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Environmentally Optimised Design for Low Volume District Roads in Tanzania

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11th International Conference on Low-Volume Roads, 12-15 July 2015, Pittsburgh

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Presentation Outline

- Introduction
- Environmentally optimised design (EOD)
- Pavement Design
- Findings
- Discussion
- Conclusions

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Introduction

- Tanzania district roads network comprises of about 56,000 km of unpaved roads.
- Lightly trafficked and most frequently used by cyclists, motorbikes and cars.
- We wanted to implement low-cost solutions for surfacing district roads to allow **year-round access.**
- We only pave short lengths focussing on the problematic areas to maximise impact of limited funds.
- We built short trial sections on two roads in Tanzania – in Bagomoyo and Siha.

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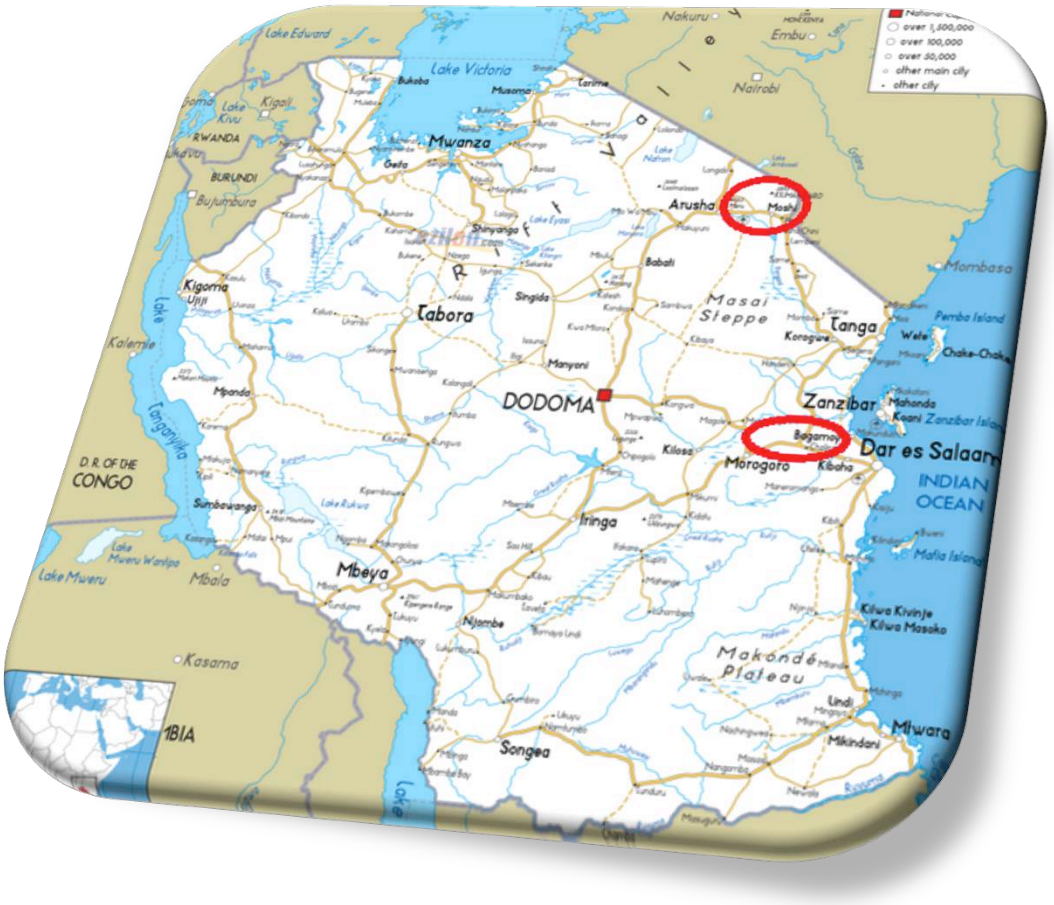
Project Location



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Environmentally Optimised Design

