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Professional paper

Installing vehicle restraint systems on the State roads in RN Macedonia according to EN1317 standard

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Abstract – **This paper analyzes the legal regulations, analyzes the existing situation with the guardrail on the roads in relation to the degree of danger of traffic participants, and with measures for the improvement of the traffic safety were proposed. The use of this European norm and its practical application in the fastest time are essential for the state, to raise the level of traffic safety.**

Keywords – **Traffic safety, Guardrail, Legal regulations and Standards.**

INTRODUCTION

Restraint systems - guardrails for vehicles are an extremely important means of passive traffic safety. Due to this fact, a strategy for fully harmonizing the criteria and technical conditions for the installation of protective guardrail is clearly defined in European countries, according to European standards EN 1317. The conditions and circumstances in which guardrails are installed change similarly to the overall social environment in which traffic processes are taking place. Continuous adaptation of normative practice, but also taking concrete measures, is imperative in reducing the consequences of traffic accidents.

In our practice, many different solutions and ways of installation of fence appear on the roads. The choice of type of the fence is defined in the project documentation, but in some sections there are frequent changes, according to the decisions of the supervisory authorities, contractors and investor, which depends on the limits imposed by the built structures at roads. A particular problem is the fact that, despite efforts to innovate technical norms, fences are not set up on roads in accordance with existing standards and needs for the protection of road users.

The situation with the guardrails on the roads in the Republic of North Macedonia is more than critical. The development of science, technology and material production in this area is advanced to the extent that the overall procedure for the use of guardrails (from materials, production, quality, appearance, testing to installation) is standardized, especially at the European level according to the EN1317 standard. By adopting this standard in the form of a national standard in the Republic of Macedonia, the possibility for its application is open. Technical instructions which has been adopted by PESR of Macedonia in 2018 should be implemented in projects. That application in areas of design, performance and surveillance, is necessary to harmonize and standardize, taking into account their specificities and conditions.

In this paper are included designed solutions for installation of vehicle restraint systems (guardrail), in accordance with the Technical instruction for the application of vehicle restraint systems on the state roads of the Republic of Macedonia and MKS EN1317 standard. These design solutions provide a more efficient level of vehicle retention, thereby enhancing the safety of all road users along State roads.

SCOPE OF AREA

The area taken for consideration in this paper are alignment of the State Road A4 section Shtip - Radovish from km5 + 066.00 to km7 + 413.09, State Road A3 sub-section Shtip - Krupiste from km0+000 to km14+300, State road A2, section Skopje – Gostivar, and State Road A1 (European Corridor X/E75) of the Republic of North Macedonia.

A. State Road A4 section Shtip - Radovish

State road A4, according to the legislation, is categorized as Expressway.

Part of the scope is also the surroundings of State Road A4 with all interchanges, underpasses and overpasses, access roads and road crossings. The scope of this section is designing of vehicle restraint systems (guardrail), in accordance to standard MKS EN1317, and in accordance with the technical regulations for the transportation infrastructure design and bylaw regulations for traffic design.

B. State Road A3 sub- section Shtip - Krupiste

State road A3, according to the legislation, is categorized as Expressway. The scope is the alignment of the State Road A3, section Shtip – Kocani, sub-section Stip - Krupiste km 0+000 – 14+300.

Part of the scope is also the surroundings of State Road A3 with all interchanges, underpasses and overpasses, access roads, road crossings and road belt. The scope of this sub-section is designing of vehicle restraint systems (protective steel fence - guardrail), in accordance to standard MKS EN1317, and in accordance with the technical regulations for

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the transportation infrastructure design and bylaw regulations for traffic design.

The maximum speed on Express way is limited to V=110km/h in the zone of exit ramps on Express way as well at the surface intersections the speed is limited to V = 30-50km/h depends on geometric element's.

C. State Road A2, section Skopje – Gostivar

The road alignment is part of the Pan-European Corridor VIII, labelled E65, which in the north starts from Malmo in Sweden and in the south ends in Chania in Greece. In the Republic of Macedonia it coincides with the national label A2. State road A2, according to the legislation, on the section from km0 + 000.00 to km53 + 600.00 is categorised as highway, and on the section from km53 + 600.00 to km57 + 500.00 is categorised as national road. The scope is the alignment of State Road A2 from the Saraj interchange to the Zdunje intersection in Gostivar, of km0+000.00 (29+730.00) to km57+500.00 (87+230.00).

The highway route has 11 road interchanges, Saraj, Matka, Grupcin, Zelino, Tetovo East, Brvenica, Tetovo South, Kamenjane, Zerovjane, Negotino, Vrapciste, and Gostivar on the trunk road. On the highway there are 4 pay toll stations at Glumovo, Zelino, Tetovo and Gostivar, and 8 supporting service area buildings and one supporting service area building is on the trunk road.

The part of zone is the area of highway with all surface connections in the form of acceleration/deceleration lanes and interchanges, supporting service area buildings, underpass and overpass roads, as a services objects and road area.

