American Scientific Research Journal for Engineering, Technology, and Sciences (ASRJETS)
ISSN (Print) 2313-4410, ISSN (Online) 2313-4402

http://asrjetsjournal.org/

Pavement Assessment of Farm Roads in Bhutan

Narayan Dungana[a]*, Tashi Dubjur[b]

[a]*Master's in Civil Engineering, University of Sannio, Benevento 82100, Italy*
[b]*Assistant Engineer (Civil), Tangsibji Hydro Energy Limited, Trongsa, Bhutan*
[a]*Email: yan8843@gmail.com*
[b]*Email: tashidubjur@gmail.com*

Abstract

A subjective assessment was carried out to study the present condition of farm road pavements in Bhutan. Three farm roads, each in Phuentsholing, Tsirang and Paro were selected for the study, taking into considerations the road environment parameters. A subjective approach of evaluation was adopted for the study. The total of 12km stretch of farm roads were segmented into unit of one kilometer and every distress parameter data was collected in an assessment form. The results were analyzed to identify the conditioning factors for deterioration of the pavement of farm roads. The results obtained from three different farm roads were also compared to study the impact of pavement layer, climate, soil type and terrain on the performance of the pavement of farm roads. The constructional defect was identified as one of the main contributors for the failure of the pavement of farm roads. The degree of distresses was compared with some of the standard rating criteria and most of the distresses were found to contribute to the poor performance of the pavement. Accordingly, some areas of improvement were prioritized for immediate implementation for the construction of upcoming farm roads in the nation.

Keywords: Farm road; pavement; distress; level of severity; subjective assessment; California Bearing Ratio (CBR).

1. Introduction

Roads are the backbones of a country and leads to increased spatial mobility of people and goods between rural and urban communities. The movement of goods between two areas or regions activates the flow of capital, trade,

---

* Corresponding author.

and technology and consumption behaviour. Therefore, rural areas in Bhutan are linked with farm roads. The functional definition of farm road is the road that links farmland areas or villages to collector roads to enable transportation of inputs to farms and agriculture products to markets [2]. However, farm roads are of low volume traffic roads in Bhutan, without asphaltic or concrete surfacing.

According to the technical guidelines and specifications on the construction of farm roads prepared by Ministry of Agriculture, the running surface for the farm road is selected based on subgrade California Bearing Ratio

(CBR) value [1,2]. Strength parameters of materials are expressed in terms of CBR. CBR of subgrade soil plays the most vital role for better roads in terms of rideability and maintenance strategy. CBR of subgrade soil fluctuates with variation of water table or flood water. Support provided by the in-place soil (subgrade) is the most basic factor for all pavement design procedures. Surface deflection is highly dependent on subgrade support. Pavement structural response is expressed in terms of stress, strain and deflection and are dependent on subgrade soil. If the subgrade CBR is greater than 10%, the subgrade forms the finished pavement surface. If the subgrade CBR is less than 10%, additional base course layer should be provided.

Although, farm roads lead to economic development of the rural communities in Bhutan, its performance for all weather accessibility is a major issue. Many of the farm roads, constructed in the past, failed to serve the purpose of improved accessibility and strengthening marketability for farm products [6]. Villagers are affected as the roads are in bad conditions; hindering vehicle-traffic toward the village even in winter given that monsoon always hindered road conditions in summer.

As per the Road Act of Bhutan (2013), road users or beneficiaries of farm road must contribute to and maintain periodically or in an emergency as may be required by the concerned local government/agency. The duty of beneficiaries to maintain such roads extends to routine and periodic maintenance which includes removing obstruction, clearing the drains etc. and which may be determined by the government/agency from time to time through local public hearings.

Low volume roads are constructed and managed within a low cost framework, which results in frequent damage of the road surface. In general, the pavement of the low volume roads is of low standards, which prohibit any form of transport during wet rainy condition which is elaborated by the author in [5].

The deterioration of farm roads is governed by the strength of the road materials, the drainage capacity under the combined action of traffic and climate, and the lack of routine maintenance activities [4]. All these combinations lead to dust, rutting, potholes, corrugations, loose materials, erosion of channels and other deformations.

