LOW COST ROADS

Unsealed rural roads with earth and gravel/brick surfaces comprise the greater proportion of the length of public road in rural areas in developing regions.

Reliable rural road access improves:

• Marketing opportunities for subsistence farmers. Impassable roads lead to loss of market opportunities, spoiling of crops, reduced or lost income. Agricultural input to the economy is highest during or shortly after the rains and it is essential to move produce at this time.

• Rural community health through better access to health care. Maintaining wet season access is important because it is at this time that instances of malaria, dengue and other water borne diseases are at their peak.

• Education through better access to schools and shorter travel times.

• Social welfare. Maintaining inter-community access to family and friends has important social benefits, which help promote a better quality of life for the rural poor.

Natural gravel/brick aggregate surfacing is generally used as a low cost solution to rural access problems in many developing countries.

This material provides an intermediate surface between basic engineered earth and higher cost, usually bituminous, paving.

Ranges from soil-stabilized road to bituminous surfacing

In BD, LGED/Municipality/Zilla Parisad roads

Gravel is appropriate where suitable material is available and laid to surfacing specifications, gravel haul distances are short, road gradients are less than about 6%, rainfall is low or moderate, traffic is relatively low, finance and resources are available for periodic regravelling, and dry season dust generation is not severe.

Disadvantages

Maintenance of gravel is expensive, especially for periodic regravelling, which is typically required at 3 to 5 year intervals. Routine maintenance of a gravel road can be achieved for US$250 - 650/km/year, depending on the method used. However the need to replace the surface losses by periodic maintenance re-gravelling can cost a further US$400 - 2,000/km/year.

health hazard, discomfort and nuisance, air pollution, and reductions in agricultural yields and livestock health. Dust spread over people, villages, in homes and fields has many impacts and costs, many of which have yet to be quantified. Food stores and water resources can be polluted .

Research has shown that typically 30% of ambient particulate matter is attributed to road dust. One vehicle travelling one kilometre once a day every day of the year will typically generate between 0.2 and 0.6 tonnes of fines, this being lost from the road and causing the impacts described above. Put another way, in a dry season, vehicles and wind can remove of the order of 25 tonnes of dust per kilometre of unsealed road every year.

During rain periods, runoff of fines into streams has serious impacts on water quality. Runoff siltation causes a high maintenance requirement in the drainage system. Roads also become slippery leading to increased safety hazards.

Gravel pit excavations can eventually fill with water and become loci for disease. They are dangerous for children and livestock and inevitably become dumping sites for garbage, building rubble and scrap.

Perhaps the biggest environmental issue associated with gravel roads is that of sustainability of a non-renewable resource. Suitable gravel is becoming a scarce commodity and its injudicious use will eventually lead to there being no such material for any form of road construction.

Env. Concerns for open brick burning in BD!!!

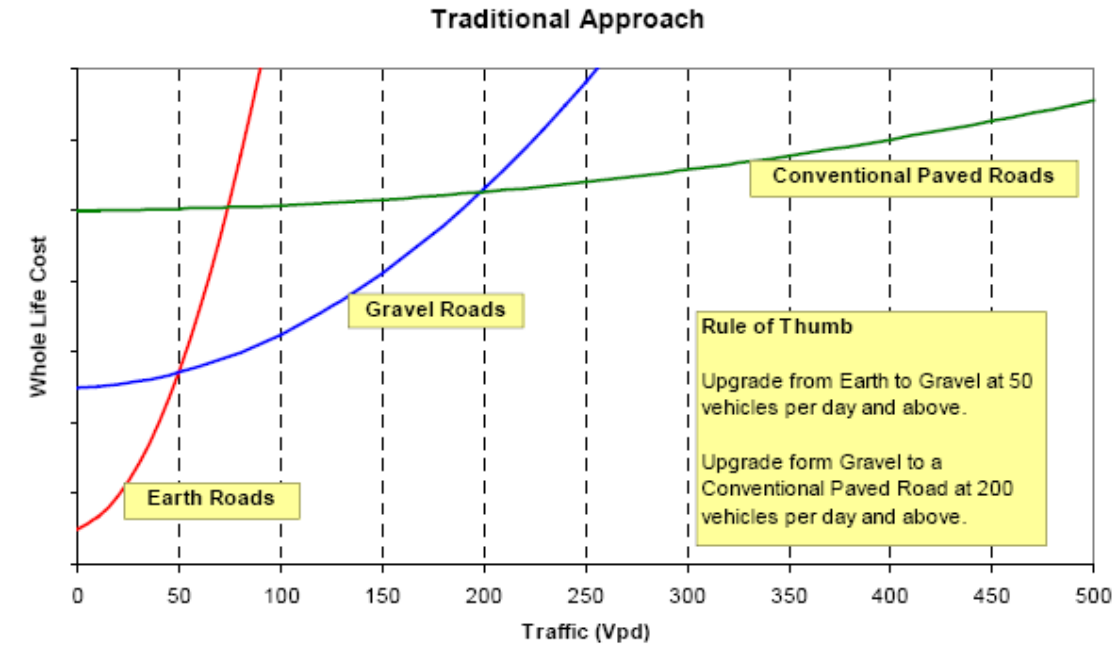
Options?

