

4 CONSTRUCTION

4.1 Subgrade preparation

- The subgrade may eventually become that of a higher trafficked unsealed or even a sealed road
- Preparation must therefore be good
  - Clear all vegetation over full road prism width
  - Remove all roots and top soil
  - Rip and shape the subgrade
  - Compact at OMC to at least 90% Mod AASHTO max dry density
  - Check density (Sand replacement ?, Nuclear (with MC correction) or DCP
  - May be highly variable - DCP – more in less time – do compaction trials
  - Smooth and shape with 4% camber
  - Beware problem materials

4 CONSTRUCTION

4.1 Subgrade preparation

- Conventional compaction usually adequate:
- Variable, weak or sandy materials - high energy impact compaction best
- Compaction:
  - Reduces potential for rutting (permanent deformation)
  - Increases shear strength
  - Reduces permeability

4 CONSTRUCTION

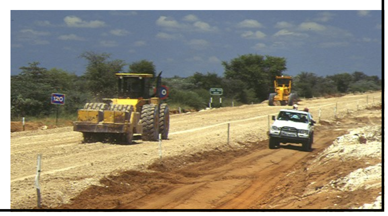
4.1 Subgrade preparation

- Formation and drains
  - Formation material must have CBR of at least 5%
  - Not less than 300 mm above NGL in flat terrain
  - Material from side and mitre drains often suitable
  - If not then import from borrow
- Formation must not interfere with natural drainage
- In flat areas formation must be sufficient to cover drainage pipes
- Side and mitre drains must be wide and deep enough to remove all expected water without ponding or erosion

4 CONSTRUCTION

4.1 Subgrade preparation

- Formation materials should preferably be slightly plastic (PI about 4%) to provide stable platform for WC
- It should be spread and compacted to at least 93% Mod (preferably refusal)
- Smoothed and shaped with camber at least the same as the subgrade and more than final wearing course
- Must be smooth to avoid “ponding” of water – NB differential permeabilities
- Lightly scarify before next layer



4 CONSTRUCTION

4.1 Subgrade preparation

- Wearing course usually placed directly on formation
- “Subbase” can be used:
  - if support is weak
  - for large number of heavies
  - for future upgrading

4 CONSTRUCTION

4.2 Material operations

- Location, winning and transportation of materials are the most expensive component of unsealed roads
- Use optimum material from as close to the project as possible
- Material location and selection as described in Sec 3
- Material specifications determined after processing
- Once the material is:
  - Located
  - Proved to be adequate
  - And Admin complete (expropriation, EMP, etc)
- Commission the borrow pit

4 CONSTRUCTION

4.2 Material operations

- Demarcate and excavate
  - Extent of suitable materials must be clearly marked
  - Depth of excavation carefully controlled (less weathered with depth)
  - Cut face downwards through entire depth of usable material
  - Move parallel to face to facilitate mixing
  - Slope floor away to remove precipitation from foot of face
  - Spot the error !

4 CONSTRUCTION

4.2 Material operations

- Mix and stockpile
  - Natural, weathered materials are highly variable
  - Therefore win (preferably with a bulldozer) and stockpile
  - Allows improved mixing and reduction of variability
  - Better control testing
  - Keep stockpiles low to reduce segregation (regular inspections)
  - If segregation is noted, loading must be closely supervised

4 CONSTRUCTION

4.2 Material operations

- Stone removal
  - Optimally done in borrow pit – reduces haulage of waste
  - Grizzly is cheap and portable – slows down production !
  - Does not remove large elongated particles
  - If excessive oversize, rather crush (too much waste)
  - Particularly rounded alluvial gravels – produce fractured faces
  - Increase shear strength
  - New innovations