Besides, slope instability and landslides, pavement failure is a major concern for the maintenance of all-weather accessibility of farm roads in Bhutan. Considering the need of farm roads in all rural areas for economical, educational and agricultural purposes, its performance in terms of rideability for all weather access is essential.

Therefore, this research is intended to assess the present condition of surface course of farm roads in Bhutan, identify the distresses of pavement and causes of distresses so that the areas of improvement can be prioritized

for the future rehabilitation work of pavement of farm roads in the country.

2. Methodology

Three farm roads with total stretch of 12km consisting Wangdigatshel Farm Road (R1) in Phuentsholing, Salami Farm Road (R2) in Tsirang and Nemjo Farm Road (R3) in Paro were selected for study. The selection was based on variance in road environment parameters such as climate and terrain. The details of the study areas are presented in Table 1.

The roads were segmented into manageable unit of 1km each. First 3 segments form total stretch of R1, second 4 segments form R2 and last 5 segments form R3. The distresses in each segment were subjectively measured. Potholes, ruts, erosion tracks and stoniness were quantified with their depth. Slipperiness, dust and loose materials were quantified with their degree of acceptance. All the tangible distresses above the depth of 20mm were evaluated.

The classification of soil was done according to ASTM D2488. The classified soil in R1 was coarse sand, silt and clay in R2 and medium sand in R3. The soils were classified in order to study the effect of soil type on the performance of pavement of farm roads.

Table 1: Details of Study Area

Study Areas	Length (km)	Beneficiaries (No. of households)	Avg. annual rainfall (mm)	Min. and max. temperature	Geographical location
R1	3	96	7500	15^0C – 35^0C	Southern Foothills, 26 52’18.66” N
R2	4	163	1818	6.5^0C – 26.4^0C	Middle Mountains, 27 00’45.22” N
R3	5	200	646	-3.8^0C – 25.6^0C	High Mountains, 27 26’22.69” N

3. Results, Analysis and Discussion

3.1. Distress Quantification

Table 2 shows the concentration of different distresses in different segments:

3.1.1 Potholes

Rainfall and traffic were observed to be the main triggering factors for formation of potholes. The number of potholes, maximum and minimum depth of potholes in most affected portions are shown in Figure 1 and Figure 2.

Table 2: Segments Affected by Various Distress

Sl. No.	Pavement	Affected Segments
1	Pothole	S2, S3, S5, S8, S9
2	Rutting	S2, S3, S5, S6, S10
3	Dust	S2, S4, S5, S6, S7, S12
4	Stoniness	S1, S3, S4, S6, S7, S8, S9
5	Erosion	S1, S2 and S4
6	Loose	All segments
7	Slipperiness	S2, S4, S5, S6, S7

