RELATION BETWEEN ACCIDENT RATES AND SPEED VARIATIONS ESTABLISHED BY THE GEOMETRY OF THE ROADS

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ABSTRACT

On a wide experimental basis based upon surveys carried out on some stretches of the A3 freeway in Calabria, the authors of the present work, in the past, elaborated semi-empirical models of the relation between geometrical characteristics of a route element of a dual carriageway road (similar to B type roads legally) and the speed effectively used by the road users (V_{85}) , and from the latter the statistical number of accidents expected.

1) $\mathbf{V_{85} = 155 - 1352 \cdot 1/R - 0,41 \cdot \Sigma_i\ \alpha i/2 - 4,1 \cdot |i|}$

2) $\mathbf{N_{expected\ accidents} = -1,492 * V_{85\text{-}avarage} + 206,44}$

In the present note reference is made to the validation of the aforementioned models on different stretches from the initial experimental ones.

With this aim, three different stretches were chosen, in the provinces of "Catanzaro–Vibo Valentia" and "Naples–Salerno" respectively, for which the geometrical parameters of the axis (central line) and the accident rate data from 2000 to 2004 were acquired.

The good statistical agreement between the estimated parameters and those surveyed confirms the validity of the models and, at the same time, their reliability in the planning of modernisation works of the stretch aimed at improving safety of the route (road safety).

Keywords: Road Safety ,V_{85}, compound elements.

INTRODUCTION

In Italy, to a greater extent, speeds used by road users are noticeably higher than project theoretical and imposed legal limits, than compared to other countries.

Many authors, including the current writers, in a previous note [1], have demonstrated that, for this reason, in relation to anomalous sectors of the road, above all if affected by bad plane-altimetric coordination which produces uncertain and/or incorrect reading, can be identified high danger accident scenes. However, defects in perception at a distance from the road platform are identified only with the consideration of compound elements. .

The criteria for selecting the series of simple geometric elements, which constitute in their series an anomalous trunk for stretch reading, possible accident scenes and dangerousness of the stretch (procedure essentially based on two semi-empirical models previously obtained for simple elements) constitutes the nucleus of the contribution proposed by the authors.

1. EXPERIMENTAL INVESTIGATION

Ample experimentation was carried out on three motorway sections with average single development of about 20 km and with different geometrical characteristics, traffic and accident rates. The trunks considered fall within the territory of Calabria and Campania, but they are different from those for which the simple models at the base of the procedure were built.

1.1 Description of analysed database.

Direct experimentation was carried out on three different motorway sections, whose technical, geometrical and functional characteristics are reported in table 1.

Table 1 – Studied Stretch

Stretch's denomination	Length Stretch's [km+m]	Curve Development [%]	Average Curving	Development with |i|>2%	$V_{85\ average}$ On the stretch	T.G.M. On the Stretch [vehicles/day]	Number accident South Direction	Number accident North Direction
Stretch 1 (NA – SA)	21+503	57%	0,00128	69%	122,21	35.000	144	109
Stretch 2 (Salerno – Battipaglia)	19+169	32%	0,00100	64%	123,03	22.000	97	106
Stretch 3 (CZ-Vibo)	20+135	50%	0,00050	24%	139,80	15.000	18	16

Geometrical parameters were obtained on a cartographic basis (scale 1:10.000) provided by management bodies, together with traffic data. The archive of accidents was extracted from police reports written immediately following the events: from this, events certainly not attributable to systematic defects in reading of the stretch were removed (for example manoeuvres on “freeway exit”, presence of holes, run over animals, and strange objects on the carriageway, etc.)

1.2 Application of models for stretch’s analysis.

The data obtained was examined in light of the following models, implemented in sequence (Figure 1):

- model 1: estimation of V_{85} implemented by users on the basis of some simple geometrical tract information

$$V_{85} = 155 - 1352 \bullet 1/R - 0,41 \bullet \Sigma_i \alpha i/2 - 4,1 \bullet |i| \qquad \text{(Eq. 1)}$$

- model (2): estimation of expected accident rate on the series of plane-altimetrical elements which form the homogenous tract upon the basis of implemented average V_{85}.

$$N_{\text{expected accidents}} = -1,492 * V_{85\text{-avarage}} + 206,44 \quad (\text{with } N._{\text{expected accidents}} \geq 0) \qquad \text{(Eq. 2)}$$

