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THE ROLE OF SHOULDERS ON RURAL ROADS PERFORMANCE AND ACCIDENTS

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ABSTRACT

Smoothly unpaved or paved shoulders adjacent to the pavement lanes can significantly improve the safety of road users. Shoulder can provide a reasonably safe area for the traffic stream of high-speed motor vehicle traffic and also increase lateral clearance during over taking operation on rural roads. Further, shoulders can provide a buffer between bicyclists and the turbulence created by passing trucks. Studies have shown that they can reduce roadway maintenance costs and run-of-the-road motor vehicle accidents. So an attempt is made to study the role of shoulders on rural roads performance and Accidents by selecting two sections of rural roads in Khammam district in Telangana. The first road section is from Khammam to Bonakal and the second from Nayakangudem to Vallapuram. Initially an inventory study has been carried out for both the sections. A traffic survey is carried out for 7 days 24 hours for every 15 minutes interval. ADT(average daily traffic) and AADT (Annual Average Daily Traffic) are calculated based upon the data obtained for traffic survey. Mode wise traffic data separated based on the guidelines provided by the PMGSY. It was observed from the study that Nayakangudem to Vallapuram section is very poor compared to Khammam to Bonakal section. Other aspects in geometric parameters of the rural roads are not meeting with the standard specifications provided by rural roads manual (2000). Data and inventory studies reveals that also 40% of geometrics are matching with the standards. From the accident data a relationship is developed between traffic and accident data. Further it was observed that without shoulder the accident rate is 20.34% more than the roads with proper shoulder. It was observed that due to absence of extra widening on curves at 3km, 4km, and 6km and 8km frequently accident 30% of total is taking place. Finally, proper shoulder with standard specification will reduce considerably

Keywords: Shoulder, Average Daily Traffic, Annual Average Daily Traffic, Inventory survey

I. INTRODUCTION

The motorized traffic on rural roads has been increasing in rural areas over the years due to the increase in income level and easy availability of such vehicles in the market. Moreover, public transport modes such as buses and trucks have also started playing in interior areas. However, with improved accessibility, the accidents on such roads have also increased over the years. Rural road crashes are generally more fatal than crashes on urban roads due to inadequate shoulders, differences in operating speeds (higher on rural roads), road geometry (rural roads have evolved rather than having been designed), functionality (rural roads are multi-functional), enforcement levels (rural roads receive a lower priority) and other factors. Thus, the possibility of fatal accidents (per kilometer driven) is generally higher on rural roads than on urban roads.

The shoulder is most important element in roadway and for the pavement support, stopping the vehicle at roadside; it can provide a reasonably safe area for vehicles to ride that is out of the lane of high-speed motor vehicle traffic, that they can reduce roadway maintenance costs and run-off-the-road motor vehicle crashes. In some cases, particularly on older rural roadways, shoulders that do exist are made of gravel rather than hard asphalt or concrete. These are known as soft shoulders in comparison. Because the road surface changes at that point, they are less safe if they need to be used for emergency maneuvers.

II. NEED OF PRESENT STUDY

- To distinguish present condition of shoulder in research study sections (Rural Roads Shoulders) by conduct inventory survey.
- Attentively to reduce the accident rate with effect of shoulder.
- The impact of vehicle characteristics and traffic movements on rural road shoulders.
- The driver characteristics impact on rural road accidents.

III. OBJECTIVES OF THE STUDY

A review of previous studies was undertaken, with aim of guiding the work into promising areas as well as providing a basis and keeping the above facts in view, the following objectives have been set for this study.

- To identify the irregularity of existing shoulders.
- To determine the traffic volume of the study sections
- To collect and quantify the accidents of the study sections (Khammam to Bonakal&Nayakangudem to Vallapuram).
- To compare the accident rate and traffic volume of rural road study sections.
- To determine the percentage of accidents in rural roads with effect of shoulders.