• Adopting a flexible, realistic and innovative approach to access needs, provision and maintenance,
Maximising the use of earth (provision of good camber, drainage and traffic control can often extend the serviceability of earth roads) where in-situ soils are suitable,

• Spot improvements where limited available resources are targeted toward appropriate improvement measures at strategic points on the route to ensure an optimal level of access. These would include:
- Judicious use of gravel (if resources are scarce)

- Provision of short section of bituminous or non-bituminous surfacings.

By promoting innovation, using labour-based and light equipment technologies and developing design approaches and maintenance strategies that work with the environment, both the initial construction costs and longer term maintenance demand can be significantly reduced (see Figure below).


Traditional Approach
Whole Life Cost
Conventional Paved Roads
Gravel Roads
Earth Roads
Rule of Thumb
Upgrade from Earth to Gravel at 50 vehicles per day and above.
Upgrade form Gravel to a Conventional Paved Road at 200 vehicles per day and above.
0
50
100
150
200
250
300
350
400
450
500
Traffic (Vpd)

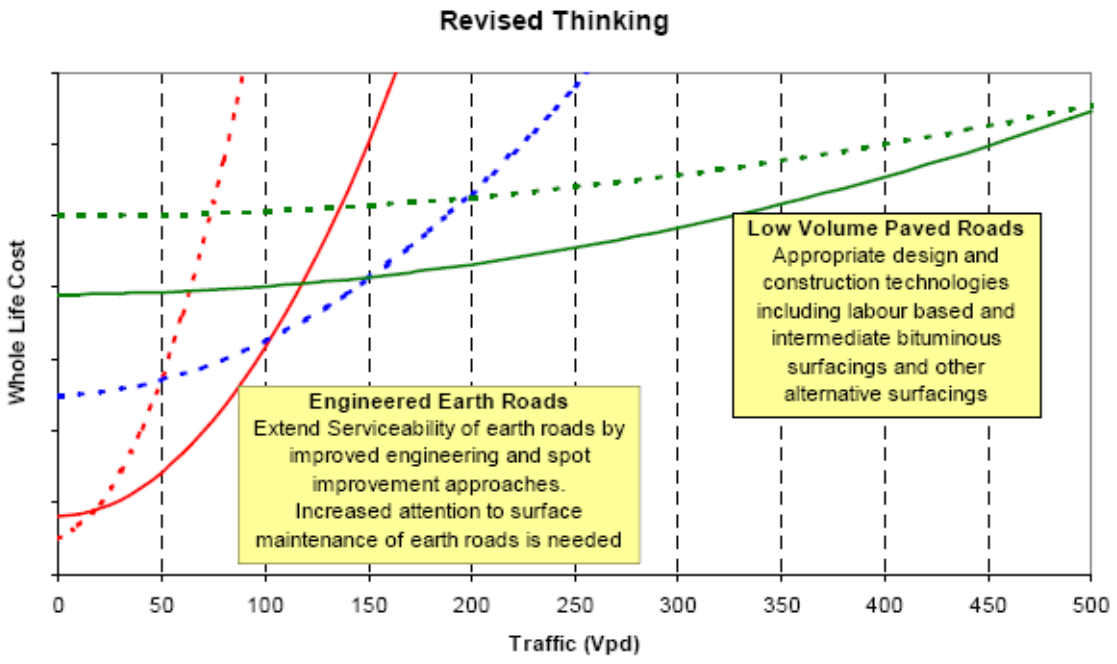

Revised Thinking
Whole Life Cost
Low Volume Paved Roads
Appropriate design and construction technologies including labour based and intermediate bituminous surfacings and other alternative surfacings
Engineered Earth Roads
Extend Serviceability of earth roads by improved engineering and spot improvement approaches.
Increased attention to surface maintenance of earth roads is needed
0
50
100
150
200
250
300
350
400
450
500
Traffic (Vpd)

