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REGULATING OF PASSAGES IN THE MOTORWAY CENTRAL RESERVE

ABSTRACT

Passages in the central reserves of motorways are intended for redirection of traffic during planned special maintenance of motorways and in accident situations, as well as for the requirements of emergency vehicles (ambulance, fire-brigade, police).

The observed problems in deficient legal regulations of the design and length of the passages are reflected on the existing condition of the passages in the central reserve on the Croatian motorways. Our practice shows diverse solutions, especially regarding the lengths of the passages.

Considering the issue of the passages in the motorway central reserves in a certain number of the European Union countries one can notice various design solutions contained in the national standards. Having in mind the purpose of the passages under the condition of safe flow of traffic, the required passage dimensions have been studied regarding their position on the motorway. The study resulted in two design type solutions.

As result of the performed study and the observation of the national and foreign practice, recommendations are given for the design solution of the passage in the central reserve on the Croatian motorways.

KEY WORDS

passages in motorway central reserves, passage length, passage design solution, passage type solution

1. INTRODUCTION

The passages in the motorway central reserves are primarily intended for redirection of traffic to the adjacent carriageway during the reconstruction of motorway sections and in accident situations, as well as for the requirements of the emergency service vehicles. Otherwise, the passages have to be closed in order to avoid any risk for the traffic safety.

The actual situation in the field and the absence of regulations that should define the design of the passages in the motorway central reserve, resulted in the need to make a more detailed analysis of the mentioned problems.

2. CURRENT DESIGN OF OFFICIAL PASSAGES IN THE CENTRAL RESERVE OF MOTORWAYS

2.1 Republic of Croatia

In the Republic of Croatia there are no regulations that would define precisely the design and distribution of passages in the motorway central reserve.

The regulations which generalized refer to the issues of the passage in the motorway central reserves specify the following:

- speed on the road under normal conditions shall not be limited below 40 km/h, and vehicles that cannot reach speeds greater than 60km/h are not allowed on the motorway [1].
- no U-turns are allowed on the motorways crossing the central reserves, and the priority vehicles are allowed U-turns in exceptional cases provided the traffic has been stopped [1],
- public roads are planned, designed, constructed, reconstructed and maintained so that they ensure safe travelling of all the traffic participants [2],
- the motorway central reserve is 4 or 3m wide (exceptionally 2.50m) [3].

The design elements of passages in the central reserve are not specially regulated so that they do not have to comply with the general regulations that have been defined for the rural public roads according to the Regulations [3].

On our motorways the lack of uniformity of passage design has been observed (Table 1), along with a note that the field recordings of the conditions (winter 2005) marked even up to $^3/_4$ partly or completely open

passages on individual motorways. The found condition does not contribute to safe and undisturbed traffic flows.

Table 1 - Lengths of official passages on motorways A1, A3, A4, A6 and A7

Motorway	Passage length [m]
A1 (Zagreb - Split)	40 – 165
A3 (Bregana - Lipovac)	36 – 115.5
A4 (Zagreb - Goričan)	40 – 120
A6 (Rijeka - Zagreb)	50
A7 (Rupa – Rijeka – Žuta Lokva)	60 – 151

2.2 European Union

There is no unique standard in the European Union that would define the design of the passages at the level of the entire Union, but it has been left to single state members to regulate the passage issue in the motorway central reserve through national regulations.

Germany stipulated the standard speed of V = 80km/h in the area of traffic diversion which refers also to the passage. This is the speed which defines the length of the passage in the motorway central reserves of 135m in the shape of "S" curve with radius R= 350m (300m on more demanding sections) and the inter-line of at least 20m which allows a two-lane passage [4].

In Italy there is a regulation in force which regulates the minimum length of the passage, for traffic redirection, of 80m, whereas the passages meant for emergency services (ambulance, police, fire brigade) have maximum length of 34m [5].

In Slovakia the passage length on the motorway straight section amounts to 120m, and in curve 135m whereas the width of the central reserve is 4 and 3m depending on the road category [6].

The Slovenian standard regulates the minimum width of the central reserve of 4m and the length of the passage which accommodates two lanes of 7m width with elements for the design speed V_p = 60km/h. In practice, such passages are 135m long, whereas those of a single lane are 90m long [7].