IV. IDENTIFICATION OF PARAMETERS OF THE STUDY SECTIONS

After the initial review of literature and discussions with experts and village representatives, the various factors responsible for road accidents on one-lane unpaved roads in rural areas were identified and analyzed and finally the following parameters were considered for the study to determine the accident potential of the rural roads.

- Geometric characteristics of road
- Width and quality of shoulder,
- Mode of transport used by the public, and
- Traffic volume and mix on the road.
- Weightages of parameters

V. LITERATURE REVIEW

A review of a literature pertaining to existing study on rural road shoulders impact on accidents. To identify the inconsistency of existing shoulders.To determine the traffic volume of the study sections.To quantify the accidents of the study sections (Khammam to Bonakal&Nayakangudem to Vallapuram).To compare the accident rate of rural road with shoulder and rural road without shoulder. In Khammam, A.P, some 20 percent of casualty accidents and 33 percent of fatal accidents occur on roads of rural areas. The most common type of accident is vehicle leaving the road and hitting fixed object.

A detailed investigation of such accidents are occurred and concluded that roadside objects were considered to have affected the severity of 27 percent of accidents and the condition of unpaved shoulders was considered to have contributed to 30 percent of accidents. Narrow lanes, curves, unpaved shoulders, and low skid resistance pavements were shown to have been associated with increased accident rates. By comparison, driver fatigue was considered to have been a factor in 33 percent of accidents, and excessive or inappropriate speed in 25 percent.

A. Geometric characteristics of roads

The geometric standard for rural roads has been improved over the years. The older roads constructed during the first few phases do not have excellent alignments, but gradually things have improved. In many cases proper alignments could not be provided due to land acquisition problems. Providing inadequate camber leads to deformation of pavement and shoulder. Very often shoulders and road markings are absent in rural roads, due to

which accidents are held frequently. The scores assigned on alignment and geometrics considered for the accident study are given in Table I for the study section Khammam to Bonakal& Table II for Nayakangudem to Vallapuram. The road geometric characteristics of the study section from Nayakangudem to Vallapuram are carried out and the scores are given based on accidents in the section.

B. Types of shoulders

Adequately designed shoulders should be provided on rural roads. In case soft soils are used for embankment, hard shoulders of 1 m width shall be provided on either side. Where availability of land is not a constraint, extra width of shoulders can be provided near bus stops and to provide platforms for storing material during maintenance. Road shoulders are areas beside the travel lane that allow drivers to stop in emergencies and avert accidents, and are designed with safety in mind. A growing trend is also to allow shoulders to double as areas to support non-motorized travel, usually bicycling but also occasionally walking. There are two shoulder types: 1) Unpaved shoulders consisting of earthen or granular materials. 2) Paved shoulders consisting of bituminous or concrete materials.

C. Shoulder width description

While the requirement of shoulder width for heavily trafficked highways may be as much as 3m, it will generally not be possible to provide such wide shoulders on low volume rural roads. The shoulder width on rural roads may preferably be

Tablei. Score on alignment and geometrics of section 1

Road Geometric Characteristics	Score
Number of sharp curves with shoulder and markings	5
Moderately straight level road	4
Camber	3
Visibility obstructions	2

Tableii.Score On Alignment And Geometrics Of Section 2

Road Geometric Characteristics	Score
Number of sharp curves with shoulder and markings	1
Moderately straight level road	3
Camber	2
Visibility obstructions	4

1.8m to 2.5m, but should never be less than 0.6m. Where a large number of slow moving vehicles like animal drawn carts and bicyclists are to use the shoulder, a minimum width of 1.2m should be considered necessary. On long bridges or in hilly terrain, partial shoulders may be used where full shoulders may work out to be highly uneconomical. Irrespective of the width, the shoulders should be continuous. Any narrowing down or loss of shoulders on bridges and culverts can prove to be hazardous. For Rural Roads, an absolute minimum shoulder width of 0.6m is considered acceptable for ADT<40%, but for higher traffic volumes, a minimum 1.2m width is required.

