Practical guide

Signing bends
Traffic signing
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- help with the asset management;
- define, apply and evaluate the public policies;
- guarantee the coherence of the road network and state of the art;
- put forward the public interests, in particular within the framework of European standardization;
- bring an expertise on complex projects.

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- fosters the exchanges of experience;
- evaluates technical progress and the scientific results;
- develops knowledge and good practices through technical guides, softwares;
- contributes to the training and information of the technical community.

The Sétra, a work in partnership

- The Sétra associates all the players of the French road community to its action: operational services; research organizations; Scientific and Technical Network (Réseau Scientifique et Technique de l'Équipement – RST), in particular the Public Works Regional Engineering Offices (Centres d'Études Techniques de l'Équipement – CETE), companies and professional organizations; motorway concessionary operators; other organizations such as French Rail Network Company (Réseau Ferré de France – RFF) and French Waterways Network (Voies Navigables de France - VNF); Departments like the department for Ecology and Sustainable Development…
- The Sétra regularly exchanges its experience and projects with its foreign counterparts, through bilateral co-operations, presentations in conferences and congresses, by welcoming delegations, through missions and expertises in other countries. It takes part in the European standardization commissions and many authorities and international working groups. The Sétra is an organization for technical approval, as an EOTA member (European Organisation for Technical Approvals).
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Introduction

This practical guide is based on the report entitled *Méthode de sélection des virages à signaler et niveau de signalisation à implanter* (Method for selecting bends to be signed and type of signing to be installed) published in May 2000 [1].

It is intended as a guide to the implementation of the method described in the report by agencies responsible for the installation of road signing.

The practical aspects of this guide are based on our initial experiments.

These show that, in order to apply the method correctly, it is necessary to have a general understanding of road signing and the criteria used to assess the safety of a particular site. These include:

- Legibility.
- Visibility.
- The factors contributing to accidents on bends.

A training module has been organised to coincide with the publication of this guide. This training is strongly recommended.

A software package is included with this guide to format the necessary data and calculate the speed differences.

L’instruction interministérielle de la signalisation routière (The inter-ministerial enquiry on road signing) [2] now takes account of the hierarchical structure used to determine the signing of bends (see the Decree dated 8 April 2002 modifying the conditions applying to the installation of road signing - NOR EQUS 0200683A).

The method described improves signing, ensures that it is applied consistently in all areas, and supports efforts currently underway to fight against the inflation of unnecessary road signs.
2 - Bends: A significant stake

Forty percent of all fatal accidents on rural roads occur on bends.

The following factors contribute to accidents on bends:

- The difference between the speed of approach and the speed in the bend.
- A progressively reducing radius of curvature.
- The legibility of the bend.
- The visibility of the bend.
- The length of the bend.
3 - Proposed method to be applied in each direction of route

- Collection of basic data.

- Automated calculation of the speed of approach and the speed in the bend.
  The difference between these two speeds is used to:
  - Select which bends to sign.
  - Determine the theoretical signing to be installed.
  - Identify those bends lying close to the boundary between two classes.

- Site visit to confirm or correct the results given by the model.

- Additional visit at night if required.

- Application of the classification upgrading and downgrading rules according to criteria of:
  - Legibility.
  - Visibility approaching the bend.
  - Visibility in the bend.
  - Reducing radius of curvature.
  - Compatibility with the previous bend.
  - Length of the bend.
  - Accident of the bend.

- Start and end kilometre mark
- Radius
- Alignment
- Gradient

- Calculation of speed differences

- Theoretical signing level

- Site survey
  - Legibility
  - Visibility
  - Reducing radius of curvature
  - Length of bend

- Number of accidents

- Confirmation or modification of the theoretical signing level
4 - Scope

This method may be applied to the following:

- An entire road section rather than a single bend (route approach).
- Major roads.
- Two-way two-lane roads, with or without overtaking gaps.

Slip roads and dual carriageway roads are excluded.

5 - Data collection

Create an EXCEL database containing the following:

- Start and end kilometre marks.
- Radius of curvature of the bend, taking the minimum radius over a distance of 10 metres.
- Length of all straight sections.
- Gradient approaching the bend (in %), negative for a descent and positive for an ascent. This data does not have a great effect on the result of the calculation. If the gradient is unknown, assume it is zero.

This data may be taken from VISAGE\(^1\) if it can be guaranteed to be reliable. The use of heavy duty measuring equipment is recommended.

