Structural Sustainability of Low Volume Sealed Roads

Presented By:

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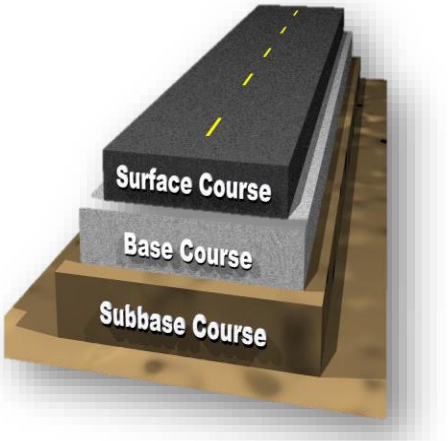
Introduction

- Low Volume Roads (LVRs) form primary links to the highway transportation system. They also provide access to socioeconomic, educational and medical centres in rural areas;
- It is estimated that 85% of roads in the world are LVRs;
- Accessibility in rural areas can be improved by upgrading LVRs to Low Volume Sealed Roads (LVSRs);
- Kenya has started an ambitious plan to upgrade LVRs to LVSRs;
- To preserve this investment, LVSRs should be structurally sustainable.

Definition of Low Volume Sealed Roads

- What constitutes a LVR depends on an individual's or organisations perspective.
- Definition:
  - A widely recognized LVR definition sets the upper limit at 500 VPD
  - Roads that carry < 200 VPD, including up to 20% commercial vehicles, and often include NMT(SADC, PDG for LVSRs, 2003).
  - Two-lane paved roads with up to 2,000 VPD and a minimum of 10% heavy vehicles (Ahangari & Evans, 2011).
  - Roads with up to 1.0 million ESAs even at higher annual traffic growth rate for a 15-year design period (Kenyan PDG for LVSR, 2017).

Conventional design methods



- Methods used to decide pavement thickness design in order to carry the expected traffic loading without failures?
- Kenyan RDM III, 1987 was based on Multilayer Linear Elastic Theory (MLET);
- The pavement materials were assumed to be linear elastic, homogenous and isotropic while the sub-grade materials were assumed and semi-infinite.
- However, most granular material used for LVSR are non-linear elastic.

Objectives of the study

Performance testing of LVSRs is therefore critical. The principle aim of this paper is to discuss Structural Sustainability of LVSRs based on evaluation of existing LVSRs in Good Condition.

The specific objectives are:

- Conduct and report structural condition of two adjoining LVSRs;
- Evaluate LVSRs performance under multi-load level FWD testing;
- Establish the key factors influencing performance of LVSRs.

Study Area

- Baricho – Kibirigwi (D454) Road is a single 150mm subbase quality pavement for up to 0.1 ESAs;
- Kerugoya – Baricho - Kagio (D455) Road has 125 and 150 mm base and subbase layers for up to 1.0 million ESAs;
- The two LVSRs have double chippings seal;
- The pavements are 6-7 years old.
- The roads are in same geographic, climatic and geological zone