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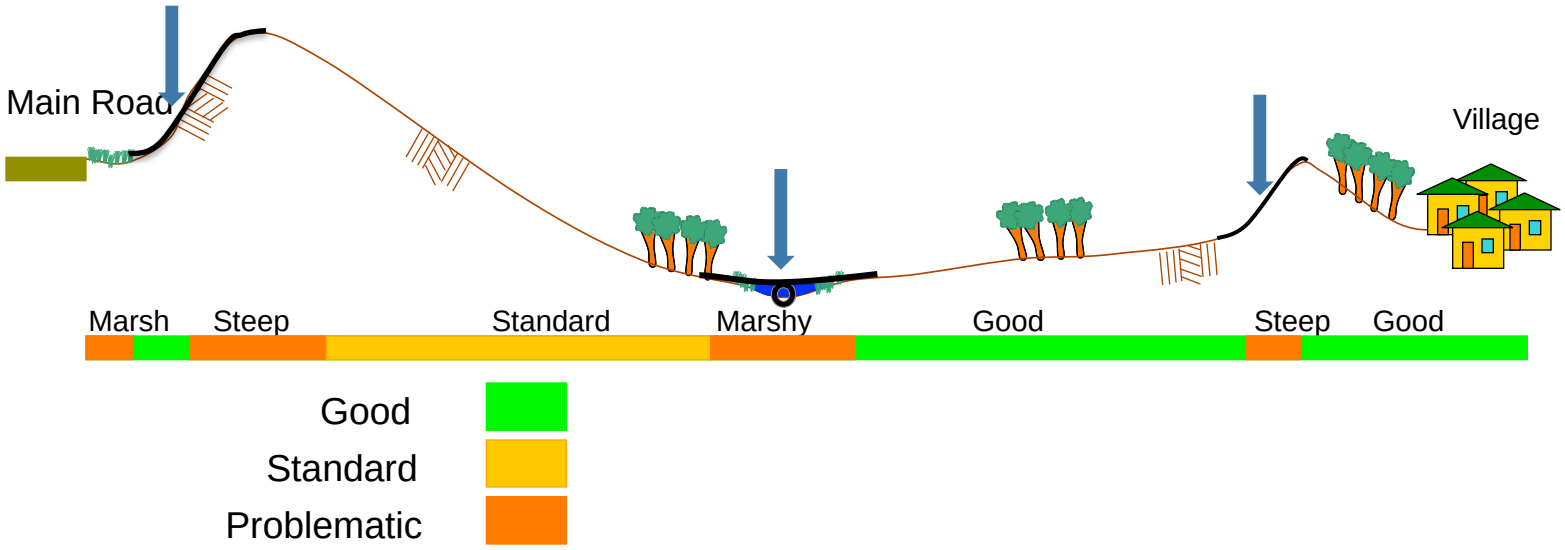
ENVIRONMENTALLY OPTIMISED DESIGN (EOD)



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Design Stage

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Design Focus

- Roads mostly used by bicycles, motorbikes, cars and other light traffic.
- Designing for low design traffic loading <200,000 equivalent standard axles.
- Some heavy trucks during pineapple harvesting season in Bagomoyo – low volume not always low axle load!
- **Year-round access** is the critical focus not speed of travel.
- Try to use local materials and labour-based construction as much as possible.

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Pavement Design

- Initially based on Tanzanian Pavement and Materials Design Manual.
- Adjustments made based on local experience to fit with the concept of low-volume roads.
- Marly limestone used in Bagomoyo because it was a local material and reduced costs.
- In Siha the DCP design approach was used for bituminous surfaces/flexible pavement design.
- DCP design optimised these designs and made savings.

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Trial Sections

Bagomoyo

- Single Otta seal with sand seal
- Double surface dressing
- Double sand seal
- Slurry seal
- Concrete strips
- Concrete geocells
- Hand packed stone
- Gravel wearing course

Siha

- Penetration macadam
- Double surface dressing
- Concrete geocells
- Concrete strips
- Concrete slabs - lightly reinforced and unreinforced
- Gravel wearing course

- Only short lengths ranging from 140m to 1,100m long.

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Findings

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Bituminous Seals

- Double surface dressing, double sand seal, Otta seal and penetration macadam performing well with only minor defects.
- Marly limestone used in Bagomoyo. Would not comply with a conventional base specification.
- Minor rutting of 5-10mm – likely due to lack of compaction during construction and/or overloaded agricultural vehicles.
- May ultimately have an impact on the life of the pavement.
- DCP CBR indicate adequate strength at in-situ density and moisture content.

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Bituminous Seals

- CBR reduced in Siha under the macadam.
- Thought to be a result of moisture ingress.
- Only section performing badly is the slurry seal surface in Bagomoyo.

- Surface failing due to poor construction.
- Good serviceability even on slurry sealed section.
- All sections provide year-round access.

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Concrete Pavements

- Concrete geocells (above) also performing very well.
- Only minor deterioration around cell edges.

- Lightly reinforced concrete sections are performing well.
- This includes slabs and concrete strips.