Screening bucket

4 CONSTRUCTION

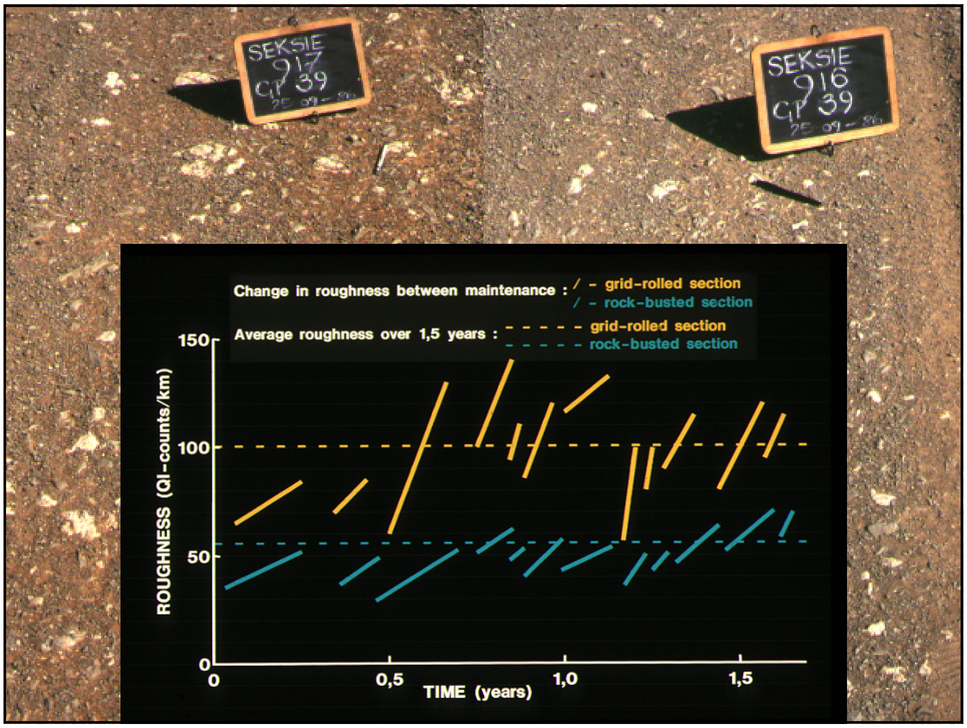
4.2 Material operations

- Breaking oversize
  - Typically done with a grid roller on the road
  - Not always successful
  - Good supervision and correct use of roller essential
  - Make use of rolling trials
  - Corestones seldom breakdown adequately – Treton Impact value

4 CONSTRUCTION

4.2 Material operations

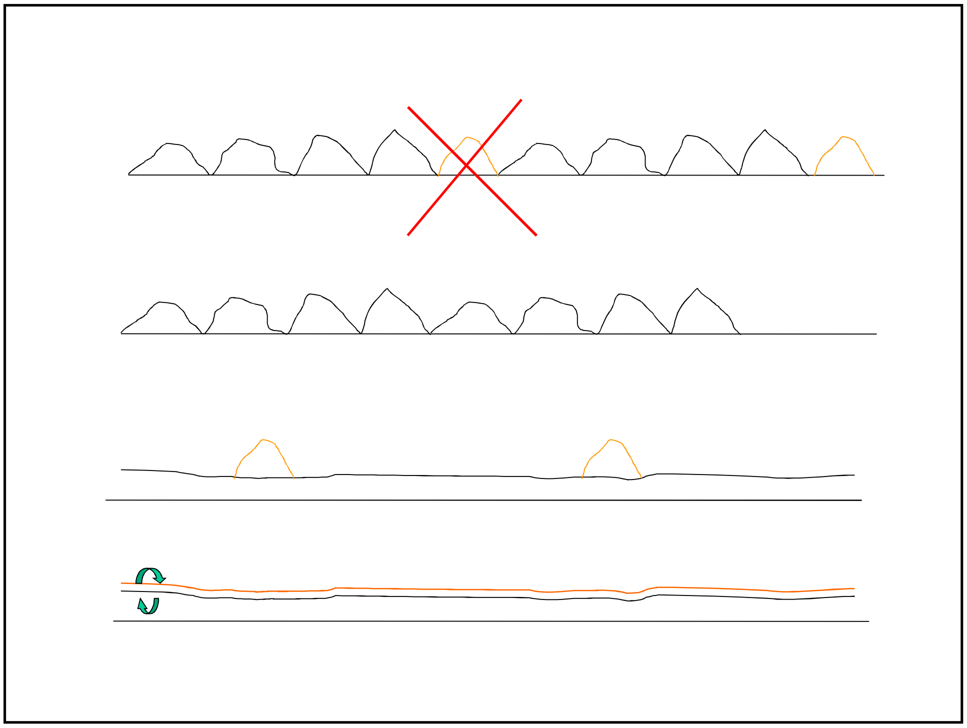
- Breaking oversize
  - Two-stage crusher – with screen ?
  - Generally gives improved grading
  - Rockbuster – effective but slow
  - Manual removal – better in borrow pit (little oversize) than on road but needs good team and supervision