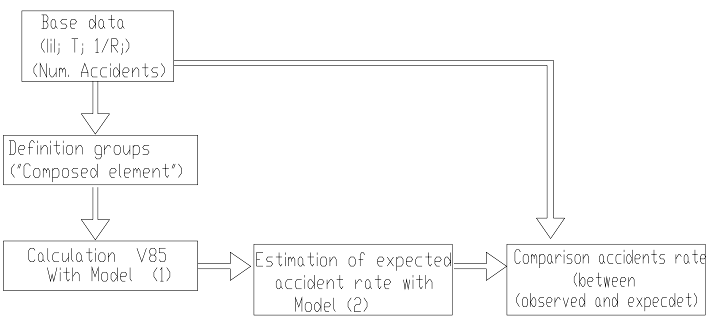

Figure 1 – “Flow diagram” of models

2. MANAGEMENT OF STRETCH ANALYSIS PROCESS

The following limits were imposed in the selection of homogenous trunks:

- Lower limit: length ≥ 2,5 km, to include at least two principal elements of the stretch;
- Upper limit: length ≤ 4.0 km, in order not to sacrifice the level of analysis detail.

The calculation results and statistical developments are summarised in tables 2,3,4, respectively for the three trunks considered, and represented in figures 2,3,4,5,6,7. In the last column of each table the comparison between the observed accident rate and that expected is reported.

Stretch 1 : A3 Freeway "Napoli-Pompei–Salerno" From Km 25+000 to Km 50+000

Table 2 - database "Stretch 1"

Group code	Beginning Progressive [km]	End progressive [km]	Sv, Group development [m]	Average curving (1/R)average [1/m]	S, Sum angle (Sai) * [degrees]	T, Tortuosness =S/Sv [degrees/km]	Longitudinal Grade [%] (Average)	$V_{85\ average}$ Esteem With model (1) [km/h]	Number accident's Observed South direction	Number accident's Observed North direction	Esteem accident's number with model (2)
1	28,678	31,279	2601	0,0006	88,50	34,0	2,5	**130,2**	11	17	12
2	31,279	34,222	2943	0,0003	52,40	17,8	3,3	**133,5**	10	12	7
3	34,222	36,532	2310	0,0008	80,80	35,0	2,8	**127,0**	18	15	17
4	36,532	39,126	2594	0,0006	61,80	23,8	2,5	**133,8**	9	5	7
5	39,126	42,180	3054	0,0007	106,30	34,8	2,5	**130,2**	11	12	12
6	42,180	44,674	2494	0,0011	131,10	52,6	2,0	**123,6**	11	17	22
7	44,674	47,320	2646	0,0019	184,60	69,7	2,0	**115,5**	21	24	34
8	47,320	50,181	2861	0,0019	234,00	81,8	2,2	**109,9**	28	29	42

* For the meaning of this symbols refer to endnote [1]