Table 1 - SCHEDULE OF ALTERNATIVE ROAD SURFACE IMPROVEMENTS

	Road Surface Improvement Options	***Description*** *(A roadbase option may need to be used in combination with the selected surface improvement)*
C1	Dragging Road Surface	Smoothing out minor defects on an earth or gravel road surface and redistributing loose material on the surface, using tyre or blade drag.
C2	Light Grading/Reshaping of Surface	Minor reshaping of an earth or gravel surface to restore correct camber using labour or light/heavy grading equipment.
C3	Natural Gravel Surface	A layer of compacted natural gravel wearing course (typically 15 – 20cm thick)
C4	Lime Stabilization of Existing Surface	Addition of and mixing of quicklime or hydrated lime to a soil or surface material, watering and compaction to increase its strength and reduce its susceptibility to the weakening effect of increasing moisture content. This is achieved by chemical reaction of the lime with the clay particles. Mixing and compaction by light or heavy equipment.
C5	Stone Chippings Surface	A layer of single sized (typically 20mm) crushed stone chippings.
C6	Hand Packed Stone Surface	A layer (typically 20 – 30cm thick) of large broken stone pieces, tightly packed and wedged in place with stone chips rammed by hand into joints, with remaining voids filled with sand. The Hand Packed Stone is normally bedded on a thin layer of sand/gravel.
C7	Dressed Stone Surface	A layer (typically 15 – 20cm thick) of stone blocks cut (dressed) to a cubic shape by hand, laid by hand. Joints mortared/sealed or tightly packed and wedged with stone chips rammed into place with remaining voids filled with sand. The Dressed Stone is normally bedded on a thin layer of sand/gravel.
C8	Stone Sett Surface (Pavé)	As dressed stone, however stone blocks are smaller; typically about 10cm x 10cm x 10cm with mortared joints.
C9	Concrete Block Surface	A layer of concrete blocks (typically each 10cm x 20cm and 7 – 10cm thick) laid by hand on a thin (3 – 5cm) sand bed with joints also filled with sand and lightly compacted.
C10	Clay Brick Surface	A layer of high quality clay bricks (typically each 10cm x 20cm and 7 – 10cm thick) laid by hand on a thin sand bed with joints also filled with sand and lightly compacted, or bedded & jointed with cement mortar.
C11	Bamboo Reinforced Concrete Surface	Jointed slabs of structural quality concrete reinforced with a split bamboo rod grid. Joints with steel weight transfer dowels and bitumen seal.
C12	Steel Reinforced Concrete Surface	Jointed slabs of structural quality concrete reinforced with a mild steel rod grid. Joints with steel weight transfer dowels and bitumen seal.
C13	Bituminous/Tar Sand Seal Surface	A seal consisting of a hand or machine applied film of bitumen (straight run, cutback or emulsion) or road tar followed by the application of excess angular sand or fine crushed stone, lightly rolled into the bitumen/tar.
C14	Ottaseal Surface	A layer consisting of a hand or machine applied film of relatively soft bitumen (usually straight run or cutback) followed by the application of graded natural gravel or crushed stone aggregate (typically 16mm downwards), rolled into the bitumen using heavy pneumatic tyred rollers.
C15	Bitumen/Tar Surface Dressing Surface	A seal consisting of a hand or machine applied film of bitumen (straight run, cutback or emulsion) or road tar followed by the application of a single layer of single sized (6 – 20mm) stone chippings, lightly rolled into the bitumen/tar.
C16	Bitumen Slurry Seal Surface (and "Cape" Seals)	A seal consisting of fine graded aggregates (typically 10mm downwards), water, bitumen emulsion, cement, and sometimes an additive, mixed in a concrete mixer or other machine and spread on the road surface by hand or machine. Cape seals are combinations of Surface Dressing and Slurry Seal.
C17	Bituminous Premix Macadam Surface	Graded crushed stone material (typically 28mm downwards) usually derived from fresh sound quarried rock, boulders or granular material and mixed with a bituminous binder (straight run, cutback or emulsion) and laid and compacted. Material may be hand or machine mixed and laid. Compaction by light or heavy equipment.
C18	Penetration Macadam Surface	Two or three layers of single size crushed stone (of decreasing nominal aggregate size, e.g. 63 mm downwards) each compacted and with bitumen (straight run, cutback or emulsion) or road tar sprayed between each stone application.
C19	Water Bound Macadam Roadbase	A layer of nominal single sized (typically up to 50mm) crushed stone compacted and fully blinded with well graded fine aggregate which is watered into the voids and compacted to produce a dense stable material. Layer thickness up to twice the nominal stone size. Material may be hand or machine crushed and laid.
C20	Dry Bound Macadam Roadbase	A layer of nominal single sized (typically up to 50mm) crushed stone compacted and fully blinded with angular sand or fine crushed stone material which is then vibro-compacted to produce a dense stable material. Layer thickness up to twice the nominal stone size. Material may be hand or machine crushed and laid. Suitable in areas short of water.
C21	Slurry Bound Macadam Roadbase	A layer (about 7cm thick) of single size aggregate (typically 50mm) blinded with smaller aggregate (typically 25mm), plate compacted and grouted with bitumen emulsion slurry before final compaction.
C22	Crushed Stone Roadbase	A layer (usually up to 20cm thick) of graded crushed stone material (typically 50mm downwards) usually derived from fresh sound quarried rock, boulders or granular material. The angular material derives its strength primarily from mechanical interlock. Material may be hand or machine crushed.
C23	Mechanically Stabilised Roadbase	Addition and mixing of granular material such as crushed stone or sand to a material to increase its strength and achieve the properties required of a roadbase.
C24	Chemical or Emulsion Stabilized Roadbase	Addition and mixing of a stabilizer such as lime, cement, or ion exchange chemicals, to a material to increase its strength and achieve the properties required of a roadbase. Mixing and compaction by light or heavy equipment.
C25	Improvement using Recycled Materials	Use of recycled road pavement materials, brick kiln waste, broken brick, demolition materials, industrial slags, etc.