4 CONSTRUCTION

4.2 Material operations

- Blending in borrow pit
  - To alter grading or shrinkage product
  - Can be done in BP if sources are close
  - Usually more effective on the road
  - Close supervision of dumping and mixing – correct proportions
  - Dump and spread largest component first
  - Then second component before mixing
  - Grader or recycler



4 CONSTRUCTION

4.2 Material operations

- Adding moisture in borrow pit
  - Most effective method – less transportation of water
  - Reduces segregation during handling
  - Also reduces dustiness – loss and nuisance
  - Makes sense if compaction follows rapidly (< 24 h)
  - Otherwise do conventional moisture addition

4 CONSTRUCTION

4.2 Material operations

- Slaking materials
  - Some mudrocks, basic crystalline materials and tillites
  - Slake rapidly on exposure to the atmosphere
  - Stockpile to achieve the required breakdown (days to weeks)
  - Should be done in BP and not on road – safety hazard
  - Should not use material that disintegrates to fine powder

4 CONSTRUCTION

4.2 Material operations

- Compaction
  - The heavier the plant the better
  - Certain plant is best for certain operations
    - High energy impact compaction
    - Sheepsfoot rollers (tamping)
    - Grid rollers
    - Smooth steel-wheeled rollers (vibrating)
    - Pneumatic tyred rollers (PTR)
  - More use should be made of “intelligent compaction”

4 CONSTRUCTION

4.2 Material operations

- High energy impact compaction
  - 3, 4 or 5 sided “rollers”
  - Free fall under gravity
  - Very high energy – greater depth affected
  - Material doesn't need to be at OMC

4 CONSTRUCTION

4.2 Material operations

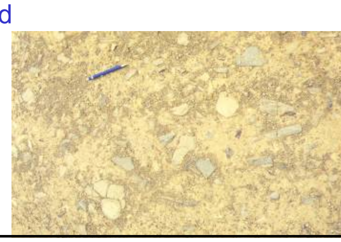
- Sheepsfoot rollers
  - Have protuberances on the drum that exert high stresses and also provide a kneading action
  - Most effective on cohesive soils where voids and pore pressures are expelled
  - Seldom used for wearing course compaction
  - Effective for cohesive subgrades and formations
  - Effective mass can be increased by vibration
  - Use until protuberances “walk out” of layer

ie, no longer compresses points of contact but travel on layer

4 CONSTRUCTION

4.2 Material operations

- Grid rollers
  - Widely used for compaction of gravel wearing course
  - Particularly when larger particles need to be broken down
  - Ballast to > 12 or 15 tonnes
  - Tow at 8 – 10 km/h with tractor
  - Leave impressions – don't use for final rolling of WC.
  - When breaking down aggregate – mix after breaking.
  - Check condition of grid – square not round



4 CONSTRUCTION

4.2 Material operations

- Smooth steel wheeled rollers
  - Probably most widely used
  - Very effective on well-graded low to medium plasticity gravels
  - Vibration mode effective on 150-200 mm thick layers
  - Smooth surface
  - NB: Careful not to over-vibrate – delamination or crumbling
  - Also formation of shear planes in low cohesion materials

4 CONSTRUCTION

4.2 Material operations

- Pneumatic Tyred Roller (PTR)
  - Useful for final smooth finish on good selected gravels
  - Heavy static (at least 27 to 30 tonnes)
  - No vibration
  - Advantage over smooth steel drum as it does not “bridge” oversize stones
  - Used for slushing

4 CONSTRUCTION

4.2 Material operations

- Traffic management
  - Important that construction traffic does not use newly constructed road excessively
  - If compacted properly, construction vehicles cause more damage than benefit
  - Potholes and ravelling and not compaction
  - If compaction is poor (why?) there may be benefits of controlled trafficking

4 CONSTRUCTION

4.2 Material operations

- Supervision and control
  - Major problem is lack of supervision and control testing
  - Close supervision and control by experienced personnel during borrow pit operations and construction make a big difference
  - Simplified procedure developed for ILO
  - Mainly for labour-based but equally applicable to conventional roads
  - Portable test kit

4 CONSTRUCTION

4.3 Wearing Course Construction

Good construction practice will:

- Provide the correct thickness of material
- Provide adequate compaction
- Provide a smooth finish with a good cross-sectional shape

