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INFLUENCE OF DRIVER EYE HEIGHT AND OBSTACLE HEIGHT ON SIGHT DISTANCE

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Abstract

Road traffic safety is a series of methods and measures aimed to reducing the risk of injury for road users.

Road accidents are events that have an extremely strong socio-economic impact on society as a whole and directly on its members.

The road is a basic component of the road safety system and is represented by the road and the area adjacent to it, which influences the flow of road traffic. Basically, the driver "reads" the road and based on that information adopts the behaviour, mainly speed.

The road elements of the road and the homogeneity of these characteristics, visibility in curves, the layout of intersections, the uniformity and roughness of the road surface are only some of the essential elements of the traffic safety study at the design stage. But even on a very well-designed road, many accidents occur because of the other possible factors.

The road elements characteristic of roads are the totality of the road components in plan view, elevation and cross section.

In this case study, a section of road of technical class III was considered.

The design speed of the road section studied is 80 km/h and the lane width is 3.50 m, according to the technical standards in force.

The study was carried out for design speeds of 80 km/h and 60 km/h respectively, the height of the eyes will be considered as 1.00 m, 1.10 m, 1.20 m and 1.30 m, and for the height of the obstacle will have variable height, more precisely, for the speed of 80 km/h the heights will be 0.20 m, 0.40 m, 0.60 m, 0.80 m, 1.00 m, and for the speed of 60 km/h, they will be 0.00 m, 0.10 m, 0.20 m.

Keywords: road elements, road safety, sight distance

1. INTRODUCTION

Over time, the European Union has recognised the importance of road safety and has responded with Directive 2008/96/EC of the European Parliament and of the Council of 19 November 2008 on road safety management. The United Nations, in a resolution adopted on 2 March 2010, also recognises the seriousness of the problem and declares 2011-2020 the Decade of Action for Road Traffic Safety.

Road traffic safety is the sum of four factors working together: the human being (as driver, pedestrian or passenger), the environment, the vehicle and the road.

Of the four factors involved, it is undoubtedly man who is the most important, not only because it is man who is responsible for the safety of road traffic, and the way in which he knows and observes the written and unwritten rules of the road, but also because it is man who manufactures and repairs vehicles (well and sometimes not so well), because it is also man who builds and maintains roads, in most cases succeeding in creating modern roads, but sometimes neglecting some of the 'details' which encourage road accidents.

The Environment - Road - Man - Vehicle system is the conceptual framework within which road traffic and all its components must be understood and analysed. Studies show that the "human" factor is predominant in road accidents. These four factors do not work in isolation.

They are always present in the chain of road events that contribute to an accident.

The road is a basic component of the road safety system and is represented by the road and the area adjacent to it, which influences the flow of road traffic. Basically, the driver 'reads' the road and based on that information, he or she decides how to behave, mainly in terms of speed.

The road elements and the homogeneity of these characteristics, visibility in curves, the layout of intersections, the uniformity and roughness of the road surface are only some of the essential elements of the traffic safety study at the design stage. But even on a very well-designed road, many accidents occur because of the other possible factors.

The road elements are the totality of the components of a road in the plan view (horizontal alignment), elevation (vertical alignment) and cross section.

In alignment and declivities there is good visibility of the road. In horizontal curves, as well as on crest vertical curves or at street intersections, visibility is impeded if there are obstacles in the driver's field of vision such as embankments, retaining walls, vegetation, buildings, etc.

Most sight distance problems are related to the presence of curves in plan view and to vertical curves.

Required stopping sight distance is normally defined as the distance travelled by a vehicle during a forced stop maneuver, measured from the point where the hazard is first perceived to the point where the vehicle stops [1].

In order to measure the sight distance along the roadway on which an obstacle is visible, two basic parameters must first be considered. First parameter is the height of the driver's eye above the road surface, Although this parameter is subject to great variability, mainly due to the variety of drivers, vehicle models and vehicle types, standards in different countries propose fixed values intended to be covering. For this issue, in 2003, Fitzpatrick[2] characterised the distribution of driver eye height in the USA, while Capaldo did the same in Italy. In addition, some countries describe in their standards procedures for estimating sight distance for trucks (AASHTO[3]). According to Glennon's study [4], the higher eye height of the truck driver does not necessarily compensate for the higher mass of the vehicle when braking. Higher tangential friction is required when braking in turns due to the centripetal acceleration component. In addition, obstacles on the inside edge of the road may be higher than the truck driver's eye height.

An unfavourable overlap of horizontal and vertical alignments may result in visual discontinuities or insufficient recognition of the alignment, even if the conditions for horizontal and vertical alignment are met separately [5].

Lack of adequate spatial correlation between alignments on the horizontal and vertical projections may lead to visual distortions that could mislead or violate driver expectations.

Different cases of visual distortion are described in standards around the world. The cases listed below are usually classified into two categories. The first category includes safety-related defects that are believed to endanger road safety.

The second category corresponds to minor deficiencies, simple aesthetic defects that could hardly pose a danger to drivers.

