USE OF LOCAL MATERIALS IN REDUCING ACCIDENTS

Sunil POUDYAL
Engineer
Traffic Engineering and Safety Unit,
Department of Roads,
Babarmahal, Kathmandu,
Nepal.
Fax: +977-1-262993
E-mail: poudyal@ntc.net.np

Abstract: In the developing countries of eastern Asia, the long distance traffic is composed mostly of buses and trucks. The vehicles are over-worked and are not well maintained. The drivers tend to drive faster oblivious to the road geometry. The warning signs are either not installed or are illegible. All these factors add up to soar the rate of highway accidents.

A lot of these accidents may be prevented if safety barriers could be laid along the known accident black-spots. Experiments in Nepal have shown that a series of stone filled wire cages (SFWC) could serve as a good safety barrier. The technology is simple and the required materials are easily available. Being plastic in nature, the barrier can absorb the kinetic energy of the colliding vehicle without causing much damage to the vehicle itself and its occupants. The present paper discusses some case studies on the application of SFWC.

Key words: low cost, local material, hilly road, safety barrier

1. BACKGROUND INFORMATION

Every year about 600 people lose their life in road traffic accidents in Nepal. Though, with a daily vehicle kilometer of about $20x10^6$ road accidents per vehicle kilometer is relatively low, the accident per vehicle ratio and the accident per kilometers of road length is among the highest in the world. The losses due to road accidents have been estimated to be about US $ 12.5 million in year 2002.

As evident from Figure 1, trucks are the most numerous vehicle type followed by buses on the highways. The corresponding vehicle-kilometers and number of accidents for trucks too are the highest.

The highways on the hills have deep valley on one side. On the plain area, the height of road embankment is kept high as a safeguard against flooding. In both the cases, it is dangerous when a vehicle veers off the roadway and there is nothing to contain it.

2. STUDY AREA

The following four accident clusters along Prithivi Highway (H04) are considered here:

- Khahare Khola (chainage 12+000 to 12+500)
- Gardo Khola (chainage 23+000 to 23+500)
- Bishaltar bend (chainage 52+500 to 53+000)
- Jyamire bend (chainage 59+500 to 60+000)

H04 is a double-lane hill road with hard shoulder. The drivers mistakenly consider it for a high-speed road, which is not the case. At each of these locations a narrow bridge surprises the drivers just after a sharp curve, after driving for a considerable length along a wide and straight stretch. Moreover at Gardo Khola, squatters have settled too close to the carriageway. This has made the location a likely spot for pedestrian accidents. At other three locations, there are big drops on the valley side just after the road.