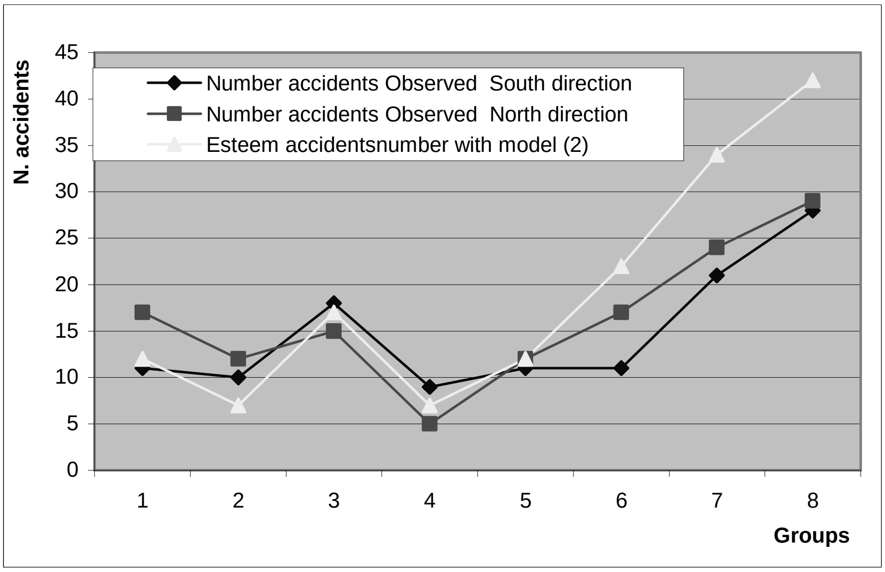

Figure 2 – Number of Accitens in the groups (Observed and Esteem) - Stretch 1-

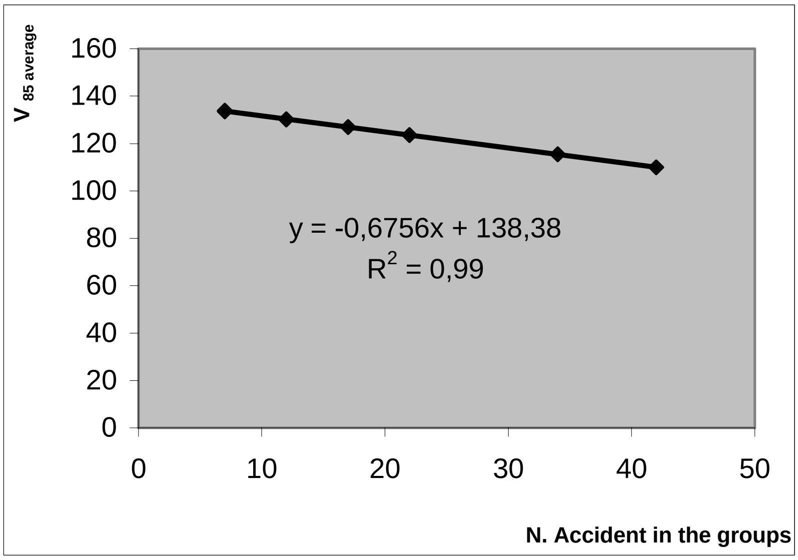

Figure 3 – **Relationship between the accident rates and the speed (V_{85}) variations - Stretch 1-**

Stretch 2 : A3 Freeway - Salerno- Battipaglia From Km 2+704 to Km 21+874

Table 3 - database "Stretch 2"

Group code	Beginning Progressive [km]	End progressive [km]	Sv, Group development [m]	Average curving (1/R)average [1/m]	S, Sum angle (Sai) * [degrees]	T, Tortuosness =S/Sv [degrees/km]	Longitudinal Grade [%] (Average)	$V_{85\ average}$ Esteem With model (1) [km/h]	Number accident's Observed South direction	Number accident's Observed North direction	Esteem accident's number with model (2)
7	2,705	5,205	2500	0,00133	139,9	56,0	3,80	114,59	29	32	35
2	5,205	8,020	2815	0,00100	71,4	25,4	2,30	133,75	11	8	7
3	8,020	10,960	2940	0,00120	181,4	61,7	2,50	115,82	22	30	34
4	10,960	13,579	2619	0,00110	128,8	49,2	2,60	122,62	19	15	23
5	13,579	16,704	3125	0,00033	15,2	4,9	3,50	138,19	5	4	0
6	16,704	19,159	2455	0,00050	26,1	10,6	3,50	135,62	5	4	4
7	19,159	21,874	2715	0,00054	74,0	27,3	2,30	134,66	5	5	6