\(^1\) Computer aided road management software package
6 - Automatic calculation of the speed difference

Calculating the speed in the bend

\[ V_d = \frac{102}{(1 + \frac{346}{R^{1.5}})} \]

where:

- \( V_d \) is the speed in the bend in km/h (maximum speed attained by 85% of drivers under freely flowing traffic conditions).
- \( R \) is the radius of curvature of the bend.

Calculating the approach speed

\[ V_a = \left[ (V_{d-1}^2 + 2 \times (0.8 - g \times Pe / 100) \times (\text{min} \ [\text{Aldroit, Distagglo}] - 75)) \right]^{1/2} \]

where:

- \( V_a \) is the approach speed in m/s.
- \( V_{d-1} \) is the speed in the previous bend in m/s.
- \( g \) is the acceleration due to gravity equal to 9.8 m/s².
- \( Pe \) is the gradient approaching the bend, negative for a descent and positive for an ascent (in m).
- \( \text{min} \) is the minimum of the two values.
- \( \text{Aldroit} \) is the length of the approaching straight section in metres. If Aldroit or Distagglo ≤ 75 m, then (min \( [\text{Aldroit, Distagglo}] - 75 \)) = 0, i.e. \( V_a = V_{d-1} \).
- \( \text{Distagglo} \) is the distance back to the nearest built-up area prior to the bend in metres.

The approach speed is estimated from the calculated speed in the previous bend with an acceleration of 0.8 m/s² in the straight section of up to 75 metres prior to the bend.

To convert m/s to km/h, multiply by 3.6.

To convert km/h to m/s, divide by 3.6.

The approach speed (\( V_a \)) and the speed in the bend (\( V_d \)) are limited to 102 km/h.
### 7 - Determining the classification

<table>
<thead>
<tr>
<th>Speed difference</th>
<th>Signing</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_a - V_d &lt; 8$ km/h</td>
<td>No signing required. Install a sign type A1 if the visibility approaching the bend is poor.</td>
</tr>
<tr>
<td>$8$ km/h $\leq V_a - V_d &lt; 16$ km/h</td>
<td>Posts type J1 and sign type A1 if the visibility around the bend is poor.</td>
</tr>
<tr>
<td>$16$ km/h $\leq V_a - V_d &lt; 40$ km/h</td>
<td>Sign type A1 + posts type J1 + posts type J4 with triple chevron sign.</td>
</tr>
<tr>
<td>$V_a - V_d \geq 40$ km/h</td>
<td>Sign type A1 + posts type J4 with single chevron signs along the full extent of the bend.</td>
</tr>
</tbody>
</table>
## 8 - Site visit report form

<table>
<thead>
<tr>
<th>Road:</th>
<th>Start kilometre mark</th>
<th>Radius of curvature of the bend:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Municipality:</td>
<td>End kilometre mark</td>
<td>Length of the bend:</td>
</tr>
<tr>
<td>County:</td>
<td>Direction of the bend:</td>
<td>Gradient:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Date of visit:</th>
<th>day</th>
<th>night</th>
<th>Forward</th>
<th>Backward</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reducing radius of curvature:</td>
<td>Yes</td>
<td>No</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Successive bends with R(-1) / R &gt; 1.3:</td>
<td>Yes</td>
<td>No</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Length of straight section: | |
| Va-Vd calculated by the model: | Classification: |

| Accident data over the past five years: | Personal injury accidents: | Damage accidents: |
| (in the direction concerned) | | |

<table>
<thead>
<tr>
<th>Signing</th>
<th>None</th>
<th>A1</th>
<th>J1</th>
<th>B14</th>
<th>J4 (triple chevrons)</th>
<th>J4 (single chevron)</th>
<th>Other</th>
</tr>
</thead>
</table>

| Existing: | |
| Model: | |
| Decision: | |

<table>
<thead>
<tr>
<th>Legibility of the bend:</th>
<th>Very good</th>
<th>Good</th>
<th>Poor</th>
<th>Very poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visibility approaching the bend:</td>
<td>Good</td>
<td>Average</td>
<td>Poor</td>
<td></td>
</tr>
<tr>
<td>Visibility in the bend:</td>
<td>Good</td>
<td>Average</td>
<td>Poor</td>
<td></td>
</tr>
</tbody>
</table>

| Comments: | |

| Result of the visit: | Model classification accepted | |
| Bend upgraded | |
| Bend downgraded | |

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June 2009
9 - Legibility of the bend

Can the driver assess the environment quickly and easily in order to drive appropriately?

**Very good legibility**

The driver is in no doubt that there is a bend ahead as the environment (vegetation, slopes, etc.) is consistent with the bend.

**Good legibility**

The driver is fairly sure that there is a bend ahead.

**Poor legibility**

The driver is not at all sure where the road is going.