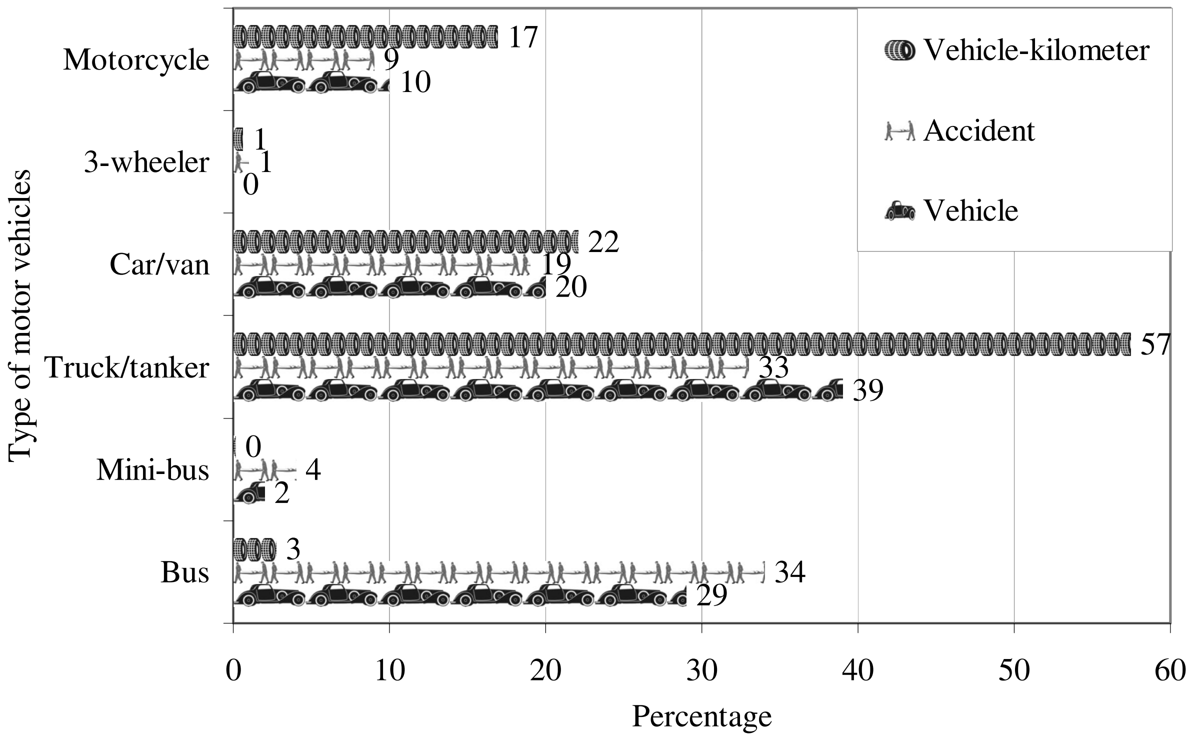

Figure 1. Composition of Vehicles, casualty accidents and vehicle-kilometers

3. TRAFFIC COMPOSITION

The average annual daily traffic on the road is around 2500. A one-day traffic count in November 2002 gave the following vehicle composition:

- Bus 22 %
- Minibus 03 %
- Truck 46 %
- Car, Jeep, Van 15 %
- Bicycle 02 %
- Motorcycle, 3-wheeler 12 %

4. REMEDIAL MEASURE

Several preventive measures have been tried at the accident locations. The most important of which is a barrier made out of stone filled wire cages (SFWC). Sometimes, retro-reflective chevron warning signs are also added.

Each of the wire cages is 1 m high, 1 m wide and 2 m long in size. They are made out of hexagonal mesh of mild steel galvanized wires of different diameters: 2.7 mm for mesh, 3.5 mm for edging and 2.0 mm for tying the cages together.

To construct a SFWC barrier, firstly a wire cage is placed on the extended shoulder of road embankment and is filled with stone blocks in a manner as in construction of dry-stone wall. The box is then sewn closed. Next, another cage is placed adjacent to the first one and is similarly filled and sewn. In this way, a long wall is made. Experience has proved that the total length of a barrier thus made should not be less than 8 m as shown on Figure 2.

In Nepal, SFWC type of barrier costs about US $ 20 per meter length. A steel beam barrier would cost twice as much. Moreover, only skilled workers with simple hand tools suffice for the construction and maintenance of the barrier.

Figure 2. Use of SFWC barrier on high embankment

5. EVALUATION METHOD

After erection of SFWC barrier along the black spots, the accidents have been found to fall well below the expected number. The theoretical verification comprises of an analysis of the change in the number of reported casualty accidents relative to what could be expected.

The following simple relation is used to determine the reduction in accident:

$$\text{accident reduction} = \frac{(\text{sum expected - sum actual})}{\text{sum expected}} \times 100 \quad \text{...} \quad (1)$$

Where,

sum expected = expected number of accidents in the period after scheme completion

$$= \begin{pmatrix}\text{number of accidents at the} \\ \text{cluster before improvement}\end{pmatrix} \times \frac{\begin{pmatrix}\text{number of accidents along the} \\ \text{road section after improvement}\end{pmatrix}}{\begin{pmatrix}\text{number of accidents along the} \\ \text{road section before improvement}\end{pmatrix}} \quad ...(2)$$

And,
sum actual = number of accidents in the accident cluster after the improvement .... (3)

For a statistical evaluation of the safety performance, Chi square test is conducted. To take account of any extraneous factors that may have influenced the accident situation, accident data before and after the erection of the SFWC barrier at the four sites are compared with the corresponding data for a control area, comprising of a 10 km long road stretch on either side of the accident cluster.