Preliminary Confirmatory Surveys

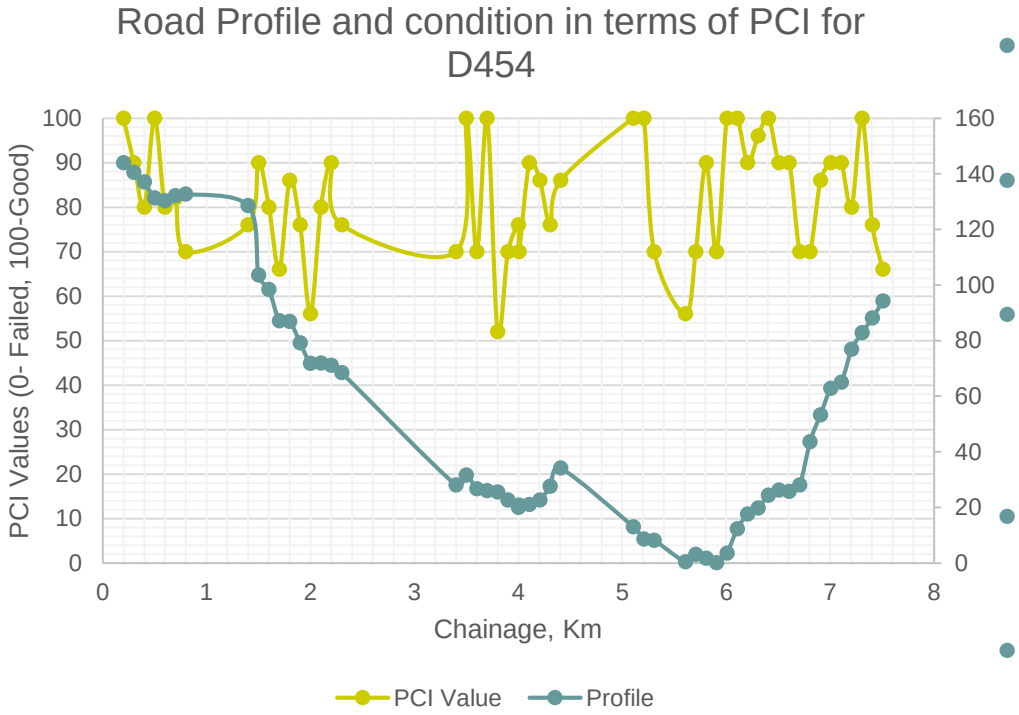
- Preliminary functional condition survey was conducted to establish if the roads are in good surface condition. Full surface condition survey was conducted using Digital laser profiler and roads Roughness in IRI, m/Km, Surface regularity Test (rut depth)in mm, visible Distress and pavement condition index established;
- D454 and D455 sections have mean roughness of 3.2 and 3.5 m/Km and both roads were in good condition ;
- Traffic studies were conducted to establish if the roads fit LVRs description. D455_Sec 1, D455_Sec 2 and D454 carry an ADT of 635,883 and 1156 motorised vehicles per day (excluding motorbikes).
- D454 and D455 Section 1 can be classified as LVR while D455 Section should be a conventional pavement.

Traffic loading analysis

Section	period years	Million ESA at 4% AGR	Million ESA at 5% AGR	Million ESA at 6% AGR	Million ESA at 7% AGR
D455_Sec 1	5	0.21	0.21	0.22	0.22
	10	0.46	0.48	0.51	0.53
	15	**0.77**	**0.83**	**0.89**	**0.97**
D455_Sec 2	5	0.35	0.36	0.37	0.37
	10	0.78	0.82	0.86	0.90
	15	**1.31**	**1.41**	**1.52**	**1.64**
D454	5	0.13	0.13	0.14	0.14
	10	0.29	0.31	0.32	0.34
	15	**0.49**	**0.53**	**0.57**	**0.61**

- D454 is LVSR from 4 to 7% AGR for up to 15-year design period
- D455 Section 1 is LVSR from 4 to 7% AGR for up to 15-year design period
- D455 Section 2 is LVSR from 4 to 7% AGR for up to 10-year design period

Surface Condition Survey



- D454 has mean and maximum IRI of 3.2m/Km and 7.1m/Km;
- D455 has mean 3.5m/Km and maximum IRI of 8.9 m/Km;
- Both sections have low severity potholes and minor rutting;
- D454 and D455 have PCI of 82 and 83 respectively;
- Surface condition was categorised as Good.