D. State Road A1 (European Corridor X/E75)

The length of the subject section of Corridor X that passes through the Republic of North Macedonia is about 170 km between the border crossings Tabanovce and Gevgelija, while the part from Demir Kapija to Smokvica (about 28 km) is not taken into consideration, because it was built recently and the vehicle restraint systems were built in accordance with the EN standard.

TRAFFIC SOLUTION

Based on research for the Implementation of Vehicle Restraint System, in accordance with MKS EN 1317 standard along the considered sections passing through Macedonia, it is found that the existing guardrail is in a rather poor condition, without proper containment level and it is not properly installed, with damages, often not enough length. Also, all dangerous locations are not protected, such as truss posts of road signs, portal posts of traffic signage, lighting poles, large and open drains/gullies, unsafe ending of "New Jersey", front part of retaining walls above the carriageway, high and steep embankments, passes on toll stations, etc.

The main purpose for the State road A4, section Stip – Radovis, is modifying and supplementing only the part of design of vehicle restraint systems (guardrail) due to the need to design it according to MKS EN1317 standard.

The guardrail for vehicles is designed according to the criteria given in the MKS EN 1317 standard, and its position is determined according to the geodetic base as well as according to the cross sections for this road.

The steel protective fence must contain three important characteristics:

- Degree of retention.
- Class of the operating range (working width W).
- Degree of device strength.

The steel protective fence is foreseen at places where there is a risk of slide off vehicles according to the criteria prescribed by the MKS standards, on embankments higher than 3 meters.

In the design of the guardrail, the standard MKS EN 1317 (1,2,3,5) is applied, according to which the required level of protection is determined.

According to the standard MKS EN 1317 (1,2,3,5), the following types of fences are designed:

- N2W3, A (Eco safe 2.0) placed on the shoulder;
- H1W3, A (Eco safe 1.33) placed on the shoulder;
- H1W5, A (EDSP 2.0) placed on the shoulder;
- H2W4, A (Super rail 1.33) placed on the shoulder;
- N2W1, A (Eco safe BW 1.33) placed on the structure;
- H1W5, A (EDSP BW 1.33) placed on the structure;
- H2W4, A (Super rail eco BW 1.33) placed on the structure;
- Starting and ending construction L=12m;
- Transition element from H1 to H2;
- Transition element from H2 to N2 and from H1 to N2;
- Constructive elements for connecting the fence with concrete elements;
- Crush cushions for V=80km/h;
- Tubular lattice parapet (pedestrian fence);
- Protective net road overpass (attaced on the pedestrian fence).

On the section Stip – Krupiste from km0+000 – km14+300 was modifying and supplementing only the part of design of vehicle restraint systems (guardrail) due to the need to design it according to MKS EN1317 standard.

The guardrail for vehicles is designed according to the criteria given in the MKS EN 1317 standard, and its position is determined according to the geodetic base as well as according to the cross sections for this road. The steel protective fence is foreseen at places where there is a risk of slide off vehicles according to the criteria prescribed by the MKS standards, on embankments higher than 3 meters. In the design of the steel fence, the standard MKS EN 1317 (1, 2, 3, and 5) is applied, according to which the required level of protection is determined with following types of fences:

- N2W3, A (Eco safe 2.0) placed on the shoulder;
- H1W3, A (Eco safe 1.33) placed on the shoulder;
- H1W5, A (EDSP 2.0) placed on the shoulder;
- H2W4, A (Super rail 1.33) placed on the shoulder;
- N2W1, A (Eco safe BW 1.33) placed on the structure;
- Starting and ending construction L=12m;
- Transition element from H1 to H2;
- Transition element from H2 to N2;
- Transition element from H1 to N2;
- Constructive elements for connecting the fence with

concrete elements;

- Crush cushions for V=120km/h

On the state road A2 from km0 + 000.00 to km53 + 600.00 which is categorized as motorway the traffic guidance is in one direction, and on the section of km53 + 600.00 to km57 + 500.00 which is categorized as trunk road the traffic guidance is in two directions.

The maximum speed of the A2/E65 highway, section Saraj - pay toll station at Tetovo is limited to 120 km/h, and the maximum speed on the section Tetovo - Gostivar between adjacent intersections with installed pay toll stations is limited to 90 km/h.. On the trunk road A2/E65 section pay toll station Gostivar - Zdunje, for safety reasons, is limited to 60 km/h. According to the standard MKS EN 1317 (1, 2, 3, 5), the following types of fences are designed:

- H1W3 (A) (1.33) placed on the shoulder in the zone of the side boards;
- H1W5 (A) (2.0) placed in the separation zone and on the shoulder;
- H1W5 (A) (2.0) anchored, placed on retaining walls;
- H1W5(A) (2.0) mounting - demounting, mounted on official crossings;
- H1W6 (A) (4.0) placed on the Tetovo East interchange between the exit ramp to Gostivar and the highway;
- H2W2 (B) (0.5) placed in the separation zone;
- H2W4 (A) (2.0) placed according to the standard;
- H2W4(B) (1.33) anchored, placed on retaining walls;
- Initial and final construction with a length of 12 meters;
- Transition construction of H1 to H2;
- Constructive elements for connecting the fence with concrete elements;

Crush cushions for 110km/h were applied to the exit section of the interchange Tetovo East in the direction of Skopje - Tetovo and the outer section of the interchange Saraj in the direction of Tetovo - Skopje.