When the start of a horizontal curve is located near the apex of a sag curve, the driver can hardly perceive the horizontal change in time[6]. The difficulty of recognising this spatial sequence of alignments is especially aggravated at night. Drivers should be able to perceive the existence of the curve and decelerate at a comfortable pace before entering the curve. A substantial part of the curve should be seen so that the driver can perceive the horizontal deformation. The French design guide[7] suggests that a horizontal curve should be perceived at least at a distance travelled for 3 seconds at speed, but does not define how much of the curve should be seen. In contrast, the German guidelines[8] consider that not only the beginning of the turn should be perceptible, but also a portion where the variation of the curve exceeds 3.5 rad.

Similarly, AASHTO [9] discourages tight horizontal curves near the apex of a vertical curve. In this regard, Easa [10] discussed the correlation of vertical joints and horizontal curves. Locations where an horizontal turn should not start relative to a sag vertical curve have been defined as red zones at sight distance, as certain overlap offsets may lead to poor perception conditions. Daytime and nighttime circumstances were considered in this study, while horizontal curves, vertical curves, change of direction, sight distance required for braking and sight distance for overtaking were included as variables. If a vertical connection and a horizontal curve overlap, the driver may consider the radius of the curve to be larger than it actually is [11].

2. CASE STUDY

The CIVIL SITE DESIGN application was used for the case studies as an extension of the AutoCAD. The Civil Site Design application is developed by Civil Survey Solutions Australia and works on top of BricsCAD, AutoCAD, AutoCAD Civil 3D platforms and provides advanced functionality for the design and rehabilitation of roads to Romanian standards. It includes basic commands for drawing road elements (in plan view and elevation), automatic intersection curve, automatic generation of elevation and cross sections and earthwork evaluation (calculation of related backfill and excavation volumes).

The Civil Site Design application is used in Romania, being one of the most powerful and dynamic software solutions for the design and rehabilitation of roads. From primary route geometrization and automatic curves arrangement according to the standards in force (STAS 863-85, PD 162-2002, forestry etc.), to the extraction of quantity lists and reporting in files of the designed elements, to the automatic printing of the execution drawings in AutoCAD format, ARD is an indispensable tool for any designing engineer.

According to STAS 863-65, the minimum sight distance for a speed of 80 km/h is 230 m and for a speed of 60 km/h is 140 m. The studied road section consists of two alignments, the first one from km 19+200 to 20+258.602, the second one from km 20+926.092 to km 21+200, joined by an arched clothoid to the right, Figure 1.

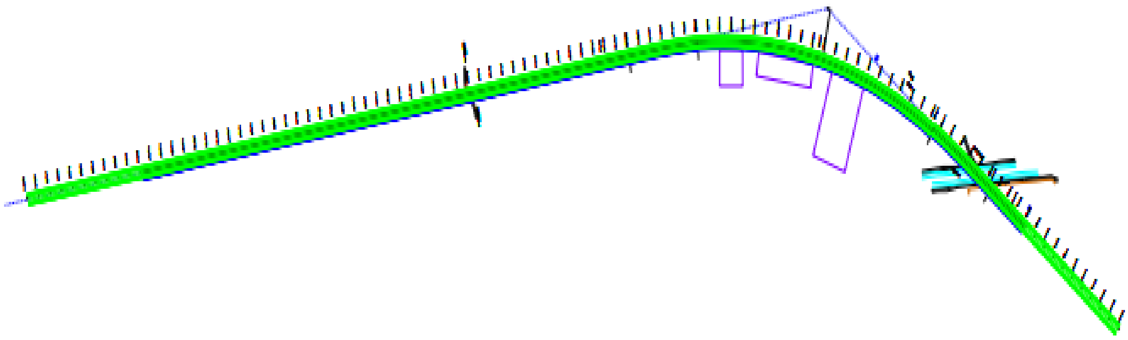

Figure 1. Route studied in plan view

The grade line from elevation consists of two declivities and a crest vertical curve, between km 19+200 and km 19+800.88: there is a 4.50% gradient followed by the crest vertical curve between km 19+800.88 and km 20+093.38 and a -2.00% gradient between km 20+093.38 and km 21+200, Figure 2.