3. STUDY OF THE DESIGN OF PASSAGE IN THE MOTORWAY CENTRAL RESERVE

The observed differences in standardization and design of passages in the motorway central reserve both on the Croatian motorways as well as by looking into the available regulations and practices of certain European Union countries (Germany, Italy, Slovenia, Slovakia...) have resulted in the need for a more detailed research of the passage design in the motorway central reserve.

Since the passages in the central reserve on the Croatian motorways are used for the traffic redirection from one carriageway to another in case of planned motorway maintenance works and in special situations (serious traffic accidents, natural elements), and since they also serve the needs of the emergency services, their primary role should be determined for the purposes of their study. Considering that the emergency services can use in a better and more efficient way the side passages along the motorway wire fence in the vicinity of over- and underpasses, as well as that the passages in the motorway central reserve intended for traffic redirection satisfy regarding their design the needs of emergency services as well, the study will deal with the design solutions of the passages for traffic redirection.

On the straight motorway sections, the length of the official passage meant for traffic redirection can be determined for the case of a single-lane transition (Figure 1) and for the case of two-lane transition (Figure 2). In both cases the transition line consists of two opposing circular arcs of equal radii (S curve).

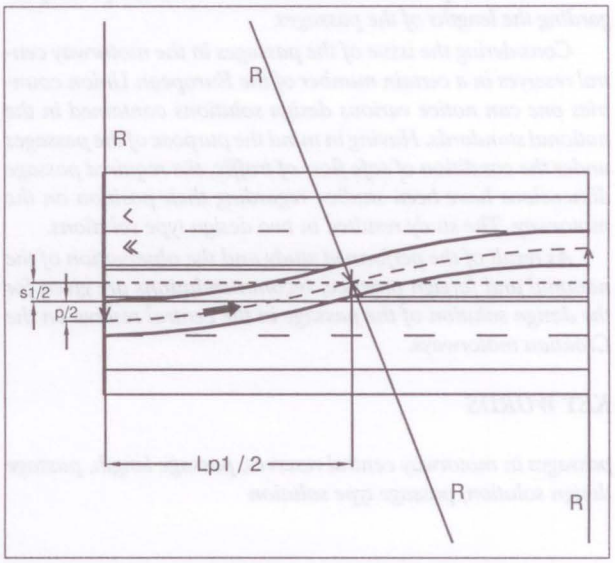

Figure 1 - Single lane transition across the official passage

The condition of transition (Figure 1) yields that the approximate length of the passage for the case of one-lane transition can be determined from the expression:

$$L_{p1} = 2\sqrt{R(s_1 + p)}, \quad (1)$$

where:

L_{p1} – length of passage necessary for single lane transition [m];

R – radius of transition [m];

Table 2 - Length of passage L_{p1} is designed as S curve with radius R and the transition speed V(km/h) for the case that the motorway is in straight line with the elements of cross-section (s, p, r) for design speed V_p

V_p [km/h]	L_{p1} [m]					
	R=450 m (V ≤ 95)	R=350 m (V ≤ 85)	R=250 m (V ≤ 75)	R=175 m (V ≤ 70)	R=120 m (V ≤ 60)	R=75 m (V ≤ 50)
≥ 120	125.50	110.68	93.54	78.26	64.81	51.23
100	123.69	109.09	92.20	77.14	63.87	50.50
90	116.19	102.47	86.60	72.46	60.00	47.43
80	111.04	97.93	82.76	69.25	57.34	45.33

Table 3 - Length of the passage necessary for two-lane transition across the motorway central reserve (L_{p2}) designed as S curve with radius R and the transition speed V for the case when the motorway is in the straight line with the elements of cross-section (s, p, r) for design speed Vp

V_p [km/h]	Lp_2 [m]					
	R=450 m (V ≤ 95)	R=350 m (V ≤ 85)	R=250 m (V ≤ 75)	R=175 m (V ≤ 70)	R=120 m (V ≤ 60)	R=75 m (V ≤ 50)
≥ 120	149.48	131.69	111.10	92.70	76.44	59.95
100	146.48	129.06	108.89	90.86	74.94	58.79
90	140.28	123.61	104.30	87.06	71.83	56.38
80	134.38	118.48	100.00	83.47	68.89	54.11

s_1 – width of central reserve (s) increased by the width of internal edge lanes (r) i. e. $s_1=s+2r$ [m];

p – lane width [m].