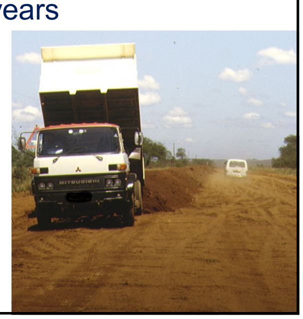
This will entail the use of tipper trucks, graders and large self-propelled or towed rollers

Can also be done using labour based techniques

4 CONSTRUCTION

4.3.1. Material thickness:

- Design thickness depends on expected gravel loss and regravelling strategy
- Minimum frequency decided by road authority
- Typically between 100 and 150 mm compacted
- May be up to 200 mm for heavy trafficking
- Generally plan to regravel every 7 to 10 years



4 CONSTRUCTION

4.3.1 Material thickness

Material must be dumped at correct spacings to provide required thickness after spreading and compaction

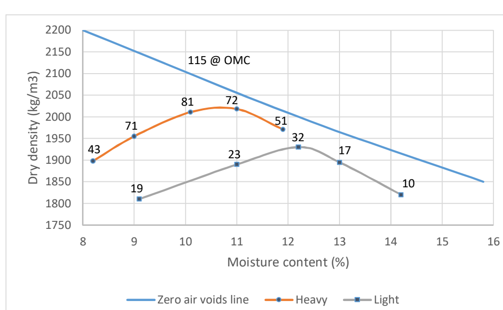
- Need to know bulking factor, truck loads, etc
- If thickness is incorrect management is affected – premature regravelling
- Or thinner layer when regravelled if remainder is too thick
- Both affect budgeting
- Thickness as consistent as possible over the road – limited loss areas
- Can check with DCP after compaction – change in rate in underlying layer

4 CONSTRUCTION

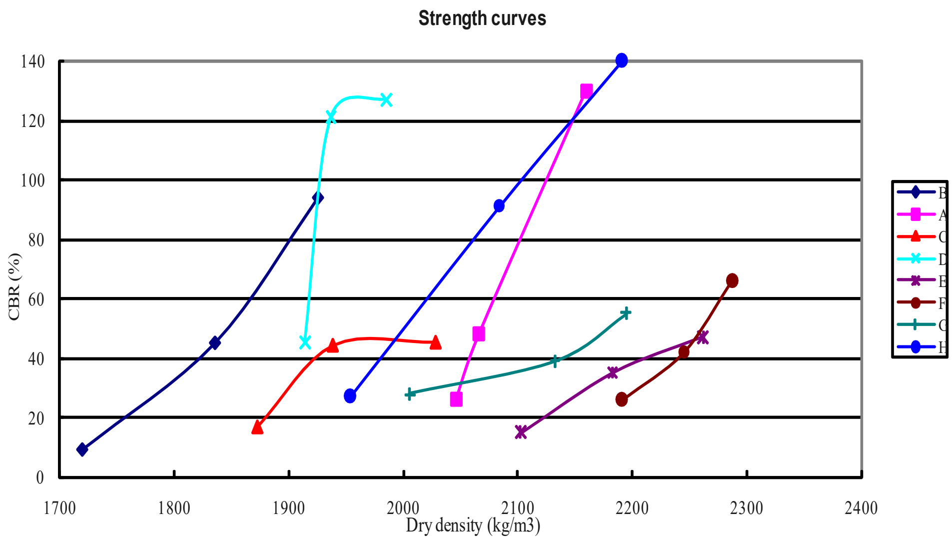
4.3.2 Compaction

Good compaction = tightly bound layer with:

- Good particle interlock
- Minimum permeability
- Maximum strength/stiffness



4 CONSTRUCTION



4 CONSTRUCTION

4.3.2 Compaction

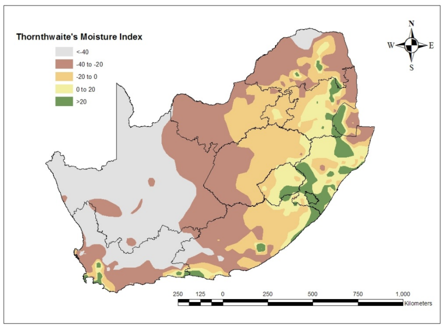
Benefits of good compaction proved in field trials