VI. DATA COLLECTION AND ANALYSIS

Field data collection is necessary for existing roads improvements (Geometrically & Construction) and new construction, and also identifythe actual condition. Many different types of data's are collected on study sections, studies as part of the shoulder performance in rural roads. This document provides the guidelines necessary for collecting inventory data on these sections.

A. Inventory Survey Data

- Identify the study section
- Collect the road way inventory data
- Collect traffic data for study section
- Accident data Collection for the study sections

B. B.Inventory Survey

1) Identifying the study section

For the research study on rural road shoulders, I have identified two study locations in the Khammam district; they are 1) Khammam to Bonakal section as a length of 10 km 2) Nayakangudem to Vallapuram section as a length of 10 km. Inventory study is carried out for the study sections from Khammam (Agraharam) to Bonakal and Nayakangudem to Vallapuram. Shoulders are found eroded and rain cuts are formed at most of the locations in the study section and the quality of the shoulder is also very poor. The level difference of the shoulder and the pavement was found in most of the section from Nayakangudem to Vallapuram. By comparing the design width of the shoulder, the existing width is much less.

C. Collection of traffic data

1) Description of traffic volume study

Classified Traffic Volume Count Survey was conducted at two locations, each location representing mid-block count station for different homogeneous sections of the rural road. The count was conducted in both directions for successive 15 minutes periods, 24 hours a day. Classified counts were made for 7 days in two locations. For carrying out the counts, the vehicles were grouped under the following categories as per IRC: 64-1990.

The Rural Road originates from Khammam (Agraharam) to destination ends at Bonakal and Nayakangudem to Vallapuram in Andhra Pradesh. It is a primary conduit for transportation of passenger as well as freight traffic. In order to understand the characteristics and the volume of traffic using the rural road& travel pattern of vehicles plying on the rural road were collected through primary surveys.

The traffic volume survey carried out according to IRC specifications are:
1. Traffic volume count survey @ Khammam (Agraharam) to Bonakal
2. Traffic volume count survey @ Nayakangudem to Vallapuram

The data collected from the traffic surveys were coded and processed in order to assess and analyze the existing traffic volume, any travel pattern and for forecasting purposes.

2) Evaluating Traffic Characteristics

The data collected from the traffic volume count surveys was coded and processed in order to analyze the results with respect to existing traffic intensity, flow pattern, hourly variation and composition of traffic on the study road network. The various traffic characteristics have been presented in the following:

- Average Daily Traffic (ADT)
- Hourly variation and Peak Hour Factor (PHF)
- Annual Average Daily Traffic (AADT)

D. Average daily traffic (ADT)

The traffic volume data collected (for seven days) at the survey location was averaged out to arrive at the average daily traffic (ADT) on the project road. The summary of ADT in terms of vehicles and PCU is given in Table. The details of the daily traffic counts by direction at the survey location are given below in Table III and Table IV.

E. Hourly variation of PHF (Peak Hour Factor)

The hourly variation of traffic illustrates the distribution of traffic over the day with respect to time and the peak hour factor is the maximum percentage of the total traffic that uses the project highway in one single hour of the day. It is

of significance as highway capacities and design calculations are based on peak hour factor. The peak hour factors observed at the count locations is summarized in table V.

F. Annual Average Daily Traffic(AADT)

The traffic plying on any road generally varies over the different periods of the year depending on the cycle of different socio-economic activities in the regions through which it passes. Therefore, in order to have more realistic picture of the traffic on the rural road, it is required to assess seasonal variation in traffic to estimate Annual Average Daily Traffic (AADT).

TABLE III. ADT observed on bonakal- khammam section.

ADT	Direction		Both Directions
	Khammam to Bonakal	Bonakal to Khammam	
Total vehicles	**593**	**588**	**1181**

TABLE IV.ADT Observed On Nayakangudem-Vallapuram Section.