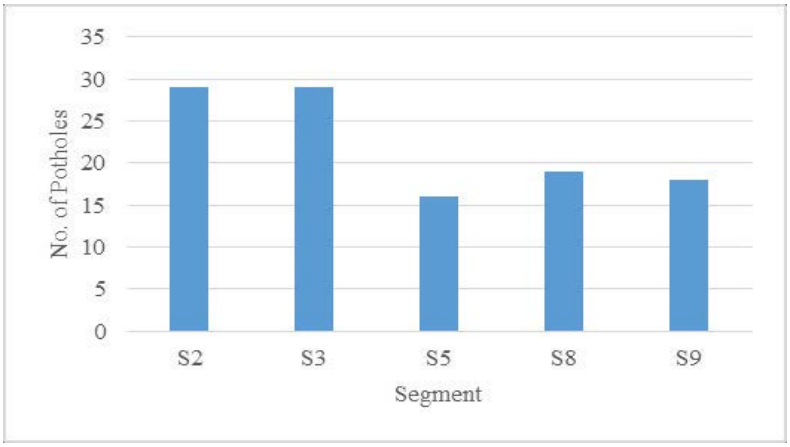

Figure 1: No. of Potholes

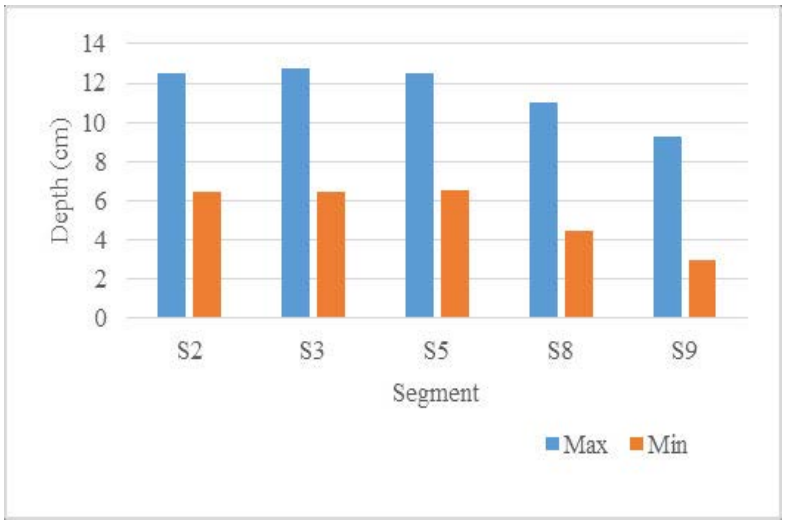

Figure 2: Depth of potholes

3.1.2 Rutting

The parallel depressions along the most affected segments were observed to be the causes of inadequate compaction of the pavement surface during the time of construction. The condition is worsened by wet clay and silt soils in some segments of R2, which are loosened by ponding of water, and get displaced laterally under traffic load. The non- cohesive soil in effected segments of R1 are also displaced laterally under traffic load. The maximum and minimum depth of ruts in most affected segments are shown in Figure 3.

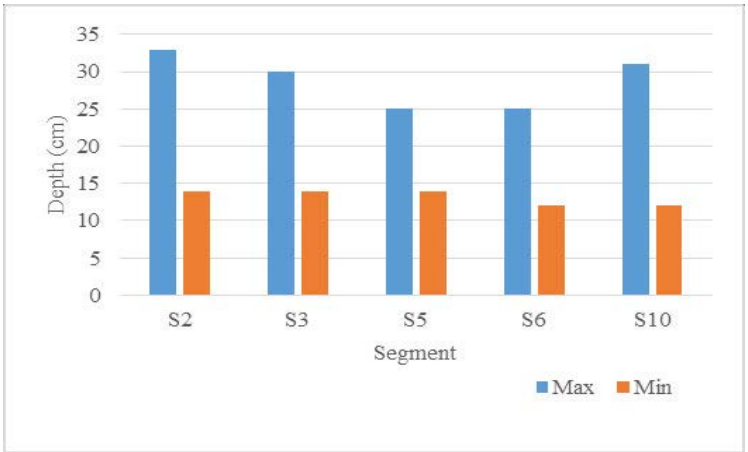

Figure 3: Depth of ruts

Figure 4: Rut formation in R1

3.1.3 Erosion

Erosion tracks were prominent in R1 and R2, where rainfall intensity was high as compared to that of R3. The

irregularity of the pavement surface, and vertical gradient as high as 10% were observed to be the contributing factors to the erosion of surface materials in some of the segments in R1. The absence of side drains, subsidence of the pavement surface and absence of cross-fall were the causes observed for the erosion in R2. In R3, the absence of side drains was prominent issue for surface erosion. The maximum and minimum depth of erosion tracks in most affected segments are depicted in Figure 5.

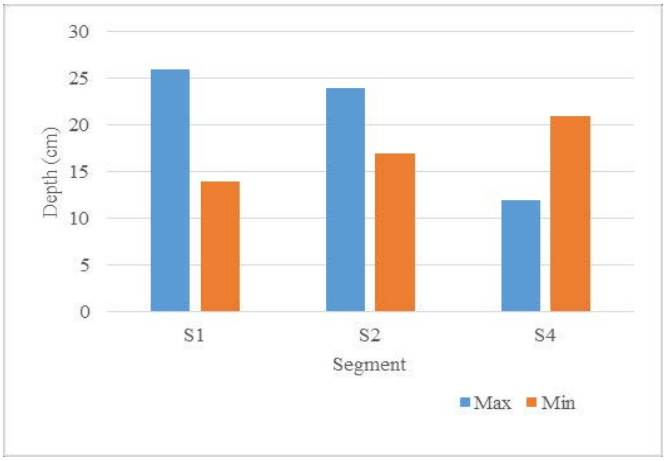

Figure 5: Depth of erosion track

3.1.4 Stoniness

The exposed subgrade stones, loose materials in most of the segments of R1 and R2 which developed due to inadequate compaction of the finished surface, were removed under traffic and erosion action of heavy rainfall. Therefore, the subgrade stones form part of running surface, affecting the safety and vehicle operating cost. In R3, the exposed stones were observed to be borrowed stones used in soling. The removal of base course layer under traffic led to the exposure of the stones.

