His Majesty's Government of Nepal

Road Safety Notes 5

Delineation Measures

Traffic Engineering and Safety Unit
Design Branch, Department of Roads
Ministry of Works and transport

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ROAD SAFETY NOTES

Road Safety Notes are produced by the Traffic Engineering and Safety Unit of the Department of Roads as a means of Increasing road safety awareness amongst highway engineers and others. Some of the Notes provide Information on aspects of the road accident ' situation Nepal, whilst others give detailed technical advice on highway safety measures. The Traffic Engineering and Safety Unit was set up In Balsakh 2052 to provide a road safety and traffic engineering service, and Is based In the Design Branch of the Department of Roads at Babarmahal, Kathmandu. The Unit Head (telephone/fax 262 843, e-mail: tesu@dor-mos.com.np) will be pleased to receive comments and suggestions which will help Improve the Road Safety Notes.

CONTENTS

DELINEATION

Introduction

In a broad sense "delineation" stands for any device or treatment whose aim is to outline the road. Delineating devices give the driver visual clues as to where the road is going. Many studies have shown that they can have great safety benefits.

Importance of delineation
Delineation is always helpful, but it is particularly important at bends. Road accident records have shown that more accidents happen on bends than on straight sections.

Good delineation of a road serves the following purposes:

- it shows the safe limits of the road,
- it helps drivers to control approach speed on bends,
- it improves lane discipline-,-..
- it aids in identifying potentially hazardous situations such as sharp bends and obstacles, and
- it helps to prevent crumbling of road edge and deterioration of shoulders.

Delineating devices will not make our roads completely safe. Nevertheless, studies elsewhere show that an intelligent mix of some of the delineating devices can reduce accidents by as much as 60 percent.

Types of delineating devices
In some respect delineators do warn of an impending hazard situation. In strict sense, however, only road indicators can be considered as delineating devices. Hence, only the following are discussed here:

- Centre and edge lines
- Post delineators
- Confidence blocks
- Earth-filled bitumen drums
- Chevron signs
- Reflective studs

Supply and installation costs in Nepalese Rupees are given in the subsequent chapters to aid cost comparison of various delineation devices. However as the costs vary widely from place to place, a detailed cost analysis is to be done before commencing any installation work.

OVERVIEW OF PRESENT PRACTICE

Some of the delineating devices, for example the centre line, edge line, post delineator, earth-filled bitumen drum and confidence blocks have already been in use in Nepal for a long time. However due to the lack of a guideline, their use has not been consistent throughout the country.

Centre and edge lines
Except on single and intermediate lane roads as per NRS-2045, white centre and lane lines are found to be widely used. Yellow edge lines have been introduced a few years ago on roads with shoulders.

The usual practice has been to apply a single coat of paint, once or twice a year, or as permitted by the allotted budget. The total cost of application at present is about Rs 200 per sq. m.

Post Delineator

DOR has standardised post delineators in 1978 (DWG. NO. DSS 006-2/2, Department of Roads Standard Designs, Design Branch, January 1978). These are prismatic concrete posts painted with black and white strips. However they are found to be constructed in many shapes and sizes.

Although relatively effective and economic elsewhere, they have not got deserved consideration in Nepal. Post delineators have been found to be used along curves, high embankments and floodways. They cost about Rs 600 per piece at present.

Fig. 1: Post delineators

Confidence blocks (masonry parapet)

Standard designs for stone masonry confidence blocks and concrete (drum) blocks were introduced in 1978 (DWG. NO. DSS 010, Department of Roads Standard Designs, Design Branch, January 1978) but different shapes and sizes are found in practice. They tend to be used as delineator-cum-safety barrier. However, experience has shown that stone masonry confidence blocks are not effective as safety barriers. They look solid, but they shear easily when hit, so they may be giving drivers a false sense of security. Painting them white helps make them more visible, but, being low, they get dirty quickly, and so they are not easily seen at night.

Fig. 2: Confidence blocks of stone masonry

Fig. 3: Confidence blocks of concrete (drum)

The cost of typical masonry and concrete (drum) confidence blocks without foundation is about Rs 750 and Rs 300 per piece respectively.

Confidence blocks of stone-filled gabion crates have been used for the first time in Lamosangu-Jiri road, and on many other roads thereafter. They may serve as a delineating device during day time in a limited way. However without reflectors, they are not prominently visible during nights. Per cubic metre cost of stone-filled gabion crates is about Rs 1000 at present.

