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A methodology to measure sight-hidden dips' parameters

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ABSTRACT

Highway design standards specify several requirements on available sight distance. Usually, compliance with these standards is ensured during the design phase of a new road. This is made through geometric calculations that take into account the terrain and the road. In this paper, a procedure for measuring distances in an existing road from georeferenced photographs is proposed. In addition, an estimation of the error committed when using this procedure is made. Distances measured using this procedure are compared with the ones measured using a Global Navigation Satellite System (GNSS). Distances error is within the error estimation and is low enough for using it in traffic safety studies. In addition, the procedure is applied to measure several parameters of a sight-hidden dip. This procedure does not need a terrain model to measure these parameters. This is an advantage compared with other existing procedures for estimating the parameters of sight-hidden dips.

1. Introduction

Highway design standards specify several requirements on available sight distance (Fig. 1). Usually, compliance with these standards is ensured during the design phase of the road. This is made through geometric calculations that take into account the terrain and the road.

On the other hand, some combinations of horizontal and vertical alignments can produce shortcomings in 3-D perspective. Among the safety-related shortcomings, the partial disappearance of a road from the driver's view with reappearance in the extension of the just-passed roadway section (called dip or diving) (Fig. 2) stand out. When connecting a crest vertical curve, followed by a sag, the road may disappear from driver's view to reappear later. Then, there is a loss of path or a diving in the road. It is essential to avoid losses when they hide dangerous points, such as intersections or unexpected changes in direction. This loss can produce driver disorientation if visible sections are nearby and visual indicators suggest that hidden section alignment is similar to visible sections alignment. This disorientation could cause erroneous decisions, which could cause an accident. In addition, in the case of an overtaking, a driver could believe that he could see all possible vehicles circulating towards him. However, this is could not be the case because some unnoticed vehicles could be in the hidden section.

When a car arrives at station A, the driver sees the phenomenon. The car follows the path and after some time (seconds), it could see the usual (correct) road perspective. Between the first and second mentioned stations, there are highway sections hidden to a driver and highway sections that "reappear". Length of diving is the difference between the first station, in which divers could see the phenomenon, and the second station (first station in which the phe-

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0263-2241/

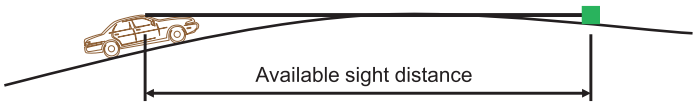

Fig. 1. Available sight distance.

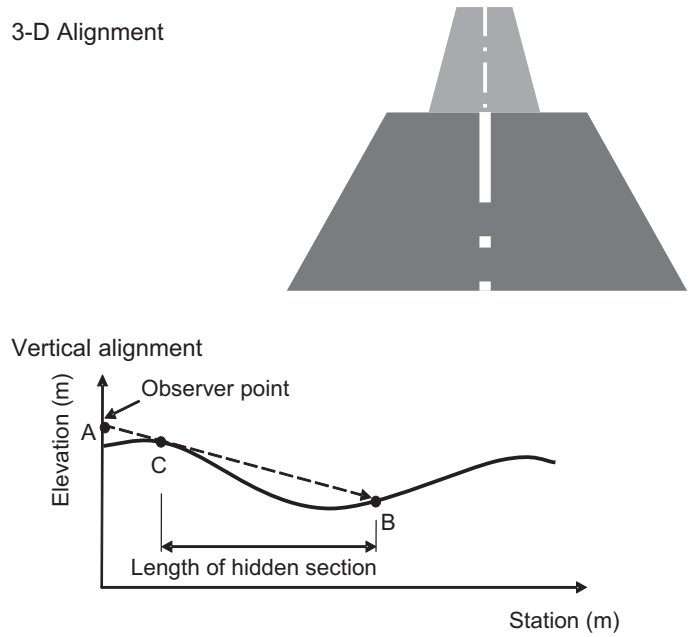

Fig. 2. Hidden-sight dip or diving.

nomenon does not exist). Length of diving is important to characterize a diving because, if it is very small, drivers could be not aware of the existence of a diving. Other relevant parameters are maximum length of hidden section (CB in Fig. 2) and maximum distance between driver and reappeared section (AB). The Swiss standard [1] and Italian standard [2] state that the reappeared section should be at a large enough distance from the observer. Both standards provide similar distance values. Nevertheless, while Swiss standard provides these minimum distances through a graphic, Italian standard provides them through a table. As could be seen (Table 1), these distances vary between 150 m for a vehicle's operating speed of 25 km/h and 860 m for 140 km/h. AB distance from observer to reappeared section (Fig. 2) should be larger than this critical distance.

Most researches show the importance of 3D shortcomings, specifically divings, but they consider the problem usually from a qualitative point of view [3,4]. To aid designers, highway design standards include recommendations (rules applicable in the design phase of a highway) about horizontal and vertical layout coordination in order to avoid 3D alignment shortcomings [5,6]. Most of these recommendations are qualitative. However, shortcomings can still occur in the three-dimensional alignment. Even for experienced design engineers, despite these recommendations (rules), and they are not recognized until the road has been built.

Table 1
Critical distance from driver to reappeared section according to Italian standard [2].

Speed (km/h)	Distance from observer to reappeared section (m)
25	150
40	180
50	220
60	280
70	350
80	420
90	500
100	560
110	640
120	720
130	800
140	860

On the other hand, more recently, highway design software that could generate virtual images of the designed highway is available. In order to check these images, designers should see them sequentially. These procedures are aimed to be applied in the design phase of a highway, and they require knowledge about project data (horizontal and vertical layout and cross section) [7–9]. In this way, if shortcomings are detected, the design could be modified. These procedures do not take into account quantitative aspects of the phenomenon and applying them to already