Study Methodology

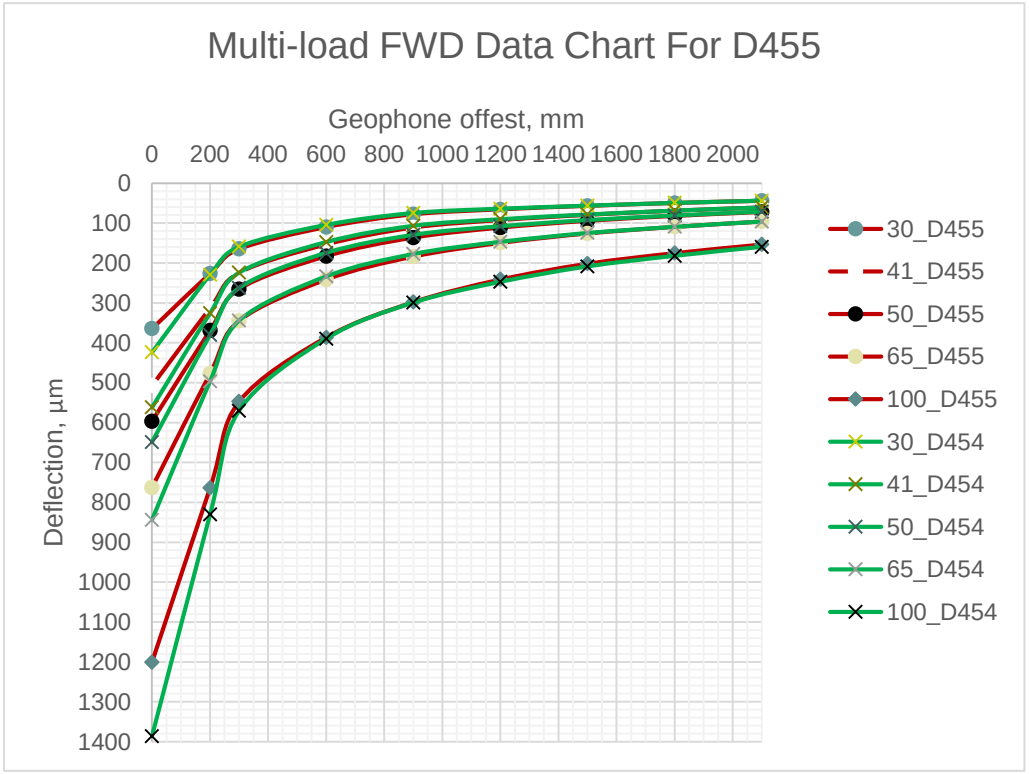
- The study involved:
  - Conducting multi-load level FWD at 0.2 Km interval and at 30, 40, 50, 60 and 100 KN test load;
  - Conducting DCP test to a depth of 500 mm below pavement layers at each FWD points and establishing DCPI for the whole pavement and individual layers
  - Pavement analysis.

DCP Test Results

Section	Depth of analysis, mm	Average Penetration Rate, mm/blow	Cumulative penetration rate, mm/blow
D454	150	4.0	30.1
	675	7.1	160.9
D455 Sec1	125	4.3	27.6
	275	5.9	52.2
	775	5.2	120.4
D455 Sec2	125	3.9	28.6
	275	5.6	53.9
	775	6.0	124.3

- The cumulative DCPI over the pavement up to 500mm for D454 and D455 is 160.9 and 122.m mm/blow respectively;
- D454 pavement has SNC ranging from 2.9 to 4.5 with mean of 3.7;
- D455 pavement has SNC ranging from minimum of 2.1 to maximum of 6.5 with mean of 4.1.