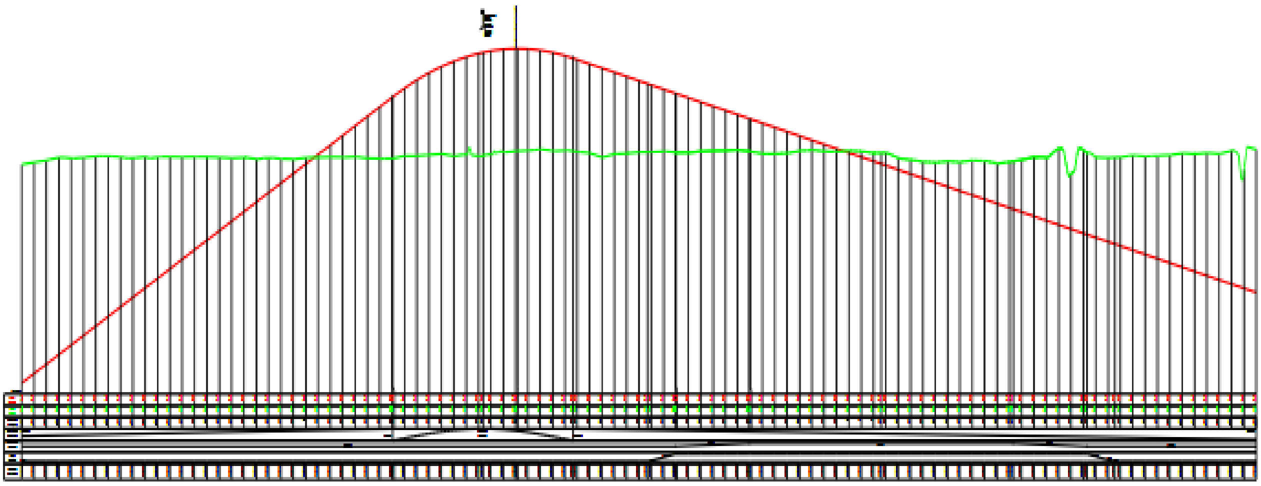

Figure 2. Route studied in elevation

In Figure 3 it is a representation of the sight distance, on the curve in the plan view, in perspective.

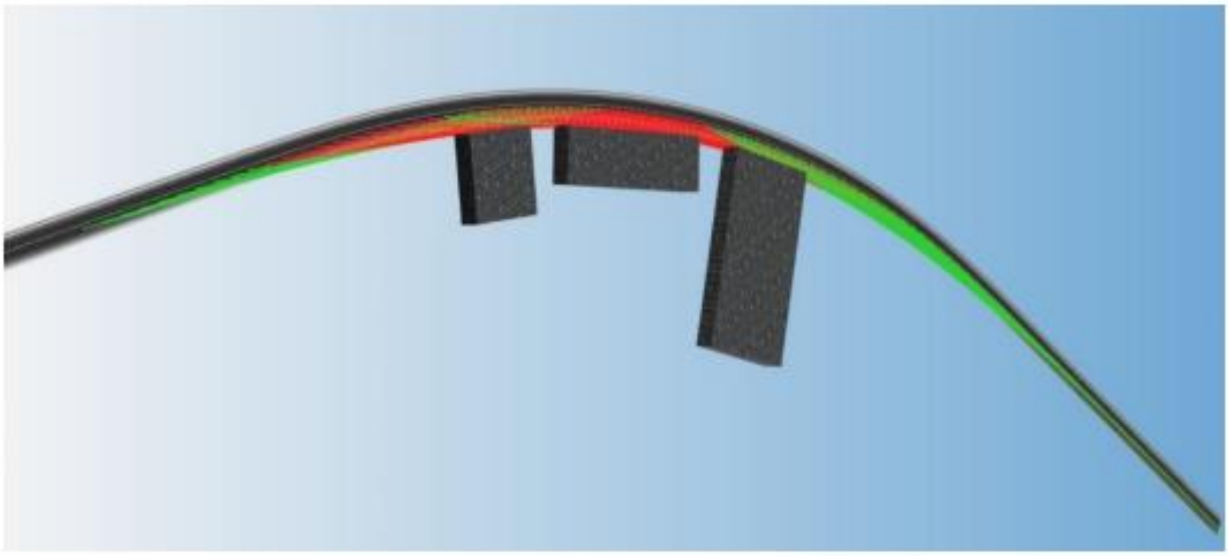

Figure 3. Sight distance on the curve in plan view, in perspective

Figure 4 shows the sight distance, in percentages depending on minimum sight distance, for driver eye height between 1.00 - 1.30 m and object height between 0.20 - 1.00 m.