Earth-filled bitumen drums

During the past, especially along roads constructed with Indian aid, earth-filled and white-painted bitumen drums have been used as delineators. They are too low to be clearly visible and the white paint quickly gets dirty. However, they are better than nothing when the funds available are insufficient. One drum will cost around RS 200.

Figure 4: Earth-filled bitumen drum as delineating device

RECOMMENDED DELINEATING DEVICES

Centre and Edge Lines

Centre and lane lines have long been considered a standard form of road delineation and should be standard on all multi-lane roads, as defined by NRS-2045. They assist the driver to locate the vehicle laterally on the roadway, and thus help in avoiding collision.

Edge lines help the drivers to be aware of the pavement edges and affect the position of vehicles in a lane. By reducing the incidence of vehicles leaving the road, the edge lines also help to prevent crumbling of road edge.

Standard to be adopted

Except for single and intermediate lane roads, as defined by NRS-2045, all the other roads shall be provided with white centre lines or lane lines. These lines shall normally be a broken line. A continuous centre line indicates that overtaking is prohibited.

Edge lines shall be yellow in colour. These lines too are normally broken lines. However they shall be continuous at hazardous locations, such as along sharp bends, bridges and bridge approaches - parking is prohibited on these sections. Edge lines shall be applied at 100 min from the edge of the pavement.

The dimensions for centre lines, lane lines, and edge lines are given in Table I below. These are provisional, and the reader is referred to the Traffic Signs Manual-2054 (to be published) for the approved dimensions.

Type of marking	Site	Length (mm)	Gap (mm)	Width (mm)	Spacing of studs if used (mm)	Use
Centre lines (white) Lanes (white)						Division of carriageway into traffic lanes
Permissive line	Urban	1500	4500	100	12000	
	Rural	2000	7000	100	18000	
Warning line	Urban	4000	2000	100	6000	Hazard ahead
	Rural	6000	3000	100	9000	Hazard ahead
Centre line(white)						
Prohibitory line	Urban	unbroken		100	4000	Overtaking prohibited
	Rural	unbroken		150	6000	Overtaking prohibited
Edge lines(yellow)						Delineation of edge of carriageway
Permissive line	Rural	1000	2000	150		
Prohibitory line	Both	unbroken		150		Parking prohibited

Table 1: Summary of centre, lane and edge lines

Materials

The present practice of using solvent-borne road paint is likely to be continued in the future too. Hot-applied thermoplastics gives a much more durable marking. However, they cost about six times more than the solvent-borne road paint.

Painting requirements and maintenance

Road paints are applied at ambient temperatures and thermoplastics are applied at elevated temperatures. The road surface to be painted should be dust free and dry. The application and re-application of paints and thermoplastics should be carried out during the dry months.

Centre and edge lines are not useful when they are not clearly visible to the driver. Therefore the lines, especially the edge lines, should be swept clean on a regular basis.

Normally, for road paints the re-application cycle as presented in Table 2 is considered to suffice for our roads. Some countries report that thermoplastic markings last from 6 to 9 years, but they are unlikely to have such a long life here in Nepal. Glass beads (Ballotini) can be added to both paint and thermoplastic to make the markings reflective at night, but the quality and durability of the reflectiveness is not very good.

Road Category	Re-application Cycle(Year)
Single lane roads	1.25
Intermediate lane roads	1.25
Two lane rural roads	1.00
Urban roads	0.50

Table 2: Proposed re-application cycle for road paints

Post Delineator

As the posts stand out prominently, they provide very good delineation even when the road is impounded with flood. The posts enable the driver to plan forward route, and thus need to be consistent.

The addition of a small reflector would make the delineator much more visible at night when good delineation is especially important. The additional cost would only be about Rs 100.

Standard to be adopted

The length of the concrete posts to be used as post delineator should be 1500 mm or more, so that 1000 mm should be above road level after erection. No concrete foundation block shall be used for erection of a post delineator.

Post delineators are especially desirable in the following situations:

- on both sides along horizontal curves
- along summit curves when the sight distance is inadequate
- on straight sections where the visibility is poor due to climatic conditions
- along temporary road diversions
- along floodways
- at the approaches to important intersections
- valley side of hill roads
- road embankments exceeding 3m,
- where the road narrows suddenly, for example, on the approaches to a narrow bridge.

The use of post delineator is recommended to be limited to suburban and rural areas.

On the delineator posts with reflective plates, the red reflectors shall face the oncoming traffic on the same lane and the white- reflectors shall faces the oncoming traffic on the opposite lane. Experiments are underway to find a cheap, effective, vandal-proof reflector. The use of recessed galvanised iron plates is currently favoured. These are fixed into the post during casting. Adhesive-backed retro-reflective sheeting (3M's Scotchlite or similar) is applied to the plate once the concrete has cured.