ADT	Direction		Both Directions
	Nayakangudem to Vallapuram	Vallapuram to Nayakangudem	
Total vehicles	**437**	**434**	**871**

TABLE V. Peak Hour Traffic For Both The Sections

Survey Location	Peak Hour Traffic in ADT (%)	Observed Peak Hour	Road Section
Chinthakaani	15.2	8.00 to 9.00 A.M	Khammam-Bonakal
CheruvuMadharam	13.5	8.00 to 9.00 A.M	Nayakangudem-Vallapuram

TABLE VI .AADT Observed On Section 1

AADT	Direction		Both Directions	AADT
	Khammam to Bonakal	Bonakal to Khammam		
Total vehicles	**593**	**588**	**1181**	**431065**

TABLE VII. AADT Observed On Section 2

AADT	Direction		Both Directions	AADT
	Nayakangudem to Vallapuram	Vallapuram to Nayakangudem		
Total vehicles	**437**	**434**	**871**	**317915**

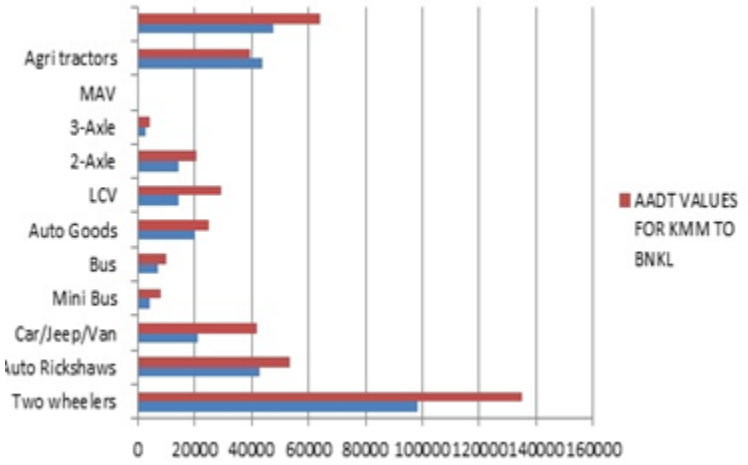

Figure 1:AADT observed on both sections

VII. ACCIDENT DATA COLLECTION AND ANALYSIS FOR THE STUDY SECTION

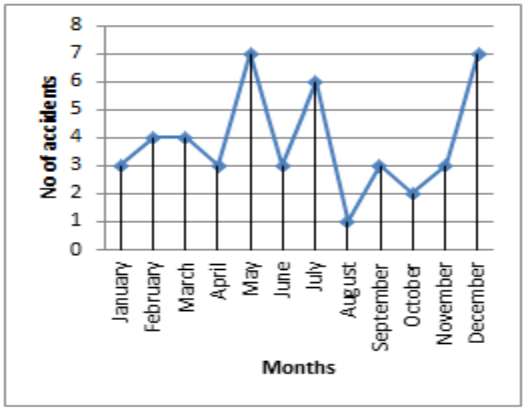

Figure 2:Number of road accidents study section 1 for the year 2012

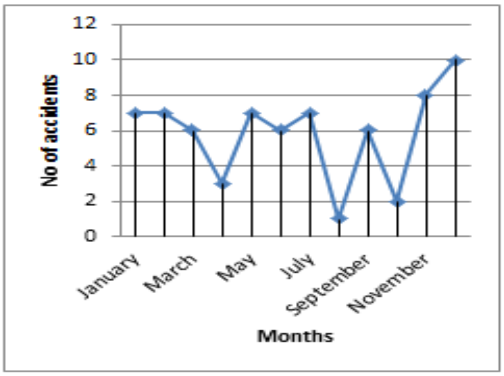

Figure3: Number of road accidents of study section 2 for the year 2012

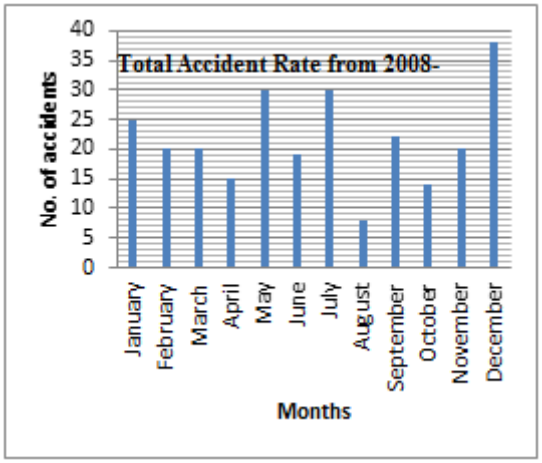

Figure 4:Accident data analysis evaluated by considering the five years in section 1