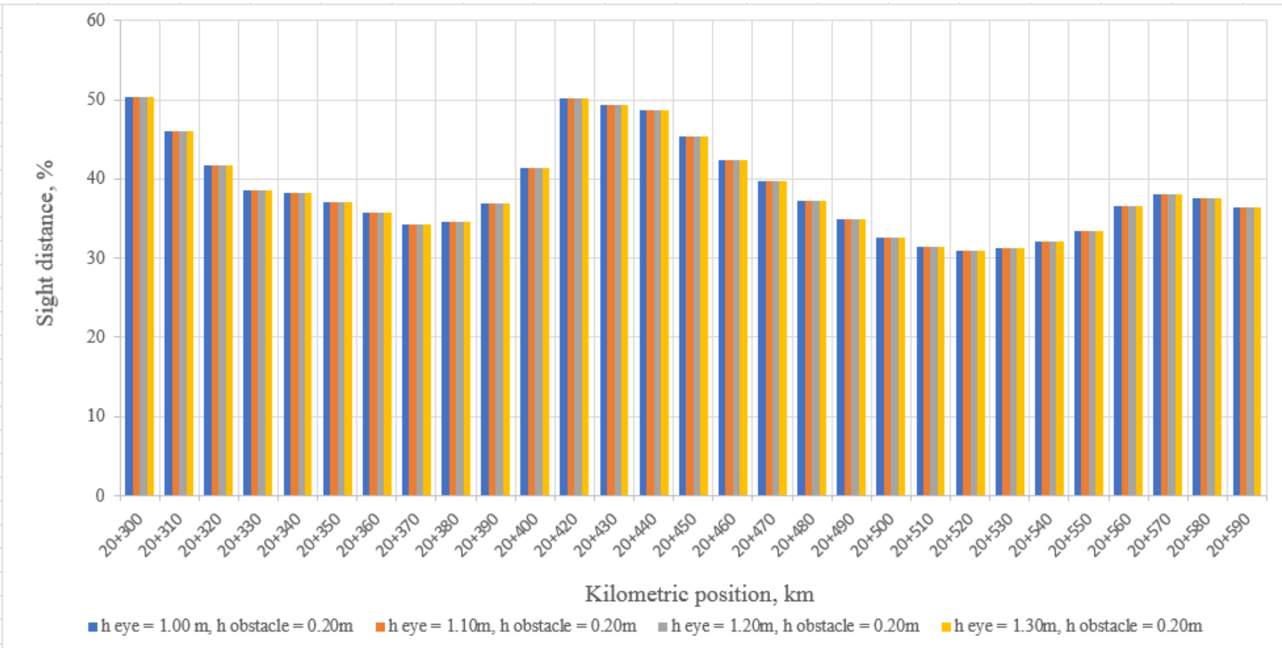

Figure 4. Sight distance, in percentages depending on minimum sight distance, for driver eye height between 1.00-1.30 m and object height between 0.20 m-1.00 m (plan view, V=80 km/h)

Figure 5 shows the sight distance, in percentages depending on minimum sight distance, in elevation for driver eye height between 1.00 - 1.30 m, object height 0.20 m and speed 80 km/h.

Figure 5. Sight distance, in percentages depending on minimum sight distance, for driver eye height between 1.00-1.30 m and object height of 0.20m (elevation, V=80 km/h)

The influence of the crest vertical curve on the sight distance is important in the horizontal alignment. Between km 19+640 and km 19+990, for h_{object} = 0,20 m, the sight distance is increases with driver eye height by 4%-22% for V = 80 km/h.

For an object height of 0.20 m, depending on the driver's eye height, the sight distance varies between 23% - 100% of the minimum sight distance, for a driver eye height of 1.30 m and between 18% - 77% of 230 m, for a driver eye height of 1.00 m. From km 19+640 for driver's eye height of 1.00 m the minimum sight distance is no longer respected, whereas for h_{eye} = 1.10 m - 1.30 m the lack of sight distance starts 10m later, i.e. at km 19+650. At km 19+990, when h_{eye} = 1.00 m, the sight distance is 36% of the minimum sight distance and for higher driver eye heights the minimum sight distance is ensured. As the height of the driver's eye increases, the sight distance increases by 4 - 64%.

Figure 6 shows the sight distance, in percentages depending on minimum sight distance, in elevation for driver eye height 1.00-1.30 m, object height 1.00 m and speed 80 km/h.

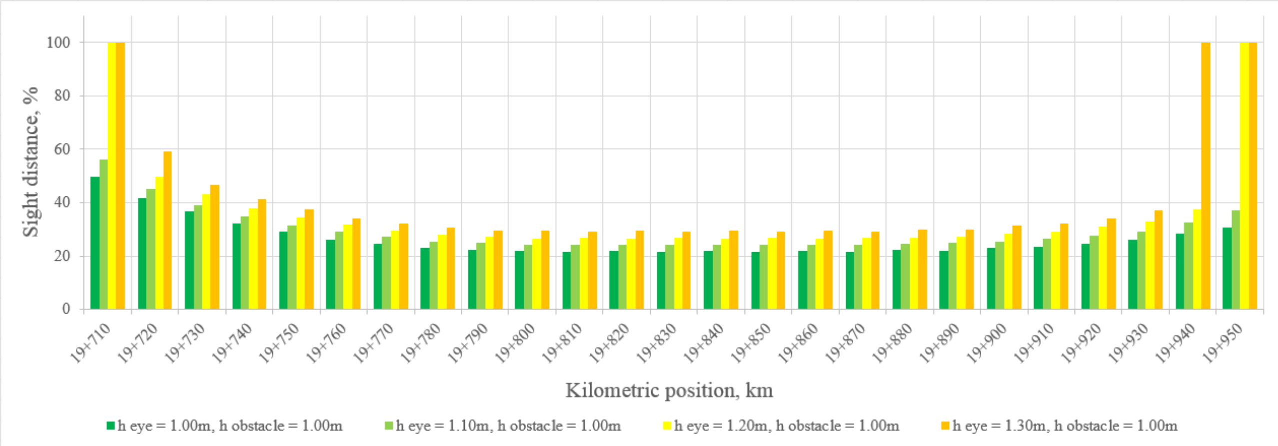

Figure 6. Sight distance, in percentages depending on minimum sight distance, for driver eye height between 1.00-1.30 m and object height of 1.00m (elevation, V=80 km/h)

At km 19+710, for h_{eye} = 1.00 - 1.10 m the sight distance value is less than 230 m and for h_{eye} = 1.20 - 1.30 m the sight distance is verified. Sight distance increases with h eye by about 8% - 63%.

Figure 7 shows the sight distance, in percentages depending on minimum sight distance, for driver eye height of 1.00 m and object height between 0.20 - 1.00 m and speed 80 km/h.

From km 19+640 to 19+660 for h_{object} = 0.20 m the sight distance varies between 59% and 77%, while at other object heights the minimum sight distance is verified. Sight distance increases with the height of the driver's eye by 5% - 64%.