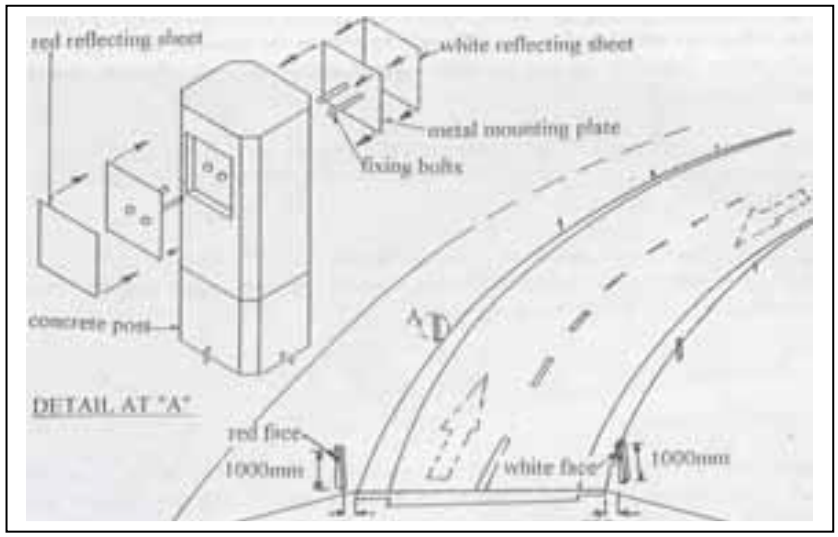

Figure 5: Post delineator and its installation

Post delineators are erected at 600 mm from the outer edge of the shoulder. On hill roads along the stretches with big drops the defineators may be placed on the top of the retaining walls. Post delineators are redundant when crash barriers are provided. They may, however, be used in combination with chevron signs.

Refer to DWG. NO. 006-2/2 of DOR-Standard Designs-1978, for the recommended spacing of post delineators on horizontal curves. -For curves with a radius of less than 100 muse the spacing given in table 3 below.

Radius of horizontal curve (m)	**Spacing of post delineator (m)**
<30.0	3.0
30.0	5.0
50.0	8.0

Table 3: Spacing of post delineators along small-radius curves

Further, on vertical curves the spacing of the post delineators is in between 30 to 50m. At high embankments exceeding 3m, other big drops, and causeways 2 to 3m spacing may be required.

An important thing is that the driver should always be able to see at least 3 posts at a time. And every alternate posts should be mounted with reflectors.

Maintenance and Up-keeping

Post delineators once installed should be able to provide the intended visual information to the driver. Therefore any dust accumulating on it, especially on its reflectors, should be regularly wiped off.

Repainting should be done on a regular basis giving due consideration to the life expectancy of the paint applied on them. Painters must be instructed not to paint over the reflectors while repainting.

As reflectors form a vital part of the posts, any lost reflector should be promptly replaced. Similarly, broken or missing posts need to be replaced quickly because a gap in a series of post delineators can be misleading.

Chevron Signs

Delineation is critical on horizontal curves, especially on isolated curves with a radius less than 600m. As chevrons provide much greater visual impact, they are found to give a better long range information on such curves.

Two type of chevron signs are recommended to be used in our context: signs with a set of three chevrons and signs with a single chevron. The sign with three chevrons furnish more visual impact and are suitable for very tight curves. The single chevron boards, however, provide 'dynamic' visual information to the driver as they negotiate curves of larger radius.

At present the sign with three chevrons and the one with single chevron cost about Rs 6500 and Rs 2500 respectively, if locally manufactured. Imported higher-quality signs will cost more than double the amount.

Standard to be adopted

It has been found that post mounted chevrons are required when the difference between the approach speed (the speed used by 85% of the vehicles) and design speed (safe speed to negotiate the curve) is of about 20 km/h.

The use of chevrons shall be limited to suburban and rural areas. And similar to the delineator posts, the chevron signs are erected in such a way that no part of the sign is within 500 mm. of the outer edge of the shoulder (or the edge of the carriageway in the case of roads with no shoulders). Care must be taken to ensure that the signs cannot be seen by the drivers travelling in the opposite direction.

All chevron signs shall be white on black background. The chevrons are made out of retro-reflective sheet (such as Scotchlitel of 3M). The background is simply painted with enamel. The Traffic Sign Manual-2054 (to be published) shall be referred for other construction details.