The appropriate equation for Chi square test will be:

$$\chi^2 = \frac{\left(|ad - bc| - \frac{n}{2}\right)^2 \times n}{efgh} \quad \text{..........} \quad (4)$$

Where,
a = accident in the cluster before treatment
b = accident in th e cluster after treatment
c = accident within the control road length before treatment
d = accident within the control road length after treatment
e = total accidents in the cluster before and after treatment
f = total accidents within the control road length before and after treatment
g = total accidents in the cluster and within the control road length before treatment
h = total accidents in the cluster and within the control road length after treatment
n = total accidents in the cluster and within the co ntrol road length before and after treatment

The corresponding probability of accident to the derived Chi squared value is then used for the economic analysis. The following method of First Year Rate of Return (FYRR) is widely used for this purpose:

$$\text{FYRR}\ \% = \frac{\text{accident savings}}{\text{capital costs}} \times 100 \quad \text{..........} \quad (5)$$

6. EVALUATION RESULT

The computerized recording of the accidents along this highway section started from September 1995. Hence only the last seven year's accident data can be used for the analysis.

The relevant data are presented in Table 1, 2, 3 and 4. To exclude the effect of environmental factors, the control data for each site exclude the site accident data. On the tables, D stands for damage only accident, M for minor, F for fatal, S for serious, R for rollover, B for hitting object on road edge, P for hitting pedestrian and H for head -on collision.

7. CONCLUSION

In all the four case studies, erection of SFWC type of safety barrier is found to give a FYRR greater 100 percent. Moreover, statistical analyses show that the probability of accident reduction stays higher than 80 percent.

Hence, SFWC type of barrier is found to be very effective and economical in reducing road accidents on hilly roads.

Table 1. Analysis of Khahare Khola cluster

	Before		After			
Year	94	95	95	96	98	02
Month	9	2	12	7	6	5
Hour of day	16	21	12	13	8	17
Severity of accident	M	F	M	S	M	M
Type of accident	R	R	R	H	P	R
Number of months	6		86			
Number of accidents on cluster	2		4			
Number of accidents on control road	52		506			
Expected number of accidents	19					
Reduction in accident (%)	79					
Capital cost of improvement (US$)	650.00					
Saving by accident reduction (US$)	933.50					
FYRR %	144					
Chi square value (X^2)	1.667					
Probability of accident reduction (%)	80.0					

Table 2. Analysis of Gardo Khola cluster

	Before							After			
Year	94	94	94	95	95	95	95	95	00	02	02
Month	9	10	10	2	3	4	5	6	7	5	10
Hour of day	12	12	2	4	12	19	4	15	17	14	16
Severity of accident	D	S	M	M	F	M	F	F	S	M	M
Type of accident	H	P	R	R	P	H	R	P	R	P	R
Number of months	9							92			
Number of accidents on cluster	7							4			
Number of accidents on control road	78							321			
Expected number of accidents	29										
Reduction in accident (%)	86										
Capital cost of improvement (US$)	600.00										
Saving by accident reduction (US$)	3541.47										
FYRR %	590										
Chi square value (X^2)	10.121										
Probability of accident reduction (%)	99.9										

Table 3. Analysis of Bishaltar cluster

	Before				After		
Year	95	95	95	95	96	98	00
Month	2	2	2	7	3	4	3
Hour of day	20	10	23	9	23	9	21
Severity of accident	S	M	D	F	D	F	M
Type of accident	R	H	R	H	R	H	H
Number of months	9				86		
Number of accidents on cluster	4				3		
Number of accidents on control road	158				1015		
Expected number of accidents	26						
Reduction in accident (%)	88						
Capital cost of improvement (US$)	1150.00						
Saving by accident reduction (US$)	2075.64						
FYRR %	180						
Chi square value (X^2)	7.822						
Probability of accident reduction (%)	99.5						

Table 4. Analysis of Jyamire cluster

	Before					After		
Year	94	95	95	95	95	97	99	00
Month	10	8	8	8	10	11	9	8
Hour of day	9	12	19	9	?	1	9	?
Severity of accident	F	S	M	M	M	F	S	D
Type of accident	R	B	R	H	R	R	H	P
Number of months	13					63		
Number of accidents on cluster	5					3		
Number of accidents on control road	164					725		
Expected number of accidents	22							
Reduction in accident (%)	86							
Capital cost of improvement (US$)	1355.00							
Saving by accident reduction (US$)	2538.81							
FYRR %	187							
Chi square value (X^2)	7.388							
Probability of accident reduction (%)	99							

REFERENCES

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