Figure 8 shows the sight distance, in percentages depending on minimum sight distance, in elevation for driver eye height of 1.30 m, object height between 0.20 - 1.00 m and speed of 80 km/h.

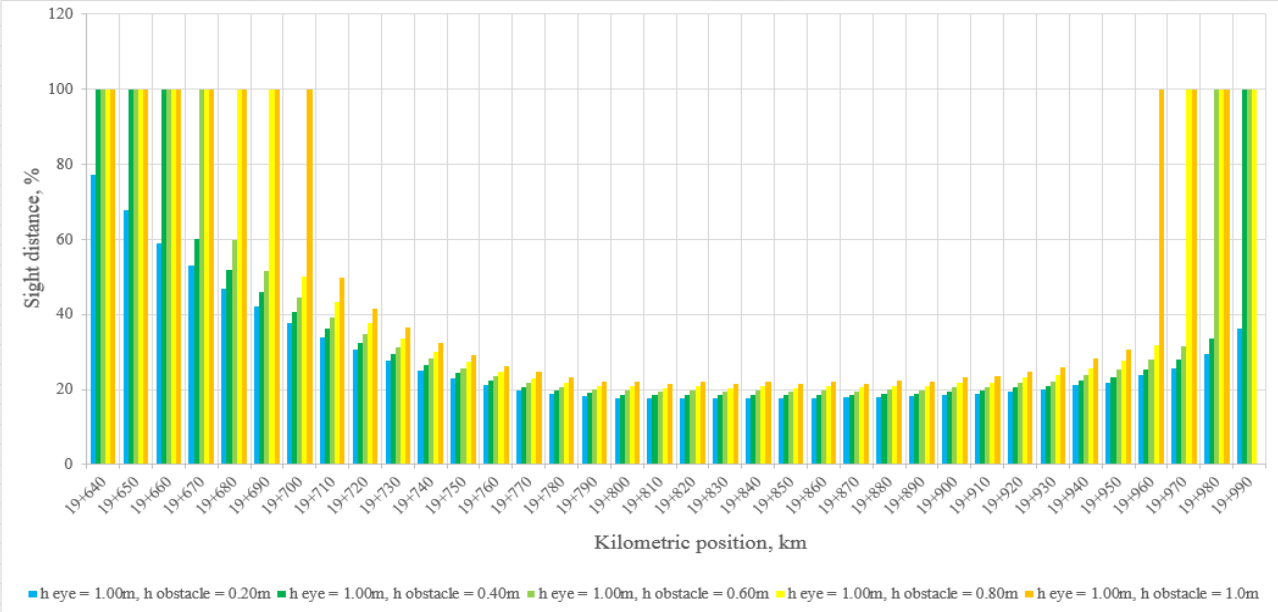

Figure 7. Sight distance, in percentages depending on minimum sight distance, for driver eye height of 1.00 and object height between 0.20-1.00m (V=80 km/h)

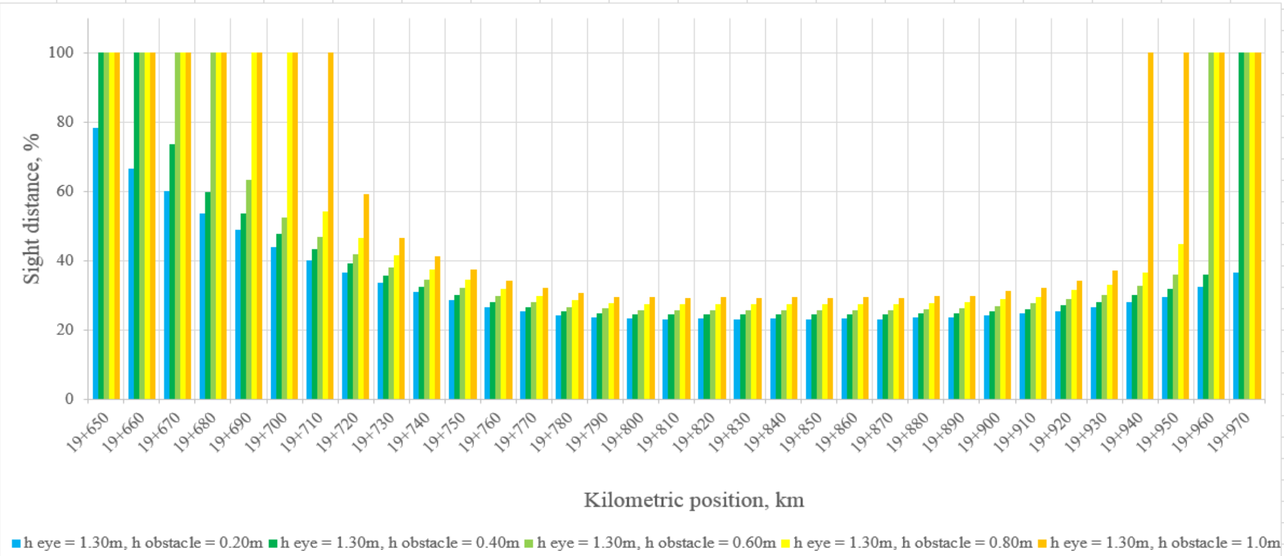

Figure 8. Sight distance, in percentages depending on minimum sight distance, for driver eye height of 1.30 and object height between 0.20-1.00m (elevation, V=80 km/h)

The sight distance for h_{object} = 0.20 m at km 19+650 – 19+660 varies between 66% - 78% for h_{object} = 1.00 m, and for object height above 0.20 m the sight distance is verified. Sight distance increases with object h by 7% - 54%.