Multi-load FWD Data



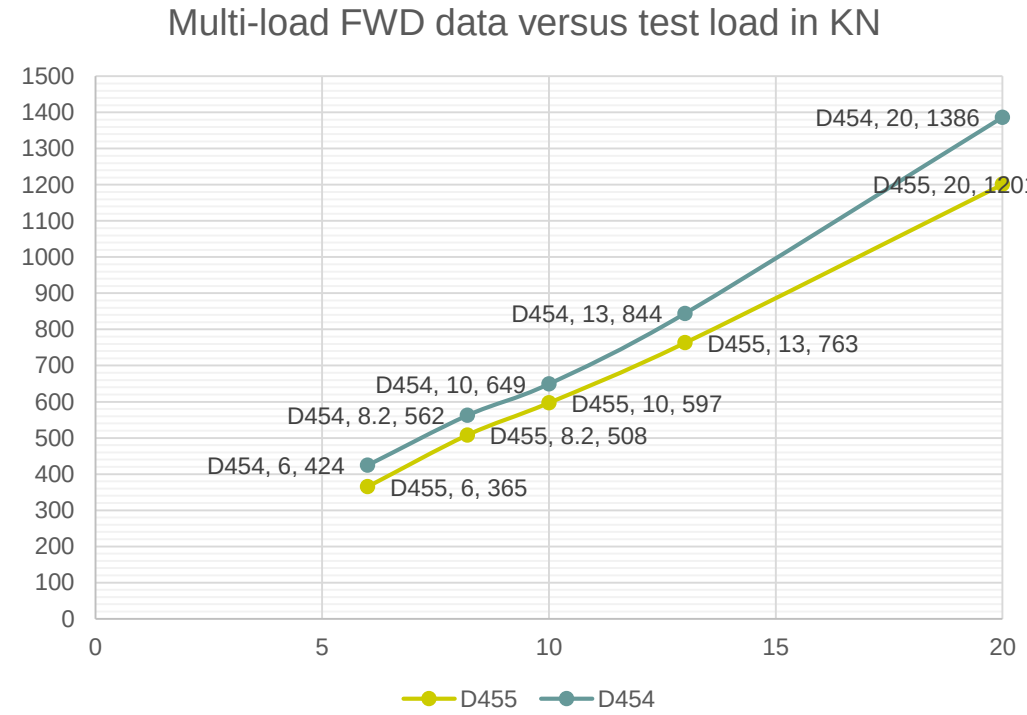
- D454 has nd1 vary from 440 to 1105µm with mean of 649 µm;
- D455 has nd1 vary from 280 to 1705 µm with mean of 597 µm
- D454 pavement has areas that are structurally stronger than D455.

Back Calculated Pavement Moduli

Road section	Base layer moduli, MPa	Subbase layer moduli, MPa	Subgrade layer Moduli
D455	1477	242	132
D454	1111	-	134

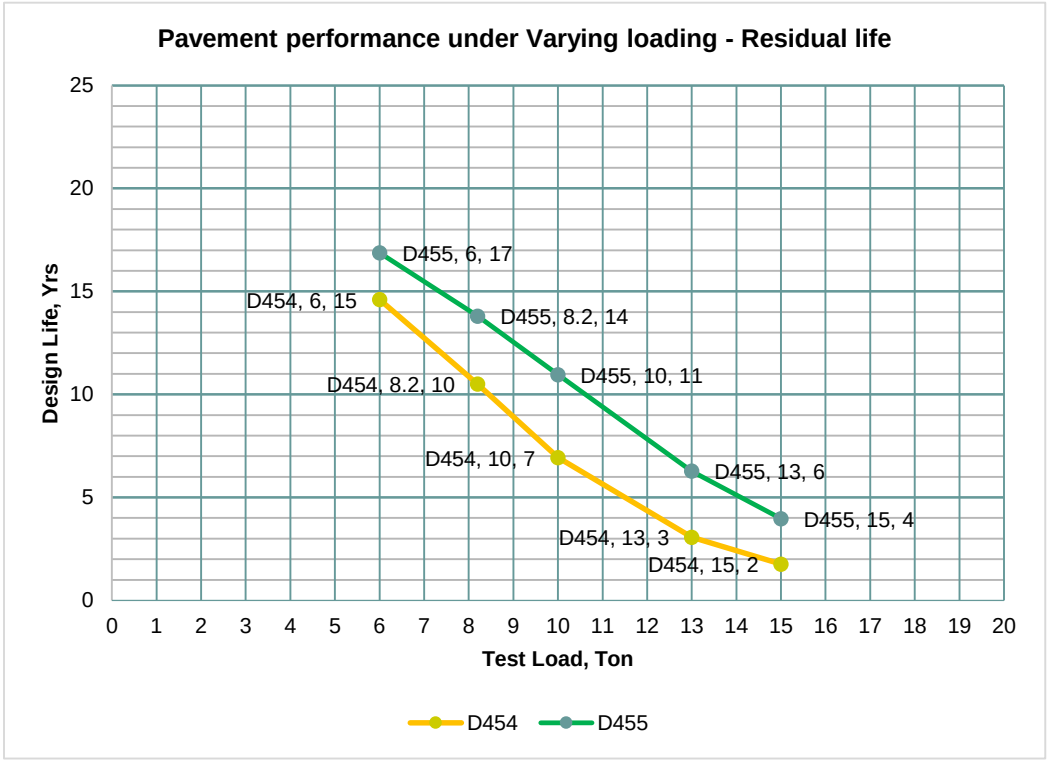
- Back calculation was conducted to establish pavement layers strength and to assist in overall pavement strength evaluation.
- Subgrade classified in in-situ condition as S5 and S2 from laboratory testing.
- Although subbase quality the single pavement in D454 has same quality to base in D455