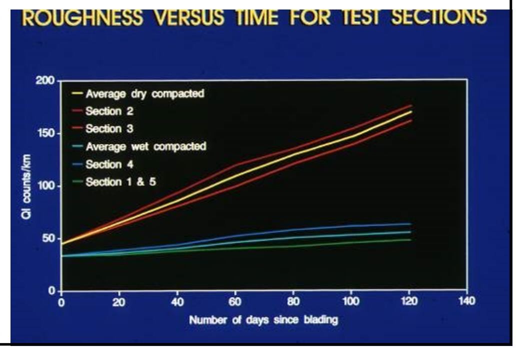
- Lower roughness and deterioration rate
- Slower gravel loss
- Less dust
- Reduced road user costs

4 CONSTRUCTION

4.3.2 Dry compaction

- Good sustainability practice – saves water
- Thornthwaite's Moisture Index
- Lack of strength due to soil suction – weakly bonded
- Not recommended for wearing courses





4 CONSTRUCTION

4.3.2 Poor compaction

- Low density – moisture sensitive
- Permeable material
- Ravelling and erodible material
- Road that ruts, compacts under traffic, potholes, corrugates, impassable when soaked
- Initial traffic-induced compaction and increased gravel loss affect management

4 CONSTRUCTION

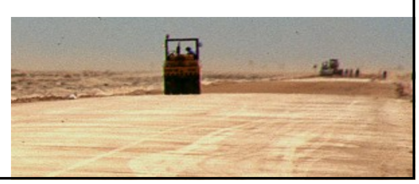
4.3.2 Compaction moisture

- If water is added in the borrow pit, dumping, spreading and compaction should be done in first 24 hours
- Careful project planning and management
- Construction during the wet season helps (additional moisture, less evaporation)
- Good control when using recycling machines

4 CONSTRUCTION

4.3.2 Compaction control

- Try and get refusal (ie maximum density for the plant)
- Not less than 95% Mod AASHTO
- No overcompaction or de-densification
- Compaction meters fitted to plant (IC)
- Slushing can be useful
- PTR on saturated material – pump excess fines
- Thin layer of tightly bound fines at surface



4 CONSTRUCTION

4.3.2 Compaction aids

- Numerous proprietary products available
- Discuss briefly later
- Best to construct trial sections
- Either reduce water or roller passes

4 CONSTRUCTION

4.3.2 Compaction

- Usually starts with a grid roller or sheepsfoot if no oversize
- Then smooth vibrating drum
- Final with PTR
- Depends on availability and economics

4 CONSTRUCTION

4.3.3 Finish and shape

- Roughness has greatest impact on road user costs
- Try and get as smooth a road as possible
- Easier to maintain

4 CONSTRUCTION

4.3.3 Finish and shape

- Construct with adequate camber (4-5%) with definite crown
- Except on horizontal curves (super-elevation)
- Remove large stones
- Discard away from the road – not available to be bladed onto road later
- Good operators can often break down or remove oversize
- Don't "bury" oversize – it soon appears

4 CONSTRUCTION

4.4. Quality control and assurance

- Unsealed roads are often seen as low cost solution to access
- QC and QA are thus often “reduced” to save costs
- Good QC and QA is critical
- Hear later how important it is - roads perform significantly better

4 CONSTRUCTION

4.4. Quality control and assurance

- Properties to be controlled
  - Material quality
  - Stoniness
  - Compaction
  - Layer thickness

4 CONSTRUCTION

4.4. Quality control and assurance

Material quality

- Material is usually natural gravel from shallow borrow pits
- Topsoil is removed and excavation to specified depth
- Natural variation of materials is high
- Quality exacerbated by poor topsoil removal and depth selection
- Stockpiling can assist with reducing this – assists with control testing
- Regular – cheap – don't take short cuts

4 CONSTRUCTION

4.4. Quality control and assurance

Stoniness/ oversize

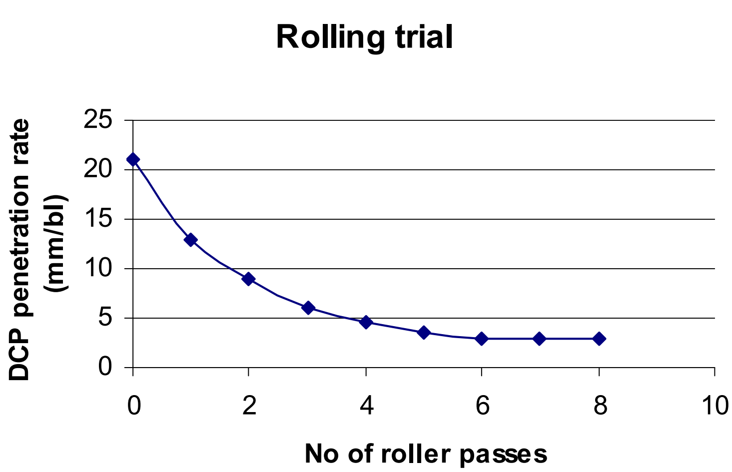
- Continuous visual inspection by supervisor
- Don't bury
- Significant effect on quality of grader maintenance