Figure 9 shows the sight distance, in percentages depending on minimum sight distance, in elevation for driver eye height between 1.00 - 1.30 m, object height 0.00 m and speed 60 km/h.

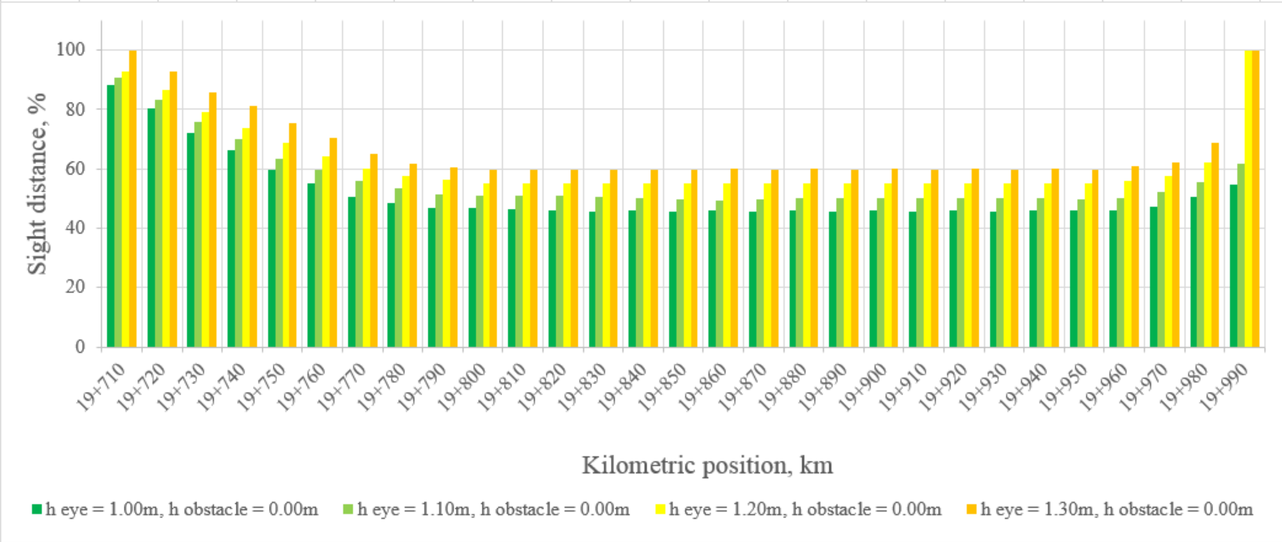

Figure 9. Sight distance, in percentages depending on minimum sight distance, for driver eye height between 1.00-1.30 m and object height of 0.00m (elevation, V=60 km/h)

Sight distance increases by about 3% - 39% with eye height, starting from h_{eye} = 1.00 m to h_{eye} = 1.30 m. Sight distance varies between 46% - 88% for driver eye height 1.00 m and between 60% - 100% for driver eye height 1.30 m. At km 19+990 for h_{eye} = 1.20 - 1.30 m the sight distance is verified and for h_{eye} = 1.00 m - 1.10 m varies between 38% - 45% lower.

Figure 10 shows the sight distance, in percentages depending on minimum sight distance, in elevation for driver eye height between 1.00 - 1.30 m, object height 0.20 m and speed 60 km/h. For driver eye heights above 1.00 m the sight distance is checked.

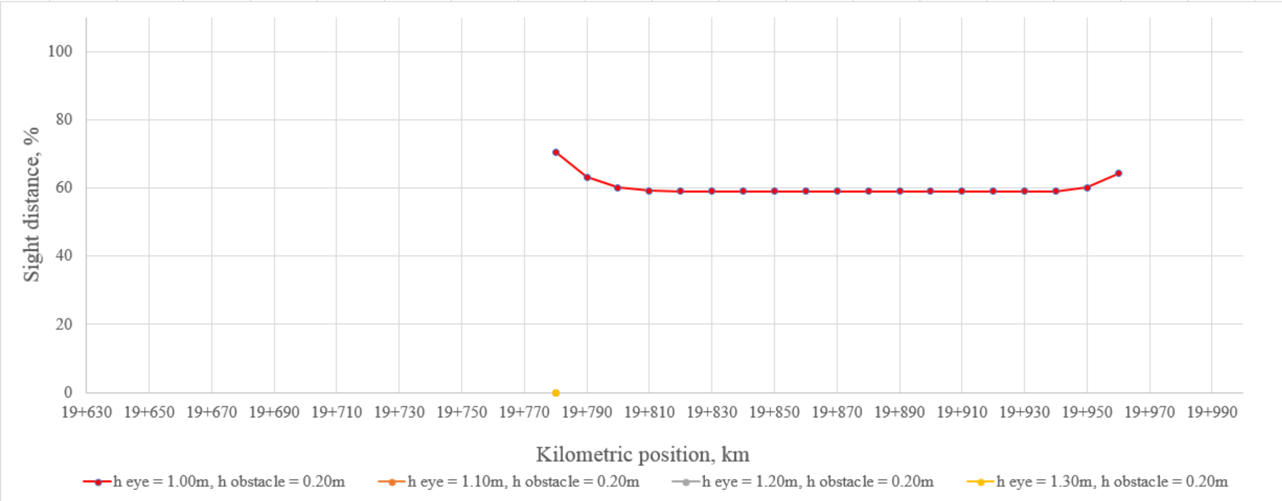

Figure 10. Sight distance, in percentages depending on minimum sight distance, for driver eye height between 1.00-1.30 m and object height of 0.20m (elevation, V=60 km/h)

