LIFE-CYCLE COST COMPARISON OF ALTERNATIVE SURFACING FOR STEEP SLOPES ON LOW-VOLUME ROADS IN GHANA

8TH AFRICA TRANSPORTATION TECHNOLOGY TRANSFER CONFERENCE – 2017

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Cardno
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SCOPE OF THE PROJECT

- Project is a two-phase study on alternative surfacing (*gravel wearing course*) for steep slopes on low-volume (feeder) roads in Ghana
  - ***Phase 1: involved a desk study, preliminary site evaluation and scoping for the phase 2 study (GHA2065A)***
    - ***CSIR/BRRI partnership (Jan 2016 – May 2016)***
  - ***Phase 2: involves design, construction and monitoring of selected pavement options identified in the phase 1 study (GHA2065B)***
    - ***CSIR/BRRI partnership (Feb 2017 – Feb 2020)***

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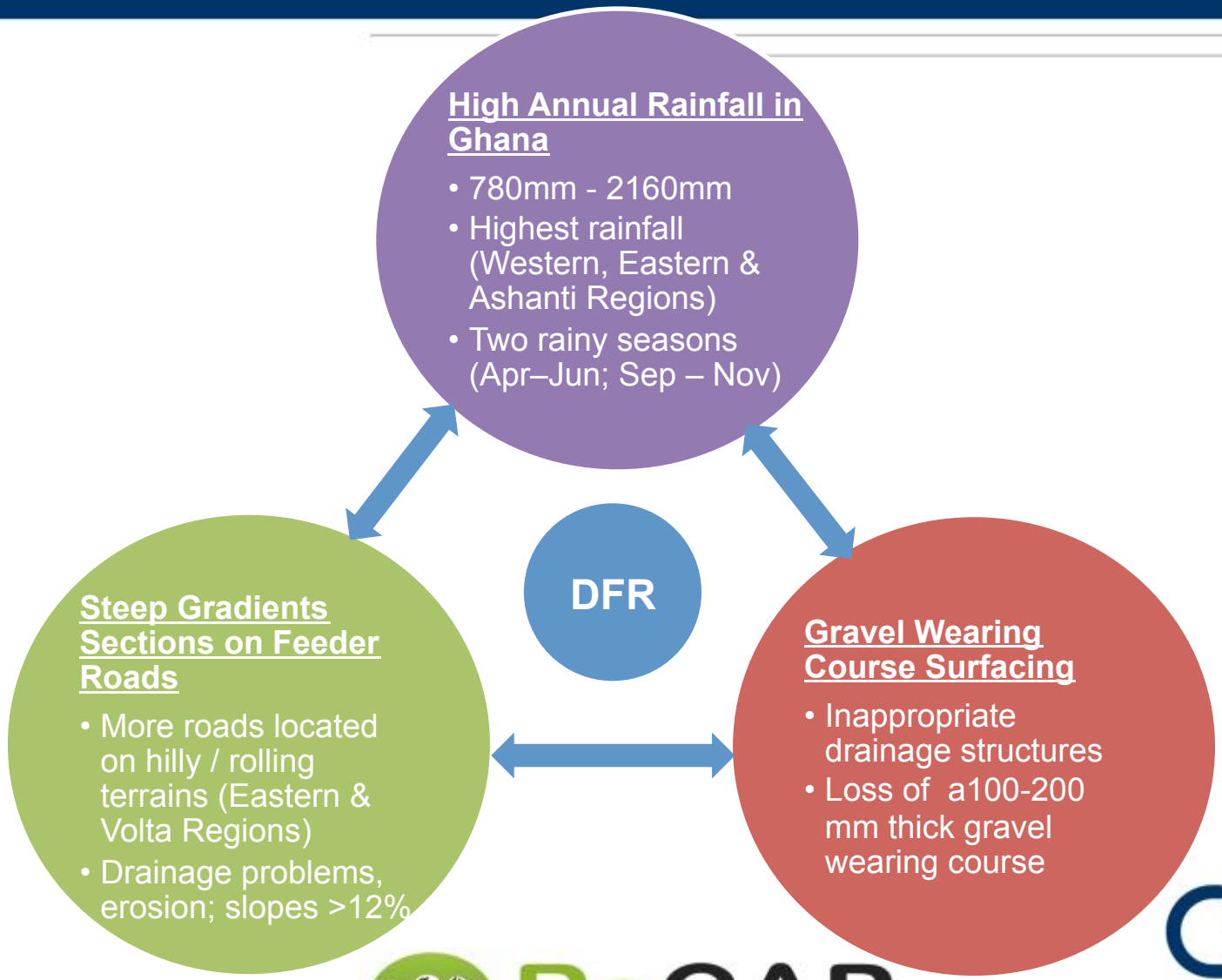
MOTIVATION / NEED



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THE SITUATION

- Erosion and drainage

THE SITUATION

- Erosion and drainage

CURRENT SOLUTIONS

- Appropriate?

CURRENT SOLUTIONS

- Appropriate?