***** For the meaning of this symbols refer to endnote [1]

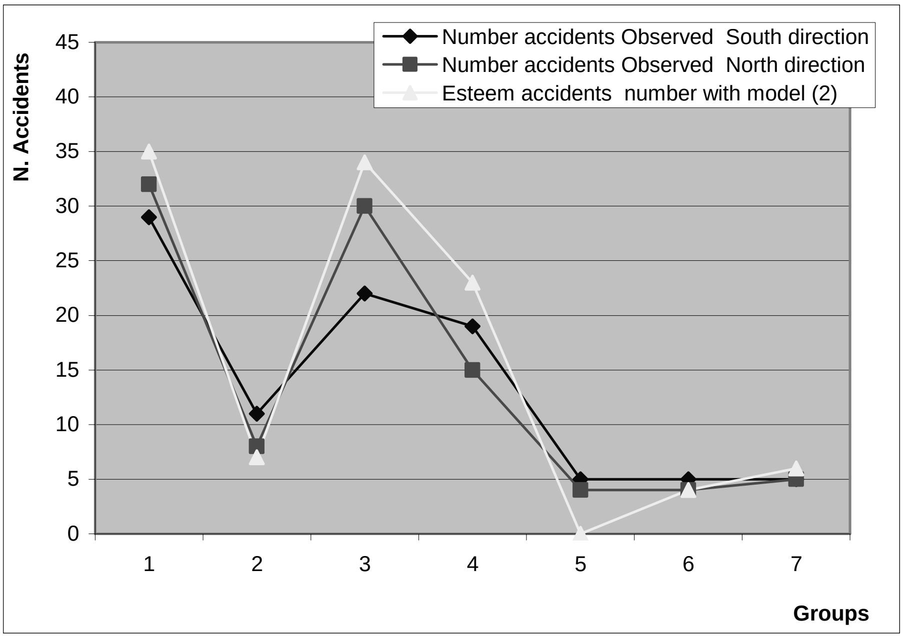

Figure 4 - Number of Accitens in the groups (Observed and Esteem) - Stretch 2-

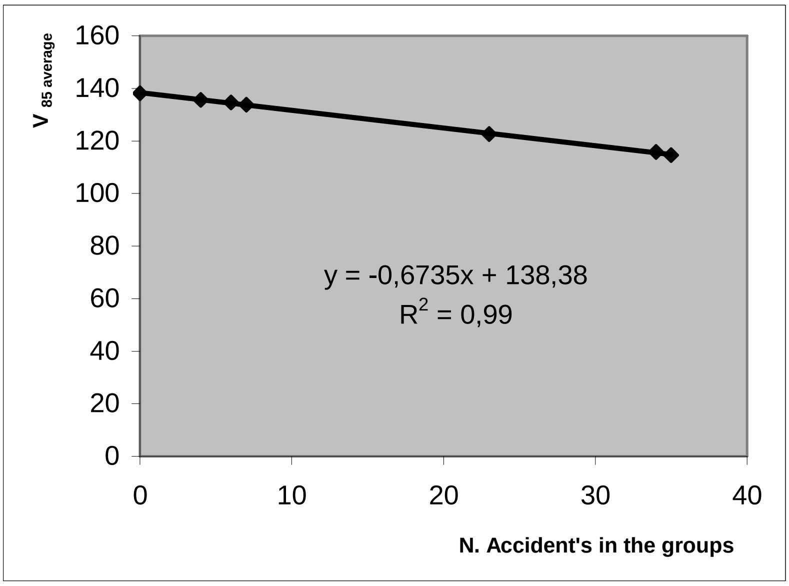

Figure 5- Relationship between the accident rates and the speed (V_{85}) variations - Stretch 2 -

Stretch 3 : A3 Freeway - Catanzaro- ViboV. From Km 304+270 to Km 324+405

Table 4 – database "Stretch 3"

Group code	Beginning Progressive [km]	End progressive [km]	Sv, Group development [m]	Average curving $(1/R)_{average}$ [1/m]	S, Sum angle (Sai) * [degrees]	T, Tortuosness =S/Sv [degrees/km]	pendenza longitudinale media [%]	$V_{85\ Media}$ stimata con il modello (1) [km/h]	Number accident's Observed South direction	Number accident's Observed North direction	Esteem accident's number with model (2)
1	304,270	306,900	2630	0,00070	90,0	34,2	1,0	135,9	**3**	**2**	**4**
2	306,900	309,625	2725	0,00063	94,4	34,6	1,0	135,5	**5**	**2**	**4**
3	309,625	312,370	2745	0,00056	68,5	25,0	1,5	137,8	**3**	**1**	**1**
4	312,370	315,300	2930	0,00029	61,2	5,1	1,5	146,4	**2**	**1**	**0**
5	315,300	318,360	3060	0,00010	26,5	8,7	1,2	147,7	**2**	**3**	**0**
6	318,360	321,585	3225	0,00033	39,2	9,0	1,3	145,4	**1**	**4**	**0**
7	321,585	324,405	2820	0,00050	23,8	2,7	1,5	147,1	**2**	**3**	**0**

* For the meaning of this symbols refer to endnote [1]