The lengths of the official passage (Lp_1) resulting from expression (1) for the case when the passage is located in the straight section of the motorway with the elements of cross-section (s, p, r) for different design speeds (V_p), according to Regulations [3] range from 45.33 to 125.50m (Table 2). The passage is designed as an S curve with the respective radius R which allows the transition speed V.

The transition speed (V) through the official passage is determined from the condition of vehicle stability to skidding in S curve with radius R for the case of designed counter-gradient of the carriageway (gradient designed in the opposite direction of the centre of curvature) of q=2.5%, which corresponds to the transversal gradient of the straight motorway and for the case of maximum value of the radial coefficient of skidding resistance f_{Rmax} according to the Regulations [3].

The length of the passage in the motorway central reserve for two-lane transition (Figure 2) can be determined from the expression:

$$L_{p2} = 2\sqrt{f(2R-f)} \qquad (2)$$

where:

L_{p2} – length of passage necessary to accommodate two lanes [m];

R – transition radius [m];

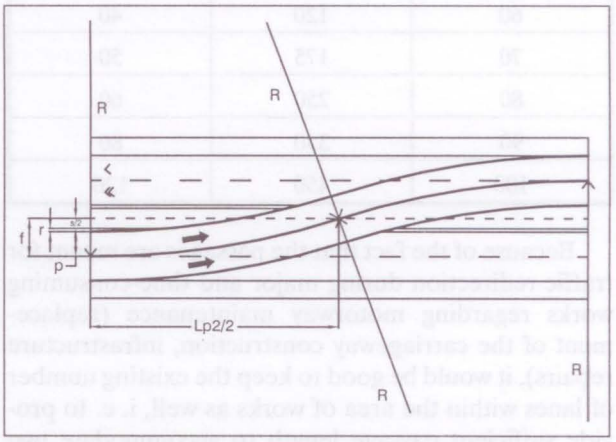

Figure 2 - Two-lane transition across the official passage

$$f = \frac{s}{2} + r + p;$$

s – width of the central reserve [m];

r – width of the internal edge lane [m];

p – lane width [m].

Lengths of the official passage L_{p2} resulting from the expression (2) when the passage is on the straight section of the motorway with the elements of the cross-section (s, p, r) for various design speeds (V_p) range from 54.11 to 149.48 m (Table 3). The passage is designed as S curve with the respective radius R that allows transition speed of V.

The presented methods of determining the length of passages L_{p1} and L_{p2} are approximations and a

rough estimate of the required straight passage length because of direct crossing of the transition line from the straight line into a circular arc, and then also into the opposite circular arc.

Safe and continuous flow across the motorway central reserve and the traffic-dynamic transition requirements are satisfied by the transition of the S curve shape with the transition arcs (Figure 3).

The transition line (Figure 3) consists of the transition arcs (L) and circular arcs (R) designed as S curve. The designing has been performed by applying the empirical values of the parameters of the transition arc of the clotoide shape (A) (Table 4).

Table 4 - Design elements of transition in the passage and their inter-relations:

V – transition speed, R – radius of circular arc transition, A – transition arc parameter of clotoide shape ($A = \sqrt{R \cdot L}$, where L is clotoide arc length)[8]

V [km/h]	R [m]	A [–]
30	25	10
40	45	20
50	75	30
60	120	40
70	175	50
80	250	60
90	350	80
100	450	120

Because of the fact that the passages are meant for traffic redirection during major and time-consuming works regarding motorway maintenance (replacement of the carriageway construction, infrastructure repairs), it would be good to keep the existing number of lanes within the area of works as well, i. e. to provide sufficient passage length to accommodate two lanes (L_{p2}).

Three layout positions have been considered for the passage on the motorway of 4m and 3m wide central reserve, and 3.75 and 3.50m wide lane as follows:

- straight;
- in circular arc of radius R= 450 m;
- in circular arc of radius R= 750 m.

The geometric measurements [8] yield the required lengths of passages for the two-lane transition Lp_2 across the motorway central reserve of the width of s = 3m and across the central reserve of the width of s = 4m (Figures 4 and 5).