C1 & C2 are maintenance/surface improvements, C3 – C18 are surface options, C19 – C25 are lower pavement layer options.

Engineered Earth Roads

Bituminous Soil Stabilization

Material

- **Well graded soil, sand, clays : very fine ones are avoided**
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- **Rapid/medium/low curing liquid asphalt or**
- **Medium/slow setting emulsion**
- **Water**

Field Control

- **By monitoring compaction and relevant CBR value**

Road mix/ Travelling/ Central Plant Construction

Compaction By: Sheep-foot or Pneumatic tyred roller

Oiled earth Surfaces

Material

- **Silt and clays**
- **low curing liquid asphalt or**
- **Medium curing cutback asphalt or**
- **Slow setting emulsion**
- **Water**

Compaction By: Under traffic or Pneumatic tyred roller

Cement Stabilization

Material

- **Soil suitable for subgrade**
- **Portland cement (7 – 14% BY VOLUME)**
- **Water**

Cement and Water content fixed by lab testing

- **M-D relationship**
- **CBR vs Density relationship**

Field Control

- **By monitoring MC, compaction and relevant CBR value**

Road mix/ Travelling/ Central Plant Construction
Construction method detail in Wright's book
Needs curing

Compaction By: Based on soil type

Compaction Equipments:

Clay/Silty soil: Sheep-foot or Pneumatic tired roller

Sandy Soil: Pneumatic tired roller, Vibratory compactor

Granular Soil: Steel – wheel roller

LIME STABILIZATION

Material

- **Plastic Clay soil**
- **Lime (3 – 6% BY VOLUME)**
- **Water**

Cement and Water content fixed by lab testing

- **M-D relationship**
- **CBR vs Density relationship**

Field Control

- **By monitoring MC, compaction and relevant CBR value**