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Concrete Pavements

- Concrete strips not liked by local boda boda drivers.
- They cannot overtake cyclists and motorcyclists easily.
- Problems with the unreinforced concrete sections.
- Longitudinal cracking on many slabs.

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Concrete Pavements

- Combination of issues:
  - Pavement cross-section too thin for an unreinforced slab.
  - Laid on weak subgrade soils.
  - Poor construction and material quality.
  - Possible early-trafficking by the Contractor.
- Issue more prevalent in Siha than in Bagomoyo.
- Construction quality better in Bagomoyo

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Hand Packed Stone


Shortly After Construction

- Laid on a short section with weak subgrade soils.
- Ensures access but is a very rough surface.
- Flooding has made the surface much worse.
- Strongly disliked by local road users.

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Hand Packed Stone

- Safety issues for cyclists.
- Potential for damage to vehicles.
- Identical issues on a similar project in Lao PDR.
- Road users actively avoided the surface by driving on the shoulders.

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Concrete Paving Blocks

- Located in Lawate village (Siha)
- Very durable. Ideal where there is turning traffic and steep grades.
- Excellent performance since construction.
- Construction is labour intensive.
- Can be maintained locally.

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Construction and Whole Life Costs

- Gravel wearing course has the cheapest capital cost.
- This is why most countries re-gravel road networks.
- Cheap up-front cost allows many km's to be re-surfaced but it needs frequent maintenance:
  - High gravel losses observed in Bagomoyo and Siha of >50mm/year.
- Gravel is also a non-renewable resource and it should only be used where suitable.
- Whole life costing (WLC) showed gravel can be more expensive than a paved alternative.

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Construction and Whole Life Costs

- Otta seal with sand seal is more cost effective in flat areas than re-gravelling – Bagomoyo.
- In hilly areas double surface dressing, concrete strips and concrete paving blocks also came out cheaper than re-gravelling.
- All of these pavements also performed very well.
- They incorporate local materials and local labour.
- They **ensure year-round access** – something gravel does not if used in unsuitable locations.

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Discussion and Conclusions

Bituminous Pavements

- With the exception of slurry seal, all bituminous sections are performing very well in Bagomoyo and Siha.
- Some minor issues – could be attributed to lack of compaction or over-loaded agricultural trucks.
- Good performance from local materials.

Conclusions

- They can provide cost-effective alternatives to re-gravelling.
- Provide year-round access and high levels of serviceability.
- Need for maintenance and local capacity to undertake it.

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Discussion and Conclusions

Concrete Pavements

- They are expensive but perform very well.
- Only exception was the unreinforced slabs and strips.

Conclusion

- Likely to be difficult to justify economically except in the most high stress or problematic areas.
- Light reinforcement recommended in any future pavements.
- Minimal additional cost overall and creates a stronger structure – particularly if using relatively thin slabs.

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Discussion and Conclusions

Hand Packed Stone

- Did what it was supposed to do – ensured year-round access even under difficult conditions.
- But it is a very rough surface and is disliked by road users.
- It is reported to have caused damage to vehicles and resulted in accidents, particularly for cyclists.
- Similar feedback from Lao PDR – cyclists and motorcyclists actively avoid it by driving on the shoulder.

Conclusion

- Limit all future use unless no other viable alternatives.

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Discussion and Conclusions

Surface Type	Adequate Level of Service	Cost Effective	Maintenance Requirements	Buildable by Local Contractors
Bituminous Surfaces				
Double Surface Dressing	Yes	Yes	Medium	Yes
Double Sand Seal	Yes	No	Usually High - Bagomoyo seems an exception	Yes
Single Otta Seal with Sand Cover Seal	Yes	Yes	Medium	Yes
Single Slurry Seal	Yes	No	High	Yes
Penetration Macadam	Yes	Yes	Medium	Yes
Concrete Surfaces				
Concrete Strips (Reinforced)	Yes	Yes	Medium	Yes
Concrete Strips (Unreinforced)	Yes	Yes	Medium	Yes
Unreinforced Concrete Slab	Yes	Yes in high stress areas	Low	Yes
Lightly Reinforced Concrete Slab	Yes	Yes in high stress areas	Low	Yes
Geocells	Yes	No	Low	Yes
Segmental and Stone Surfaces				
Concrete Paving Blocks	Yes	Yes in high stress areas	Low	Yes
Hand Packed Stone	No	No	Medium	Yes
Indicator/Comparator Surface				
Gravel	Not Always	No	High	Yes

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