3.1.5 Loose Materials

Through visual assessment of the condition of pavement of farm roads, ravelling/loose materials were observed throughout the entire 12km stretch of farm road. These loose materials consisted of the *in situ* materials or transported sediments from the cut-slope. The absence of fine materials in R1 and R3, inadequate compaction of surface in all segments were observed to be the principle causes for ravelling.

3.1.6 Dustiness and Slipperiness

Dustiness in dry seasons and slippery in wet seasons were observed to be prominent in segments of R2. The possible causes were presence of excessive fine materials, which was lacking adequate compaction. Presence of excessive silt and clay soil prohibit the infiltration of rain water during monsoon leading to slippery surface.

3.2. Areas of Improvement

The constructional defects were observed to be one of the factors contributing to the deterioration of pavement of farm roads in Bhutan, besides the natural factors. Therefore, flowing areas of improvement are prioritized through the assessment and recommendations from the authors of [7,8]:

a) Adequate compaction of the pavement surface with efficient rollers.
b) Provision of minimum of 150mm sub-base course layers in all pavements of farm roads in Bhutan. The thickness of base course layer shall be increased based on subgrade CBR. The capping layer shall be provided in farm roads constructed in southern foothills in order to arrest the effect of heavy monsoon rainfall.
c) The vertical gradient should not be more than 7%, as mentioned in the technical guidelines for construction of farm roads, to protect the surface from erosion.
d) The cross-fall of 2.5%-5% throughout the pavement surface should be provided for proper drainage of surface runoff. The side drains should be made mandatory for all pavement surfaces towards hill side, with designed capacity to drain all the surface runoff.

For the achievement of these areas of improvement, proper monitoring of the construction of farm roads by the site engineer is mandatory.

4. Conclusion

Comparing the level of severity of distresses of the pavement of farm roads in Bhutan with rural road rating criteria (such as VVMB 106, Unsurfaced Road Condition Index, and Pavement Condition Rating of ASTM and Pavement Condition Index (PCI)), most of the distresses are found with higher level of degree of severity, resulting poor condition of pavement of farm roads in Bhutan. The results show that immediate improvement in the construction of pavement of farm roads are necessary, prioritizing the area of concerns with adequate compaction, minimum vertical gradient, provision for proper drainage of surface water and additional base course layer to be provided. The purpose of the construction of farm roads should serve the rural residents whose living standard depends on the adequate transportation facilities, keeping in mind the financial constraints of the nation.

Acknowledgement

The research team would like to thank Mr. Sangey Pasang, Faculty of Civil Engineering Department at Royal University of Bhutan for his constant guidance and support.

References

[1]. Ministry of Agriculture. “Technical Guidelines for the Construction of Farm Roads”, Bhutan, 2009.
[2]. Ministry of Agriculture. “Technical Specifications and Standard Drawings for the Construction of Farm Roads”, Bhutan, 2009.
[3]. Ministry of Agriculture. “Guidelines for Farm Road Development”, Bhutan, 2009.
[4]. Cook, J. R. and Petts, R. C. “Rural Road Gravel Assessment Programme Module 4”, *SEACAP*

4, Vietnam, pp. 14, 2005.

[5]. Hearn, G. J. *Slope Engineering for Mountain Roads*, Geological Society, -London, Engineering Geology Special Publication, 2001, pp. 1-6.

[6]. Namgyal, G. "Farm Roads Blocked as the Monsoon Peaks", *Kuensel, Bhutan*, (Jan 2, 2013).

[7]. Figueroa, C. "Assessment Procedures for Gravel road". *Purdue University*. (April, 2013).

[8]. Paige-Green, P. "Appropriate Roads for Rural Access". *CSIR Built Environment*, PO Box 395. Pretoria, South Africa, 2005.