State Road A1 (European Corridor X/E75) has problems regarding the installation of restraint system on the observed road section of the highway. There are certain problems due to which it is not possible to install guardrail because of an inadequate base (e.g. bridges, overpasses, culverts, large drains, etc.), as well as problems related to guardrail because it cannot be installed in accordance with standard EN 1317. In addition, there are road sections where it does not seem rational to install the guardrail, so it is necessary to do some preliminary works (e.g. remove trees which is most often self-cultivated wild plant, replacement of inadequate curbs, rehabilitation of retaining walls, reconstruction of large concrete drains etc.) to eliminate the need for the installation of guardrail. Certain preliminary works (e.g. relocation or replacement of truss constructions, etc.) and construction works (e.g. reconstruction of inspection path on structures, reconstruction of large concrete drains, rehabilitation of retaining walls, rocky slopes, etc.) are necessary in order to install safety barrier.

Some of defined problems and their solutions are given on following figures:

Fig. 1. Sub-guide on the section Kumanovo - Miladinovci, km 20 + 112

Fig. 1 shows that there are not necessary conditions for the installation of a safety barrier on most bridges and overpasses (structures). Inspection paths are not wide enough for the installation of safety barrier of required degree of retention and dynamic deflection, while concrete of certain inspection path on some structures is in poor condition. One of solutions is reconstruct inspection paths on structures so as to ensure conditions for the installation of H2-W4 guardrail (smaller structures where third parties are endangered) or H1-W2 (smaller structures where third parties are not endangered), and second is in case of small box culverts, it is necessary to cast concrete beam along the culvert to provide conditions for the installation of H2-W4 guardrail (structures where third parties are endangered) or H1-W2 (smaller structures where third parties are not endangered).

The tops of large and open drains made from solid concrete are higher than the carriageway and positioned to the very edge

Fig. 2. Entrance head from pipeline omission, km 15 + 830 (west lane)

of the carriageway, which represents a massive, non-deformable obstacle (Fig.2). One solution is such non-deformable barriers can be protected by H1 guardrail. Second is reconstruction of drains/gullies by reducing it to the level of surrounding terrain and covering it from the top with a concrete slab, as it has already been done on the observed road section, without installation of guardrail. The third is to set a metal grid drain cover that is not raised too much, without the need for guardrail installation.

On Fig. 3 are sporadic trees on both sides of the carriageway and in central reserve on the whole road section.

Fig. 3. Trees in central reserve and along carriageway, km 105 + 550

One of possible solutions is trees should be protected by H1 guardrail on both sides of the carriageway. Barrier H1 can be installed in central reserve if both lanes are at the same height, which in a joint operation is a system with a retention level as barrier H2. If there is any obstacle in the central reserve and joint operation of H1 barrier can not be achieved, H2 barrier must be installed on both sides of central reserve. Second solution is removing trees on both sides of the carriageway and in central reserve.

Fig. 4. Entrance in tunnel

Locations of two presented tunnels (Fig. 4) are at km 47+150,00 and at km 65+200,00 (western carriageway lane). Problem is the entrance to a tunnel is not protected, so a vehicle may directly hit the tunnel portal construction. Proposed solution is installation of H2 guardrail in front of the tunnel on both sides of the carriageway and fitting to the tunnel wall using transition element.

Given that in the Republic of North Macedonia the installation of the guardrail according to the standard EN1317 is a relatively new procedure, it is necessary for the phase changing of the existing type of guardrail with a new type of guardrail.

ADDITIONAL REMARKS

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CONCLUSION

The guardrail as part of the vehicle restraint system is the most commonly used element of road equipment that directly and extremely significantly influences the realization of passive road safety.

With implementation on the design project solution for installation of vehicle restraint systems (protective steel fence - guardrail), in accordance with the Technical Guidelines for the application of vehicle restraint systems on the state roads of the Republic of Macedonia and MKS EN1317 Vehicle Retention System Design Standards, provide a more efficient level of vehicle retention, thereby enhancing the safety of all road users along the subject sections.

The applied solutions have revealed the major shortcomings in the traffic safety of the sections in question, which emphasizes the need for its immediate repair. Only current issues have been resolved.

All Vehicle Restraint Systems (VRS) must meet the requirements of the European Standard EN 1317. The systems must undergo crash tests and the associated parameters and acceptance criteria that are defined by the norm. Depending on the test results, the systems are divided into performance classes. Each type of VRS is evaluated as an individual part of the EN 1317.

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