The transition speed due to traffic redirection regarding the planned level of service C/D for motorways, ranges realistically between 60km/h (operative speed at level of service D amounts to ≥64km/h) and

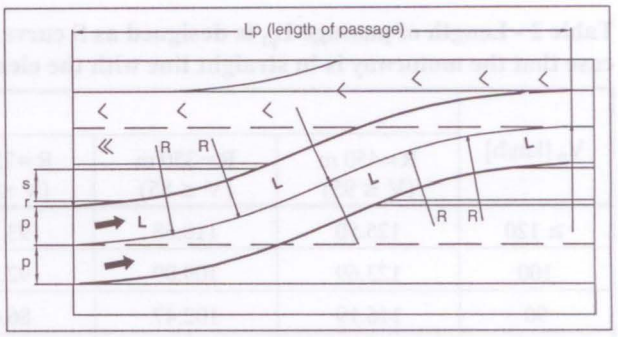

Figure 3 - Two lane transition across the passage by using transition arcs (L)

80km/h (operative speed at level of service C amounts to ≥80km/h) [9].

The lengths of passages L_{p2} in the central reserve of the width of s = 3m, determined by the dimensions of the transition lines for the observed layout cases, range between 86.83m and 133.42m at transition speeds from 60 to 80km/h (Figure 4). For the same transition speeds, the measurement of the transitions lines in the central reserve of the width s = 4m yields the passage lengths of L_{p2} from 89.91m to 142.21 m (Figure 5).

Additional analysis has been carried out for the passage in the central reserve of the width of s = 4m which is located in the circular arc of radius R = 450m. The passage designed as S curve (Figure 3) of the following characteristics: R= 350m (radius of circular arc S curve), A= 60 (parameter of transition arc of the

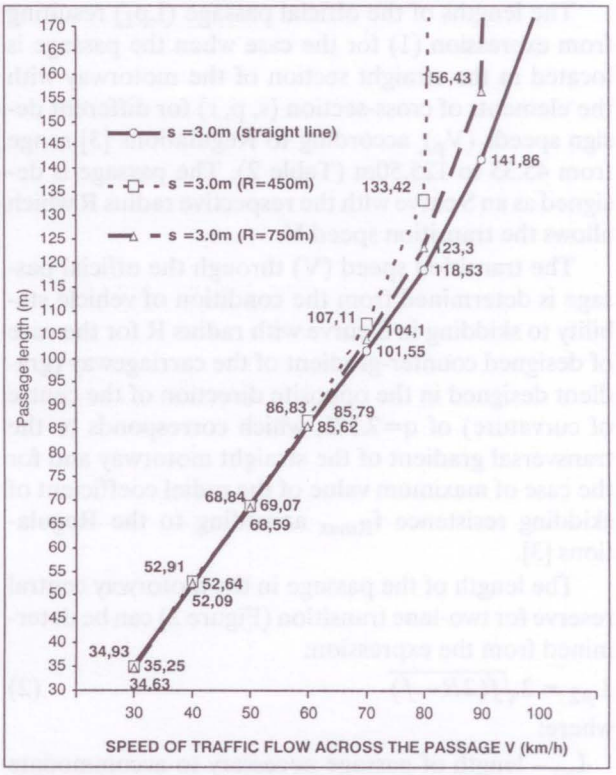

Figure 4 - Ratio between the flow speed V and the passage length Lp2 of S curve with transition arcs