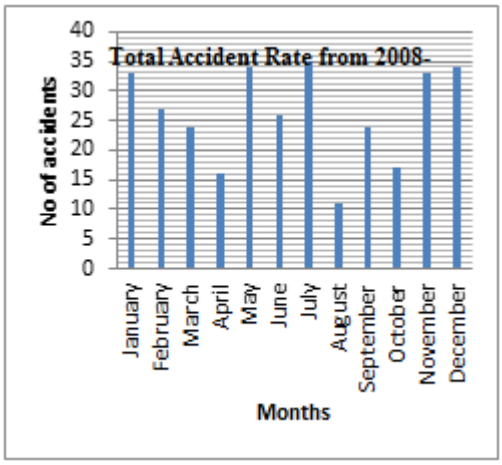

Figure5: Accident data analysis evaluated by considering the five years in Section 2

The road accident data pertaining to project stretch from Khammam to Bonakal and Nayakangudem to Vallapuram during the last five years (2008-2012). These data were collected from local Police Stations, and several police stations were approached, under the jurisdiction of which the total project road stretch falls. These data consist of year wise number of fatal accidents and non-fatal accidents occurred under the jurisdictions of different police stations. These data would be used to identify accident-prone spots along the project stretch, as far as possible depending on possibility of identification of the locations, and to propose traffic control measures or improvement in the alignment to reduce the safety hazards associated with such locations and quality of the material.

Motorized vehicles accounted for 92.4 per cent of the total road accidents in the year 2011. Amongst the vehicle categories, two-wheelers accounted for the highest share in total road accidents (23.7 per cent), followed by trucks, tempos, tractors and other articulated vehicles 22.4 per cent), cars, jeeps and taxis (21.3 per cent), other motor vehicles (9.4 per cent), buses (8.7 per cent) and auto rickshaws (6.9 per cent) in 2011. The category of 'trucks, tempos, tractors and other articulated vehicles' accounted for the highest proportion of fatalities (27.4 per cent of the persons killed).

A. .Average daily traffic (ADT)

To determine the relative weights of the parameters opinion from eight experts were collected. They were explained about the background, objectives and methodology of the study and then were asked to rate the parameters according to their importance in a scale ranging between 1 and 5, where 1 represented not at all important and 5 extremely important. The responses of the experts are shown in Table VIII.

TABLE VIII.Responses From Experts On The Weight On The Selected Parameters.

	Importance Score							
Road geometric characteristics (RGC)	4	5	4	4	4	4	5	4
Width and Quality of Shoulder (WQS)	4	4	4	4	4	5	4	4
Mode of Transport of the user (MT)	3	2	3	2	3	3	2	2
Accidents Rate (AR)	2	3	2	2	2	3	2	2
Traffic volume and mix encountered during travel (TV)	3	4	3	3	4	3	4	3

TABLE IX. Scores On The Width And Quality Of Shoulder Provided

Shoulder Characteristics	**Score**
No proper shoulder	5
Inadequate shoulder	4
Shoulder with level difference with the carriageway	3
Shoulder not properly maintained	2
Proper shoulder	1

Provision of proper shoulder is very important, especially for one-lane roads. Besides providing lateral support to the pavement, it helps pedestrians and cyclists to travel on it and also the space is being used for overtaking and crossing operations of vehicles. Proper shoulders are sometimes not provided, and when provided, they are very often inadequate and not maintained properly. In some cases it has also been observed that the farmers encroach upon the shoulder thereby reducing the width causing structural danger for the pavement and also inconvenience for the traffic. In the absence of proper maintenance over a period of time a difference in level is created between the pavement surface and the shoulder, which is very dangerous especially for pedestrians and cyclists. Keeping the above facts in view, scores have been assigned on width and quality of shoulder.