Figure 11 shows the sight distance, in percentages depending on minimum sight distance, in elevation for driver eye height of 1.00 m, object height between 0.00 - 0.20 m and speed of 60 km/h.

For object heights above 0.20 m the sight distance is checked.

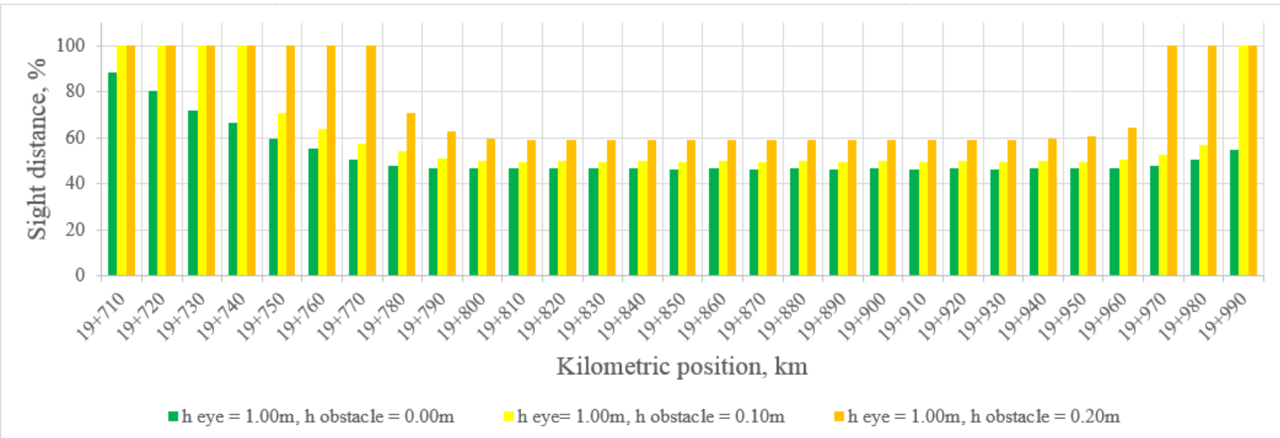

Figure 11. Sight distance, in percentages depending on minimum sight distance, for driver eye height of 1.00 and object height between 0.00-0.20m (elevation, V=60 km/h)

Between km 19+710 and km 19+740 for h_{object} = 0.00 m the visibility distance is 21% - 33% less than the value from STAS 863-65, while for h_{object} = 0.10 - 0.20 m the visibility distance is verified. From km 19+750 to km 19+770, for h_{object} = 0.10 m the minimum distance is 29% - 36% less than the value in STAS 863-65 (140 m), while for h_{object} = 0.20 m it is verified. For h_{object} = 1.30 m the visibility distance required by the standard is not checked between km 19+780 and km 19+960, it is about 40% lower. The sight distance, for h_{eye} = 1.00 m, increases with the height of the object with values between 6% - 46%.

Figure 12 shows the sight distance, in percentages depending on minimum sight distance, in elevation for driver eye height of 1.30 m, object height between 0.00 - 0.10 m and speed of 60 km/h.

For object heights above 0.10 m the sight distance is checked.

For h_{object} = 0,20 m, the minimum sight distance is respected. This has values between 71% - 100% from km 19+790 to km 19+950 for h_{object} = 0.10 m, and for h_{object} = 0.00 m varies between 60% - 100% from km 19+720 and km 19+980.

Figure 13 shows the sight distance, in percentages depending on minimum sight distance, in elevation for driver eye height of 1.00 m, object height of 0.20 m and speed of 60 km/h and 80 km/h respectively.

The sight distance is about 23% - 80% less at 80 km/h than at 60 km/h, the sight distance being calculated as a percentage of the minimum sight distances in STAS 863-65.

