ASSOCIATION OF DISTRESS TYPES WITH DIFFERENT ASPHALT PAVEMENT DESIGNS

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1. INTRODUCTION

Road pavements are ideally designed to bear and withstand the expected loads and stresses from projected vehicular traffic. The two main parameters for designing a pavement are traffic loading and bearing capacity of road subgrade. There are other factors that influence the lifespan and resilience of the road pavement like the quality of the materials used, the mix ratio of the components and how they are layered, climatic conditions, and the age of the road pavements. As a result of these factors, road pavements suffer some distress over time that eventually leads to failure if the roads are not well managed and maintained. The main objective of this study is to evaluate the occurrence of distress types associated with different asphalt pavement designs of the provincial highway network of Khyber Pakhtunkhwa, Pakistan. The findings of this study would help the road authority to adopt a maintenance management strategy based on better understanding of the association of distresses with pavement designs. This will contribute to minimizing the cost of maintenance and reducing the life-cycle cost of these roads.

2. METHODOLOGY

In this research, the occurrence of various distress types for different asphalt pavement designs was investigated. These distress types included rutting (rut), raveling (rav), alligator cracks (alg), longitudinal cracks (lgt), transverse cracks (trv), block cracks (blk), potholes (ptl), edge cracks (edg), patches (pch), and loss of pavement (lsp). The distress data that was used in the study were collected on 33 provincial highways of Khyber Pakhtunkhwa province, Pakistan, by field survey. This highway network has about 3,500 kilometers of road divided into four divisions for administrative and management purposes. The survey covered 240 kilometers of roads aged from 1-6 years across different topography and climatic conditions. The dataset consisted of 1204 data points collected for 200-meter sections. First, the data were analyzed to obtain the various pavement designs, then the percentages of road sections with different distress types in all designs were investigated. Finally, a cross-tabulation analysis was performed between pavement designs and distress types, pavement terrain, traffic load and traffic volume to gain further knowledge of distress occurrence.

3. RESULTS

Table 1 shows that there were 12 different asphaltic pavement designs used in the road network under study. There were differences in thicknesses of the structural layers in p_1, p_2, p_4, p_6, p_7, and p_10. On the other hand, p_3, p_5, p_8, p_9, P_11, and p_12 consisted of road sections without asphalt base course layer.

Table 1. Showing pavement designs

Pavement design	Subbase Thickness (m)	Water Bound Thickness (m)	Asphaltic Base Course Thickness (m)	Asphaltic Wearing Course Thickness (m)
p_1	0.3	0.3	0.07	0.05
P_2	0.3	0.25	0.08	0.05
p_3	0.3	0.25	0	0.05
p_4	0.25	0.25	0.07	0.05
p_5	0.25	0.25	0	0.05
p_6	0.2	0.25	0.08	0.05
p_7	0.2	0.25	0.07	0.05
p_8	0.2	0.25	0	0.05
p_9	0.25	0.2	0	0.05
p_10	0.175	0.225	0.07	0.06
p_11	0.15	0.15	0	0.05
p_12	0	0.15	0	0.05

Fig. 1 shows the percentage of road sections having different distress types with respect to the 12 pavement designs. It was observed that all pavement designs showed raveling on all road sections except p_4, p_7, and p_11, which still had very high percentages. The occurrence of rutting was also observed in the road sections of almost all pavement designs except p_3, p_4, p_5 and p_11. Moreover, the road sections in p_7 design were the only ones with a relatively low percentage of rutting (18%). Alligator cracks were observed in high percentages in p_6 (99%) followed by p_1 (85%) and p_8 (71%). About half of the sections of p_2 and p_4 showed alligator cracking. The rest of the designs showed relatively low percentages with p_3 and p_10 showing no alligator cracks. Highest percentages of longitudinal cracks were found in p_1 and p_6. There were no longitudinal cracks on p_3 and p_10, and the rest of the designs showed relatively low percentages. The design with the highest occurrence of transverse cracks was p_6, with a percentage of 80% whereas p_1, p_4, p_8 and

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p_9 had percentages in the range of 34% to 40%. Types p_3, p_9, p_10 and p_12 showed no block cracks, whereas p_4 showed the highest percentage at 25%. Types p_5, p_9, p_10 and p_12 had no potholes, whereas p_4 had the highest of 27% followed by p_11 (22%). About a quarter of the sections with p_9 and p_11 designs had edge cracks, and p_6 had the highest of 43%. All pavement designs except p_3 (13%), p_4(5%), p_6 (6%), and p_11 (12%) had no loss of pavement.