Studies have shown that the curve characteristics of direction and curvature may need to be assessed up to 9 seconds ahead and even detailed tracking data for actual curve negotiation may be required 3 seconds ahead of the curve. Thus the signs should be installed in such a way that, the driver receives the necessary visual information in time. Therefore, installation of chevron should not be considered as a replacement for the necessary warning sign to be installed some length before the curve.

Figure 6: The sign with three chevrons

Chevron signs provide a much better visual impact than post delineators. However, the chevrons are many times costlier. Therefore for the time being, their use may have to be limited to sites where loss-of-control accidents are common.

The sign with three chevrons are installed on sharp curves. The sign shall be installed at the crown of the curve or at the location from where a sudden change in direction begins. The rest of the curve shall be provided with post delineators. The sign can also be used to indicate temporary diversions at roadwork sites - in which case it should have yellow chevrons on a black background.

Figure 7: Single chevron sign

Single chevron signs are installed along flatter curves. The spacing of the chevrons signs shall be as shown in table 4.

Radius of Horizontal curve(m)	Spacing of Single chevron sings (m)	
	Approach speed <80kph	Approach speed 80kph
<30.00	5.0	-
30.00	8.0	4.0
50.00	10.00	6.0
100.00	16.0	10.0
200.00	28.0	18.0
300.00	40.0	26.0
400.00	52.0	34.0
500.00	64.0	42.0
600.00	76.0	50.0

Table 4: Spacing of single chevron signs along horizontal curves

Maintenance and Up-keeping

The chevron signs are effective at night only when they are retro-reflective. The reflective performance of the sheeting deteriorates over time. The retro-reflective sheets should be replaced, considering their life expectancy, as recommended by the manufacturer. Generally, the useful life of engineering grade retro-reflective sheet is about 5 years. Pains Mould be taken to motivate the local people to safeguard the signs. They should be convinced that by sticking banners on the signs or damaging them they would be risking their own lives as well as the lives of the traveller.

Reflective Road Studs

Neither road paints nor thermoplastics produce a marking which is very visible at night, even when glass beads (Ballotini) have been used. Markings are particularly difficult to see at night when it is raining. This has led many countries to install retro-reflective road studs on the centre line, which reflect the head light beam back to the driver.

Two types of retro-reflectors are presently available in the market: corner-cube and biconvex. The first one is much more effective than the latter.

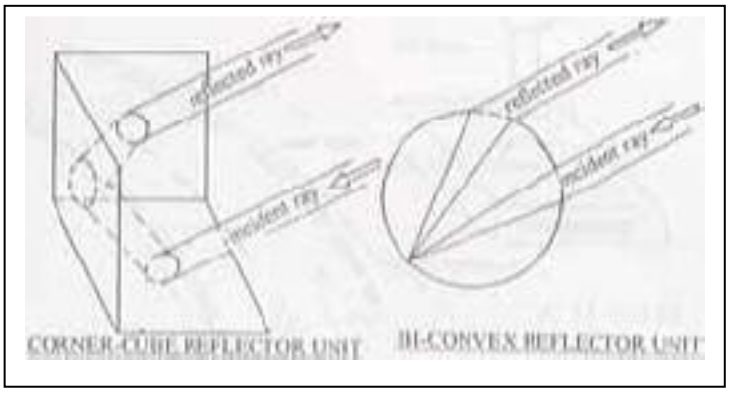

Figure 6: Principle of retro-reflection

The studs may have one reflecting surface (uni-directional) or two (bi-directional), with each reflecting surface fitted either with a corner-cube reflecting plate or with groups of bi-convex reflecting beads.

Reflective studs provide better night time delineation than painted centre lines and edge lines, especially under adverse weather condition. It is also useful in reducing encroachment across the centre line at narrow bridges. A 33 percent reduction of accidents has been reported following the installation of these delineating devices.

Raised reflective studs present a retro-reflective face to the oncoming traffic. These devices are attached along the centre and edge lines to make the lines more visible especially during night time. Recently some bi-convex type studs has been fitted on the road section in front of Babarmahal. Due to the frequent driving of the vehicles over them some of the studs have already been depressed into the road surface. However the remaining of the studs are functioning well.

Standard to be adopted

The studs should be about 25 mm thick and withstand a minimum of 200 kN of compressive force. One reflecting surface of the comer-cube type of reflector should have at least 2000 mm2 reflective area. When fitted with bi-convex retro-reflective beads, their number on the reflective surface should be at least 18. Refer to the Traffic Signs Manual2054 (to be published) for photometric requirements and other details. Recommended spacings are given in table 1.