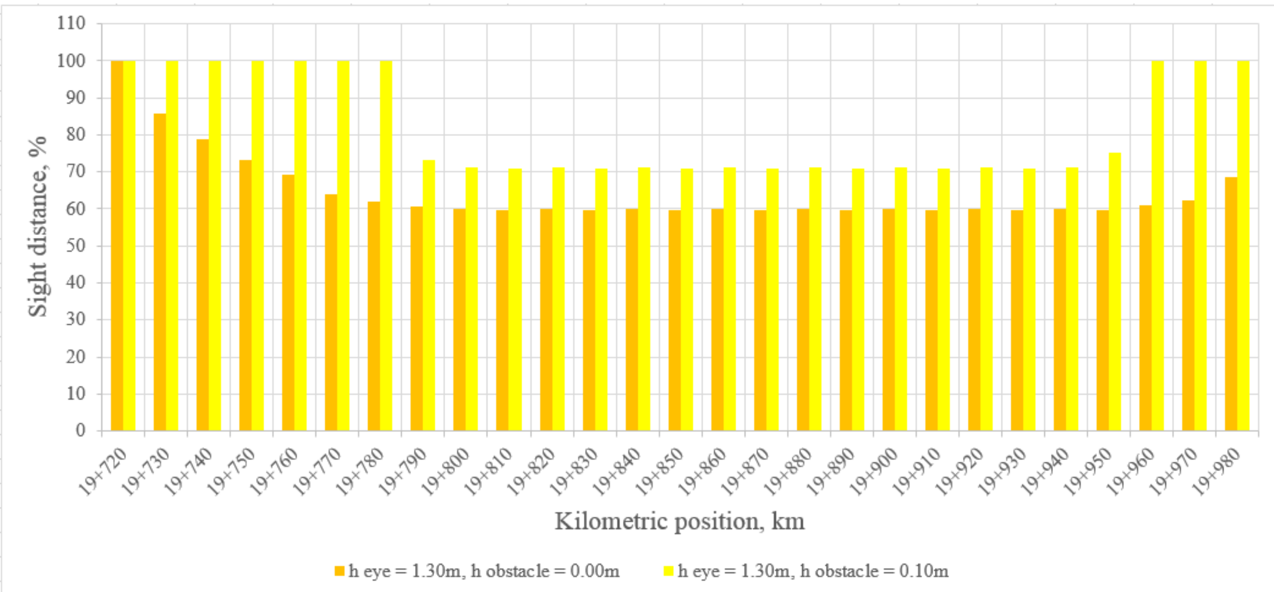

Figure 12. Sight distance, in percentages depending on minimum sight distance, for driver eye height of 1.30 and object height between 0.00-0.10m (elevation, V=60 km/h)

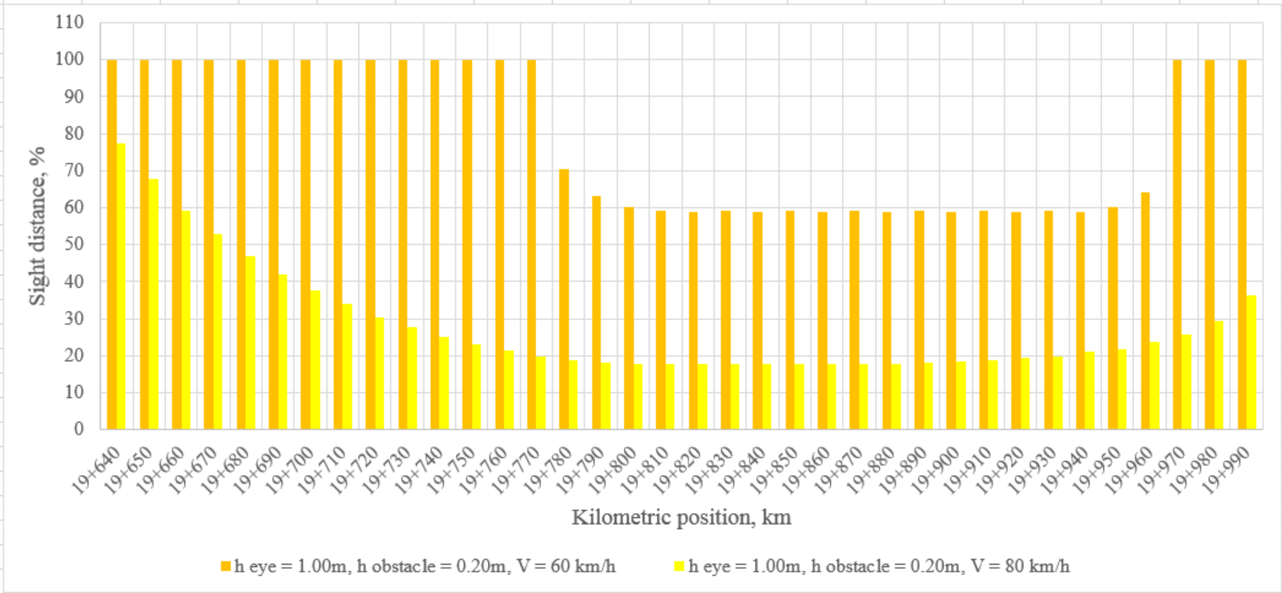

Figure 13. Sight distance, in percentages depending on minimum sight distance, for driver eye height of 1.00 and object height of 0.20m (elevation, V=60 km/h)

3. CONCLUSIONS

From the study it was observed that the sight distance is influenced by the height of the driver's eye and the height of the object.

The higher the height of the driver's eye, the greater the sight distance for the same speed and height of the object.

The greater the height of the object, the greater the sight distance, regardless of the speed and height of the driver's eye.

The plan view shows that the buildings at the edge of the carriageway have a great influence on the sight distance.

The road elements in the plan view and in elevation and their correlation have an important influence on the sight distance.

Roads must be designed in such a way that traffic participants perceive, understand and use them as road network managers and designers intended, by creating a user-friendly road environment that conveys clear messages.

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