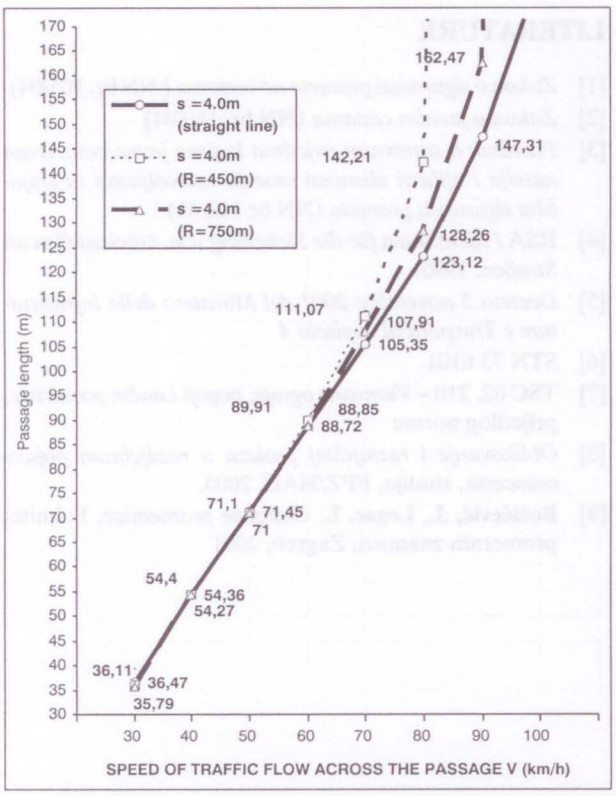

Figure 5 - Ratio of flow speed V and the passage length Lp2 of S curve with transition arcs

clotoide shape) and p = 3.25m (width of the traffic lane in passage) require smaller length of the passage of approximately 130m and check of transition speed V from the condition of stability to skidding on the section of the passage at counter-gradient q = 7% with maximum usability coefficient of the radial skidding resistance (f_{Rmax}) allows V≤81km/h.

4. RESEARCH RESULTS

Based on the carried out research of the required passage lengths in the motorway central reserve, when the passage accommodates two lanes, and considering some European solutions, there are two types of passage design solutions:

TYPE 1

- passage length L_{p2} = 135m;
- maximum transition speed V= 80km/h;
- passage designed as S curve with circular arcs of radius R = 350m;
- allows accommodation of two lanes.

TYPE 2

- passage length L_{p2}= 90 m;
- maximum transition speed V=60 km/h;
- passage designed as S curve with circular arcs of radius R=200m;
- allows accommodation of two lanes.

Type solution 1 is suitable for sections of motorways in flat country (with design speed of $V_p \geq 120$ km/h).

Type 2 is recommended for motorways in undulating countryside (V_p= 100km/h), on motorway sections in hilly areas (V_p = 90km/h) and on sections through mountains (V_p= 80km/h).

The position of passages on the motorway should be carefully selected in clearly visible locations, and the best option is on layout straight line.

5. CONCLUSION

The passages in the central reserve of motorways need to ensure safe and smooth transition to the opposing carriageway. Since the purpose of passages for the needs of long-term works regarding motorway maintenance requires maximum passage dimensions, it is also the starting basis for determining the shapes and lengths of the passages. The passage dimensions need to satisfy the forecast traffic for the planned period of 20 years.

The carried out research of the design and length of passages on the Croatian motorways, considering some European solutions, accounts for two type solutions of passages which allow two-lane transition across the motorway central reserve. Type solution 1 with transition speed of V= 80km/h results in the passage length of 135m which can be applied on the flatland section of the motorway. Type solution 2 with the transition speed of V=60km/h results in the passage length of 90m which would be applied to more demanding sections of the motorway in the undulating-hilly or mountainous countryside.

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SAŽETAK

REGULIRANJE PROLAZA U RAZDJELNOM POJASU AUTOCESTA

Prolazi u razdjelnom pojasu autocesta namijenjeni su za potrebe preusmjeravanja prometa prilikom planiranog izvanrednog održavanja autoceste i u akcidentnim situacijama, kao i za potrebe interventnih vozila (hitna pomoć, vatrogasci, policija).

Uočeni problemi manjkavog zakonskog reguliranja oblika i duljine prolaza odražavaju se na postojeće stanje prolaza u razdjelnom pojasu na našim autocestama. Naša praksa pokazuje raznolika rješenja naročito u pogledu duljine prolaza.

Uvidom u problematiku prolaza u razdjelnom pojasu autocesta određenog broja zemalja Europske unije uočavaju se različita oblikovna rješenja sadržana u nacionalnim normama.

Imajući u vidu namjenu prolaza uz uvjet sigurnog odvijanja prometa istražene su potrebne dimenzije prolaza s obzirom na njihov položaj na autocesti. Istraživanje je iznjedrilo dva oblikovna tipska rješenja.

Kao rezultat provedenog istraživanja te uvida u domaću i stranu praksu daju se preporuke oblikovnog rješenja prolaza u razdjelnom pojasu na našim autocestama.

KLJUČNE RIJEČI

prolazi u razdjelnom pojasu autocesta, duljina prolaza, oblikovno rješenje prolaza, tipsko rješenje prolaza

LITERATURE

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