B. Comparative Study

The objective of the rural road is to provide connectivity to unconnected villages by constructing road to the nearest connected village or to the nearest all-weather road and thus in most of the cases the length of the rural road is not very high. It has been presumed that the possibility of exposure to accidents is higher when the public need to travel longer distances.

The accident statistics in developing countries show that the pedestrians and cyclists are the most vulnerable road users and thus the scores on the modes of travel have been assigned accordingly.

TABLE X.Traffic Volume

Study sections		Remarks
Khammam-Bonakal	Nayakangudem-Vallapuram	
431065	317915	AADT of Nayakangudem-Vallapuram section is less than Khammam-Bonakal section, because the less AADT section is not connected with district headquarters.

TABLE XI. Accident Analysis

Study sections		Remarks
Khammam-Bonakal	Nayakangudem-Vallapuram	
261	314	By comparing both the study sections the accident rate is more in Nayakangudem-Vallapuram section due to absence of road markings & sign boards, driver faults, vehicle condition, over speed, pavement condition including shoulder & improper pavement surface.

TABLE XII.Accident Analysis

Geometric Characteristics	Study sections		Remarks
	Khammam-Bonakal	Nayakangudem-Vallapuram	
Number of sharp curves with shoulder and markings	Poor	Very Poor	Sharp curves with shoulders and markings are more in Nayakangudem-Vallapuram section
Moderately straight level road	Poor	Poor	Most of the locations in Nayakangudem –Vallapuram section the level difference is 50mm-150mm & in Bonakal section 50mm-75mm.
Camber	Good	Poor	Inadequate camber is provided in most of the locations in Nayakangudem section
Visibility obstructions	Good	Poor	In both the study sections by comparing the visibility obstructions Nayakangudem has more visibility obstructions.

TABLE XIII.Scores On Mode Of Transport Used For Traveling To School

Mode of Transport	**Score**
Walk	5
Bicycle	4
Motorized two-wheeler	3
Animal drawn vehicles	2
School Bus	1

It is difficult for the pedestrians and cyclists to travel safely in the presence of motorized vehicles, especially in the absence of proper shoulders.

VIII. CONCLUSION

Since most of the low-volume rural roads have only single-lane carriageway, the need for adequate roadside shoulders is much more critical than for multi-lane highways. The more important functions performed by roadside shoulders on rural roads are.

- To lend structural support to various pavement layers
- To provide space for pedestrians and slow-moving vehicles like animal drawn carts, bicycles etc. and for stalled vehicles
- To help drain out the surface water from the pavement to side ditches/ drains
- To provide space for bus stops
- To improve sight distance in cut sections
- To help in reducing severity of accidents
- To provide adequately proper shoulders on rural roads.
- By including, such shoulders wherever possible in new construction, reconstruction, and overlay projects.
- By independently adding unpaved shoulders to existing roadways where sufficient need has been identified
- By adopting design, standards for rural roads that include reasonably wide and smoothly paved shoulders.
- When shoulders cannot be provided immediately, by locating utilities and drainage structures far enough from the roadway to allow for eventual paving

The above requirements, however, are neglected on a bulk of the rural road network in India; on several rural roads, there are no shoulders at all. The more important aspects of providing adequate roadside shoulders are discussed in the subsequent paragraphs. The shoulder width variable was shown to have a significant influence on crashes, a consistent result for all road classes and crash severity types. The negative sign of the coefficient suggests that for rural two-lane roads, increasing shoulder width is associated with decreasing in number of crashes, all other factors remaining the same. This result is expected and can be explained by the fact that for rural two-lane roads, wider shoulders enhance safety by providing additional buffer zone where operators of stray vehicles can regain control, recover from error and resume normal travel. The model results also suggest that the impact of increasing shoulder width is greater for injury crash frequency compared to non-injury crash frequency

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