MAIN OUTCOME OF PHASE 1

1.Bituminous surfacings

- lateritic gravel modified with sand / quarry dust + AC10 binder
- Otta seal (1x) lateritic gravel modified with sand/quarry dust + emulsion
- 2x surface dressing (seal)

2. Concrete surfacings

- concrete block paving (interlocking)
- ultra-thin reinforced concrete
- roller compacted concrete

3.Cobblestone/stone setts

- granite
- quartzite
- sandstone

Mechanical stabilisation (1. *lateritic gravel + crushed stone/quarry dust; 2. lateritic gravel + sand/ pozzolana*)

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OBJECTIVE OF PAPER

- To present a life-cycle cost comparison of **six pavement options** proposed for steep slopes on feeder roads in Ghana

1. ***70 mm ultra-thin reinforced concrete*** *on mechanically stabilised laterite base [crushed stone and quarry dust]*
2. ***50 mm thin hot mix asphalt*** *on mechanically stabilised laterite base*
3. ***Interlocking concrete paving blocks*** *on mechanically stabilised laterite*
4. ***Screened gravel single Otta seal*** *[14mm-25mm aggregates] on 100mm and 150mm mechanically stabilised base and subbase layers*
5. ***Stone setts / cobbles*** *[100 mm-250 mm] arranged on spread sand/quarry dust blinding of average depth 25 mm on 100 mm stabilised laterite*
6. ***Double seal*** *[10 mm and 19 mm] on 100 mm stabilised base and 150 mm stabilised sub-base*

SURFACING OPTIONS

Ultra-thin reinforced concrete

Thin hot mix asphalt

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SURFACING OPTIONS

Interlocking concrete paving blocks

Screened gravel single Otta seal

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SURFACING OPTIONS

Stone setts / cobbles

Double seal

INITIAL CONSTRUCTION COSTS

Option #	Pavement structure	Provisional Sum GBP	Lined Side Drains Cost GBP	Pavement Layers Cost GBP	Culvert Cost GBP	Estimated Total Cost GBP	Cost Per Sq. Metre GBP
1	70 mm ultra-thin rein. concrete on 200 mm mechanically stabilised laterite base	12 450.00	28 636.00	53 340.00	6000.00	100 426.00	**66.95**
2	50 mm hot-mix asphalt with processed lateritic gravel and AC-10 bitumen on 200 mm mechanically stabilised base	12 450.00	28 636.00	89 100.00	6000.00	136 186.00	**90.79**
3	Interlocking concrete paving blocks on 150 mm stabilised laterite [crushed stone and quarry dust]	12 450.00	28 636.00	84 696.00	6000.00	131 782.00	**87.85**
4	Screened gravel single Otta seal [14mm-25mm aggregates] on 100mm mechanically stabilised base and 150mm mechanically stabilised subbase	12 450.00	28 636.00	55 200.00	6000.00	102 286.00	**68.19**
5	Stone setts / cobbles [100 mm-250 mm] arranged on spread sand/quarry dust blinding of average depth 25 mm on 100 mm stabilised laterite	12 450.00	28 636.00	74 646.00	6000.00	121 732.00	**81.15**
6	Double seal [10 mm and 14 mm] on 100 mm stabilised base and 150 mm stabilised sub-base	12 450.00	28 636.00	85 200.00	6000.00	132 286.00	**88.19**

LIFE-CYCLE COST ANALYSIS

Surfacing	Surfacing Life (Years)	Structural Maintenance		Initial Cost / m² (GBP)	Maintenance Cost /m² (GBP)	Life-Cycle Cost / m² (GBP[1])		
		Strategy	After x years			r = 8%	r = 10%	r = 12%
70 mm UTRC	30-50	Repairs	20	66.95	0.37	70.58	70.10	69.71
50 mm HMA	15-20	overlay	15	90.79	5.24	92.44	92.05	91.75
Paving Blocks	30-50	Repairs	10	87.85	4.40	94.03	92.26	91.11
Gravel Single Otta Seal	5-8	Reseal	3	68.19	4.20	71.05	70.79	70.57
Stone Setts / Cobbles	20-30	Repairs	20	81.15	9.44	81.38	81.31	81.26
Double Seal	10-15	Fog spray	3	88.19	0.52	89.27	89.12	89.00
		Fog spray	10		0.52			
		Reseal	12		1.05			