FWD Data Analysis



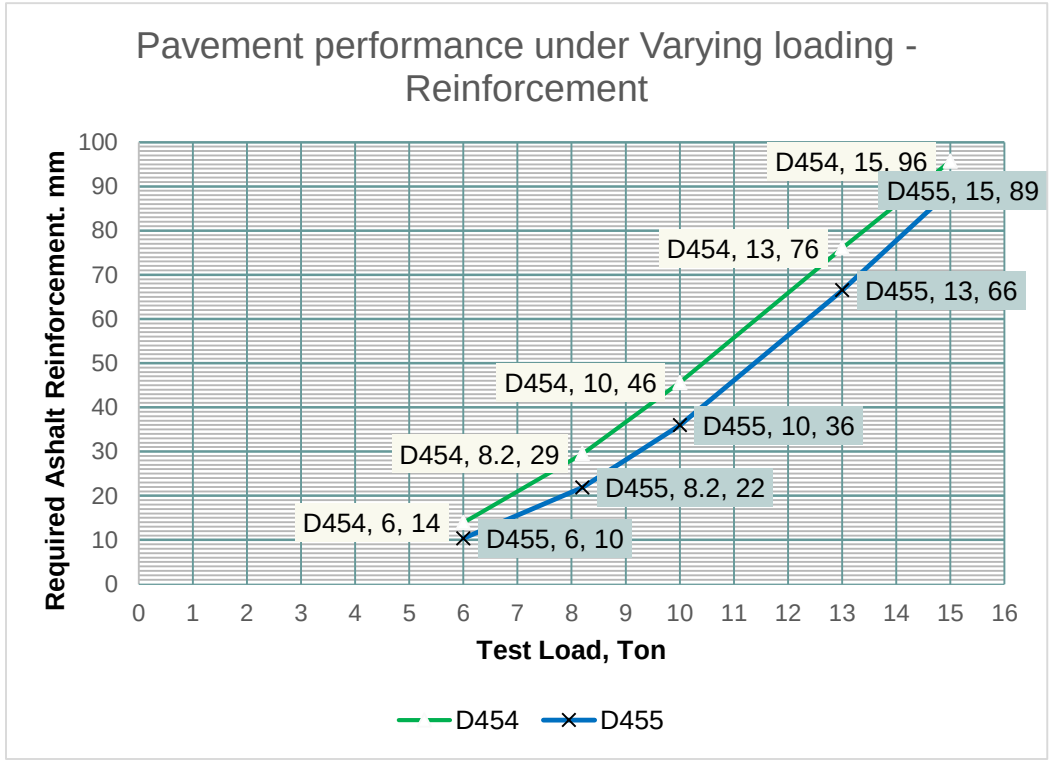
- FWD deflection increased on increase of test load. The increase follows power function;
- Comparative increase of deflection for the two pavements was insignificant;

Pavement Sustainability – Residual Life



- Required overlay vary with axle loading;
- Residual life vary with power function with axle loading;
- With 15-ton axle, the D454 can only take about 46000 axles but 410,334 with 8.2 ton axle

Pavement Sustainability – Reinforcement



- Required overlay vary with axle loading;
- Residual life vary with power function with axle loading;
- With 15-ton axle, the D454 can only take about 46000 axles but 410,334 with 8.2 ton axle

KEY CONCLUSIONS

- Road Surface Condition changes with road profile. The FWD deflection increased on increase of test load. There is structural strength difference of 11% of the two pavements based on structural number. D454 has slightly stronger foundation compared to D455
- Structural Sustainability of LVSRs was found to be associated to:
  - Road profile- More attention to LVSR drainage;
  - Foundation design – Ensure uniform foundation by spot improvements
  - Traffic loading- Enforcements of axle loads on LVSRs.

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THANK YOU