**Very poor legibility**

The road appears to go straight ahead.

Main road

Secondary road
10 - Visibility approaching the bend

Does the driver have sufficient time to react on first seeing the bend?

**Good visibility**

The driver sees the bend sufficiently far ahead to reduce speed.

**Average visibility**

The start of the bend is visible within the necessary distance, but with no time to spare, especially if approaching at high speed.

**Poor visibility**

The start of the bend is seen too late for the driver to reduce speed under good road conditions.
11 - Visibility in the bend

More accidents tend to occur in longer bends. Is it possible to assess the length of the bend?

**Good visibility**

The driver sees the end of the bend.

**Average visibility**

The driver can only see half the bend.

**Poor visibility**

The driver can only see the start of the bend.

The road markings should be maintained in good condition.
12 - Radius of curvature

- Reducing radius of curvature

If the radius of curvature suddenly becomes smaller, the driver may make a sudden adjustment to the steering and lose control of the vehicle.

This configuration is very hazardous and the road layout should be modified.

- Ratio R(-1)/R

Are successive bends similar?

A driver exiting from one bend does not necessarily expect to enter another bend with a very much smaller radius of curvature.

GOOD: \(\frac{R(-1)}{R} < 1.3\)
BAD: \(\frac{R(-1)}{R} > 1.3\)

**NB:** \(R(-1)\): Radius of curvature of the previous bend.

\(R\): Radius of curvature of the bend under consideration.

This calculation is only performed for adjacent bends where Aldroit < 500 metres between the two bends.
13 - Classification rules

- **Bend downgraded**

  Following the site visit, the bend is less hazardous than predicted by the model:
  - Good or very good legibility.
  - Good visibility approaching the bend.
  - Good visibility in the bend.
  - The bend extends over a short distance.
  - There are many bends on the approach.

  The classification of this bend is downgraded. Its signing may be at a lower level than that demanded by the model.

- **Bend upgraded**

  Following the site visit, the bend is more hazardous than predicted by the model:
  - Poor or very poor legibility.
  - Poor visibility approaching the bend.
  - Poor visibility in the bend.
  - Reducing radius of curvature.
  - Incompatibility between two adjacent bends.
  - The bend extends over a long distance.
  - History of personal injury accidents.
  - Bend located within or just after an overtaking gap.
  - Long straight section approaching the bend (> 5 km). This long straight section may result in a lack of concentration on the part of the driver.
  - Bend located at the exit from a relatively open built-up area. In this case, the model will under-estimate the speed.

  The classification of this bend is upgraded. Its signing may be at a higher level than that demanded by the model.

**NB:** The legibility, visibility, reducing radius of curvature, and accident data should be accorded more weight when deciding whether to upgrade or downgrade a bend.

One criterion with a very low score (e.g. poor visibility in the bend) may be cancelled out by another criterion with a good score (e.g. good legibility). In this case, no modifications are required.
14 - Hints and tips

In the office: Complete as much of the site visit report sheet as possible.

On site, the aim of the site visit is to confirm or modify the suggestions from the model.

- Assess all the bends from the start to the end kilometre mark, and then again in the opposite direction.
- Existing signing.
- Legibility.
- Visibility approaching and in the bend.
- Comments.
- Signing level selected.

- Signing level selected

Avoid focusing solely on legibility and visibility and take all the criteria into account, especially the radius of curvature, any straight sections, and the length of the bend.

- Section with many bends

After the first bend in a series, drivers expect further bends of varying difficulty. It is therefore possible to downgrade some bends. However, try to keep the individual bends in a series as uniform as possible.

- Overtaking gap

Consider upgrading a bend according to its difficulty if there is possibility that drivers may be accelerating to overtake and may not be concentrating on the radius of curvature of the bend.

- In case of doubt

Suggest an expert site visit.

15 - References

[1] Méthode de sélection des virages à signaler et niveau de signalisation à implanter. (Method for selecting bends to be signed and type of signing to be installed)
Report.

Published in the Official Journal of the French Government
Reference 5346.

[3] Méthode de sélection des virages à signaler et niveau de signalisation à implanter. (Method for selecting bends to be signed and type of signing to be installed)
Practical guide.
This guide is intended to serve as a methodological aid to achieving consistency in the signing of bends along a route with the aim of helping drivers to improve their perception of the level of difficulty of these bends.

The method is based on a knowledge of the approach speeds, the legibility and visibility of the bend, and other accident contributory factors.

The aim of the method is to improve signing and to ensure that it is applied consistently in all areas. This document provides departments responsible for signing with the evidence they need to fight against the inflation of unnecessary road signs.