$$PWOC = C + M_1 (1+r)^{-x_1} + \cdots + M_j (1+r)^{-x_j}) - S(1+r)^{-z}$$

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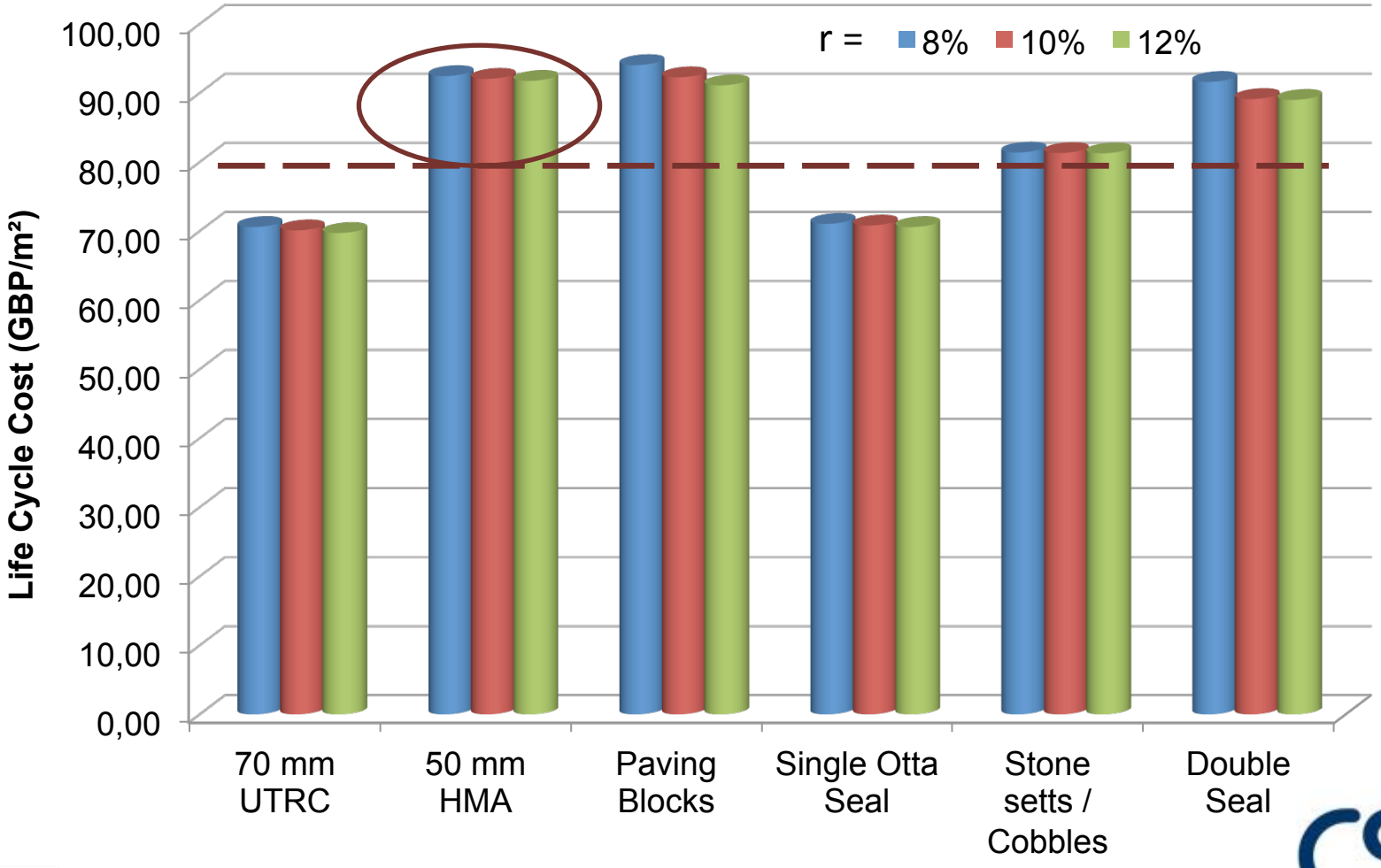
LIFE-CYCLE COST ANALYSIS



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CONCLUSIONS

- Cost difference between the initial construction and the total life-cycle insignificant for all six pavement options selected for this study
- All six pavement options identified through this project are feasible for the current and future studies
- LCCA of gravel wearing course on the steep sections of the feeder roads in Ghana (GBP 106.07 per square metre) > the three relatively expensive options (i.e. double seal, paving blocks, thin HMA)
- Current policies of the DFR may influence the final decision on which particular pavement options to adopt for the steep gradients on feeder roads in Ghana

RECOMMENDATIONS

- **Four pavement options proposed for Phase 2**

  1. *70 mm ultra-thin reinforced concrete on mechanically stabilised laterite base [crushed stone and quarry dust]*
  2. *50 mm thin hot mix asphalt on mechanically stabilised laterite base*
  3. *Stone setts / cobbles [100 mm-250 mm] arranged on spread sand/quarry dust blinding of average depth 25 mm on 100 mm stabilised laterite*
  4. *Interlocking concrete paving blocks on mechanically stabilised laterite*

- **Introduce mechanical stabilisation of lateritic soils as the common materials for the base/subbase layers of all pavement options on steep sections of feeder roads in Ghana**

ULTIMATELY…

To enable experience to be gained with a range of alternative surfacing that better utilise local resources in a sustainable way, minimising whole-life-costs and supporting the socio-economic activities of the community. The overall goal is to complement national standards with cost-effective surfacing options for steep gradient sections on feeder roads in Ghana.

Thank You

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