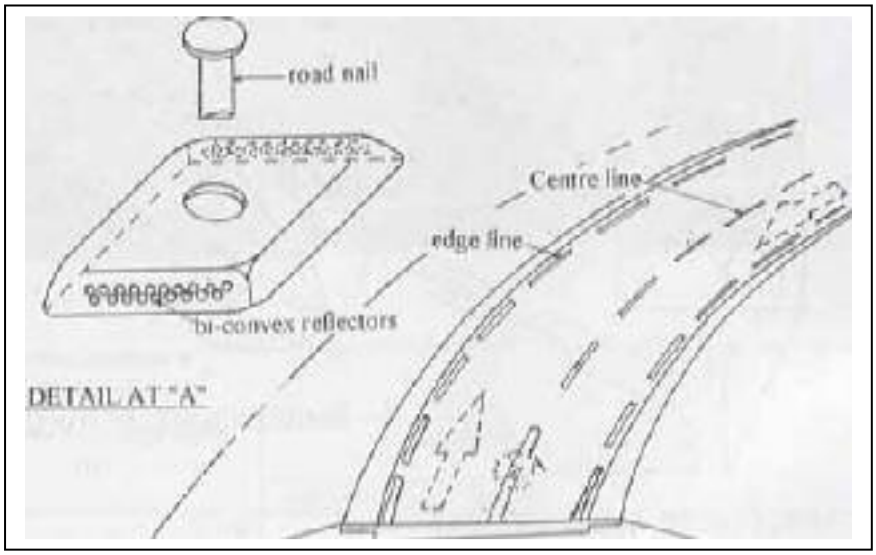

Figure 7: Typical bi-directional retro-reflective road stud and its use

Road studs are rather expensive. A bi-convex type stud would cost about Rs 700 including installation at present. Therefore for the time being they are proposed to be used only along special situation where night-time delineation is important. Installation of road studs on asphalt shall be done by either of the following methods:

- bituminous or epoxy adhesive, or
- heavy duty road nail plus epoxy adhesive.

Same method of installation, but taking extra care to ensure good bond, may be followed for surface dressed roads

Installation and Reinstallation Requirements

When the road surface is wet at the time of installation, the bonding may be adversely affected. Therefore installation of the studs is proposed to be carried out during dry months.

The life expectancy of road studs on asphalt concrete is generally taken as 5 years. Additionally, driver behaviour and cleanliness of the road surface also affects their usefulness considerably. For example, if the studs are frequently run over by heavy vehicles the reflectors may get scratched. Similarly when dirt accumulates on the reflectors, they can not reflect enough light. Thus the reflectors should be brushed and cleaned at a regular interval.

COMBINATION OF DELINEATING DEVICES

For an effective delineation, the driver should be supplied with enough visual information. As each of the delineating devices possess some unique advantages, a careful mix should be designed.

Consistency is very important for the installation of delineating devices. And any broken or missing device must be, replaced promptly. For example, if post delineators are provided along a 50m radius curve on a road, all the similar curves on this road should also be equipped with post delineators Absence of the delineation device on similar locations may cause accidents, and may further lead to disbelief in the delineation system..

Any overuse of delineating devices, alone or in combination with other traffic signs, confuses drivers. And the devices may lose their ability to gain due attention. It is not only uneconomic, but may also lead to hazardous situations.

The delineating devices should be in harmony with other road furniture such as: safety barriers, confidence blocks, traffic signs and signals. They should be according to the same standard and augment each others' intended roles.

SUMMARY OF RECOMMENDED USE

For quick reference, a summary of the recommended use of various delineating devices is presented in table 5.

Delineating device	Recommended location
Centre and lane lines	5.5 m wide or wider metalled roads
Edge lines	metalled National highways with shoulders
Post delineator (each alternate one with reflectors)	horizontal and summit curves, valley side of hill roads, poor visibility due to climate and physical obstructions, temporary diversions, floodways, approaches to intersections, big drops
Sign with three chevrons	on crown of sharp curves (or at the point from where an abrupt change in direction starts) at very hazardous and known accident sites, temporary diversions
Single chevron sign	very hazardous and known accident sites along flatter curves
Reflective studs	on centre lines along stretches with night time accident record

Table 5: Summary of recommended use of delineating devices

Earth-filled bitumen drums should only be used where there are, insufficient funds to install post delineators with reflectors.

Confidence blocks are not recommended. A proper safety barrier (see forthcoming Road Safety Note on Safety Barriers) should be installed. Where the volume of traffic does not warrant the provision of safety barrier, post delineators with reflectors will generally provide better delineation than confidence blocks.