Type	Count	Distress types									
		rav	rut	alg	lgt	trv	blk	ptl	edg	pch	lsp
p_1	60	100%	100%	85%	47%	40%	2%	5%	17%	7%	0%
p_2	93	100%	98%	55%	13%	16%	2%	5%	8%	10%	0%
p_3	55	98%	60%	2%	0%	0%	0%	2%	9%	0%	13%
p_4	218	74%	89%	56%	29%	38%	25%	27%	9%	33%	5%
p_5	62	98%	66%	3%	0%	5%	0%	0%	10%	3%	0%
p_6	162	100%	98%	99%	51%	80%	11%	6%	43%	34%	6%
p_7	103	92%	18%	19%	9%	30%	8%	9%	17%	1%	0%
p_8	69	100%	100%	71%	38%	36%	3%	6%	7%	4%	0%
p_9	50	100%	100%	38%	12%	34%	0%	0%	24%	6%	0%
p_10	36	100%	100%	0%	0%	0%	0%	0%	3%	0%	0%
p_11	286	94%	80%	20%	13%	27%	7%	22%	25%	2%	12%
p_12	10	100%	100%	20%	10%	10%	0%	0%	10%	0%	0%
All	1204	93%	82%	53%	22%	34%	9%	13%	19%	13%	5%

Fig. 1. Cross-tabulation of distress types and pavement designs

4. DISCUSSION AND CONCLUSION

From the results, p_7 had the best pavement performance on average based on the aggregated average of all distress percentages and p_6 had a low performance comparatively in terms of distress occurrence despite having similar designs. A cross-tabulation analysis performed for pavement design and the pavement terrain revealed road sections in p_6 designs were in the hilly terrain whereas the road sections in p_7 were in the plain areas. The resultant effect of increased loads due to shear stress on the pavement in hilly roads may be the cause of accelerated deterioration on p_6. From the results of cross-tabulation between pavement design and traffic volume, shown in Fig. 2, it was observed that the pavement designs with high traffic volumes, p_1, p_4, p_6, and p_8, showed very high distress levels, especially with respect to raveling and rutting. From Fig. 3, it was found that pavement designs with high loading had a high percentage of distress. The frequency of distress types varies depending on the traffic volume, load, and climate. Higher traffic loads and harsh climatic (pavement terrain) conditions may lead to more frequent distress occurrences. Regular monitoring and maintenance can help identify distresses early and prevent them from worsening.

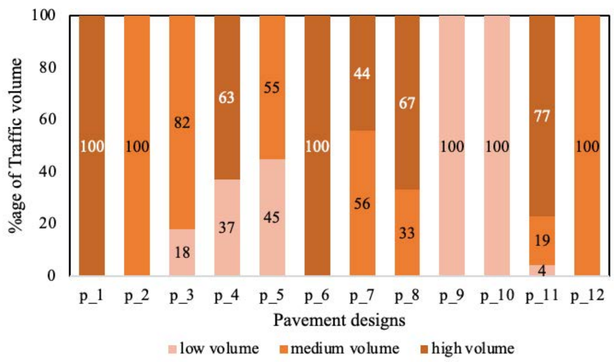

Fig. 2. Cross tab. of pavement designs and percentage of traffic volume

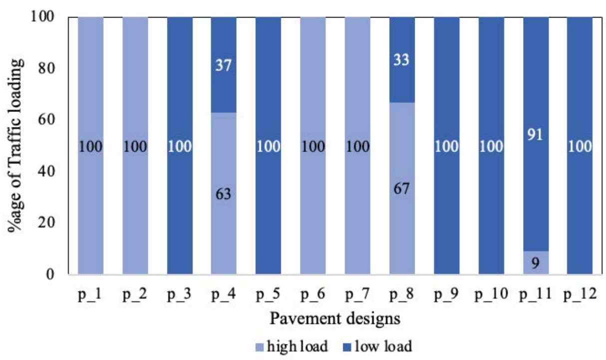

Fig. 3. Cross tab. of pavement designs and percentage of traffic loading

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