4 CONSTRUCTION

4.4. Quality control and assurance

Compaction

- 95% Mod AASHTO usually specified
- Refusal where possible (≮ 95%)
- Rolling trials
- Plot passes against density/strength/DCP etc
- Determine optimum passes for that condition (MC, material, roller, etc)
- Method specification



4 CONSTRUCTION

4.4. Quality control and assurance

Compaction

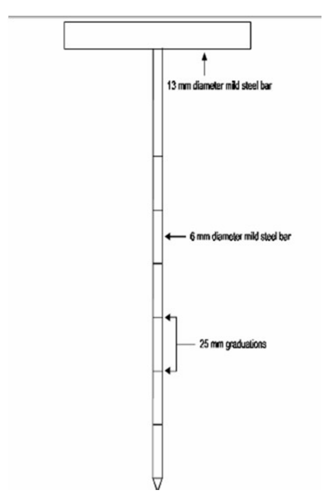
- DCP has been successfully used for QC on a number of projects
- Determine required penetration rate – lab, trials
- Use standard method as specified in COLTO Clause 8200
- More tests possible (random)
- Correct specific problems

4 CONSTRUCTION

4.4. Quality control and assurance

Layer thickness

- Standard method – excavation of holes (density)
- DCP identified it if support is dry
- Probe
- Useful before and after (bulking) 25 – 30%
- Statistical analysis



4 CONSTRUCTION

4.5. Labour intensive construction

- Conventionally machine intensive
- High volumes of material – heavy compaction
- Labour has been used successfully (ILO, Gundo Lashu, GDPTRW)
- Must still achieve specified quality
- Must do trial sections

4 CONSTRUCTION

4.5. Labour intensive construction

- Best on narrow roads (< 6 m)
- Generates significant employment in rural communities
- Create small contractors
- May need conventional compaction

4 CONSTRUCTION

4.6. Drainage

- Unsealed roads are totally exposed to elements
- Rainfall can cause severe maintenance problems
- Must have good drainage
- Control moisture in wearing course
  - Surface
  - Sub-surface

4 CONSTRUCTION

4.6. Drainage

Surface water

- Predominantly rainfall
- Infiltration can be limited by :
  - Well compacted tight, surface layer
  - Good shape
  - Leading water from surface to side drains
  - No erosion or scouring
  - Side drains should lead into good mitre drains
  - Far enough away to remove water from road

4 CONSTRUCTION

4.6. Drainage

Surface water

- Distance between mitre drains depends on grade
- Must avoid ponding but not allow water to speed up and erode
- May be made wider (1 – 1.5 m) to reduce flow velocities
- Check dams and structures
- Typically 0.6 m wide in urban areas
- Dispersive soils – 10 to 50 m depending on grade
- Suggested spacings for erodible and clayey materials

4 CONSTRUCTION

4.6. Drainage

Surface water

- Road surface must be raised above surroundings
- No canals

4 CONSTRUCTION

4.6. Drainage

Surface water

- Drains must be deep and wide enough to handle the water
- Dimensions should be such that flow velocities are not excessive
- Wide enough to be maintained (eg, grader vs labour)
- Flat bottomed drains are less likely to erode than V drains
- Erosion protection may be necessary on steeper grades

4 CONSTRUCTION

4.6. Drainage

Surface water

- If prevailing topography allows runoff to disperse naturally, the provision of drains can be minimised.
- Cost savings, reduced erosion, scouring and sedimentation
- The road should not interfere with natural cross drainage, i.e. provide culverts
- Design carefully to cater for the expected water

4 CONSTRUCTION

4.6. Drainage - Subsurface water

- Derived from high groundwater tables (temporary or permanent)
- Occasionally springs may be encountered
- Usually manifested as continuously damp areas (and constant potholes)
- Subsurface drains – expensive and require monitoring and maintenance
- Shallow rockfill embankments better alternative
- Geosynthetic separation layers – advice from suppliers
- Drainage activities are conducive to labour intensive projects

SUMMARY

Good construction critical

Good understanding of principles and supervision is equally important