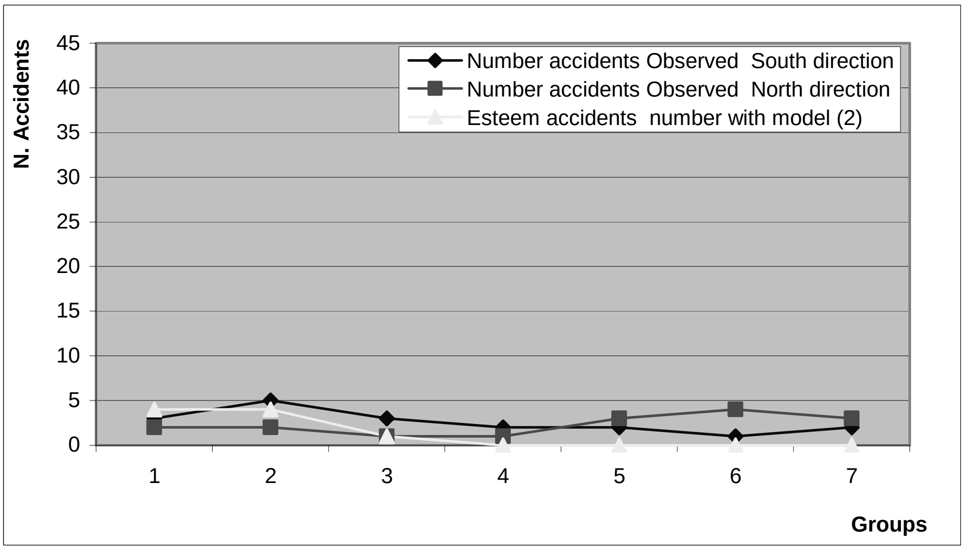

Figure 6 - Number of Accitens in the groups (Observed and Esteem) - Stretch 3-

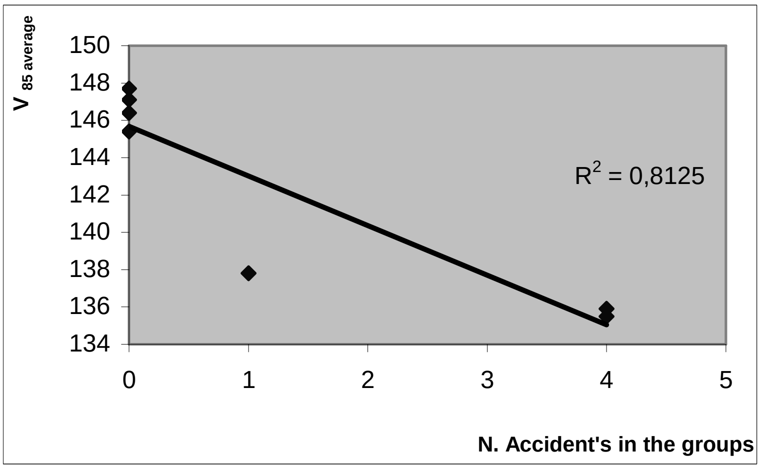

Figure 7 – Relationship between the accident rates and the speed (V_{85}) variations - Stretch 3-

From tables 2/3/4 and from figures 2/4/6 it is possible to observe good agreement between the model's estimation of the number of accidents and the corresponding registered values (in two different directions North-South). The close correlation (respectively r^2=0,90 and 0,94) found in the first two stretches considered, between $V_{85\text{-average}}$ (average of V_{85} calculated by means of model 1 on single planimetric elements of the group) and the "observed accident rate" is very interesting (fig 3/5/7). On the other hand, the calculated inferior value for trunk 3 is not an indicator of a method defect, but an indicator of the complete independence of accident rates from perception problems of the stretch in trunks with scarce tortuousness (low curvature values).

3. APPLICATION OF THE METHOD TO ACCIDENT RATE INDEX

As is known, in order to take into consideration the different lengths "L" of the stretches under observation and of the corresponding not homogenous traffic levels "T.G.M", it is preferable to refer not to absolute accident rate values "Ni" but to an "redimensionalised" accident rate index "Ii=(10^8*Ni)/(365*T.G.M.*L)" In table 5, and figure 8 the accident rate index on not homogenous trunks identified in the three observed stretches, referring to both the accidents occurred and surveyed (separately for both North and South directions) and those "expected" with the application of the proposed models, are reported respectively in numerical and graphical form. Furthermore, in the diagram, three classes of danger (low, medium, and high) were identified, which permit the administrator to select the zones, to be addressed as a priority, for structural work for the resolution of problems with reading of the stretch.

Table 5 – Accidents rate index (observed and esteemed) in the stretch 1, 2 and 3

	Stretch 1 (Napoli-Salerno)			Stretch 2 (Salerno-Battipaglia)			Stretch 3 (Catanzaro-Vibo V.)		
Code group	Index with observed accidents (South direction)	Index with observed accidents (North direction)	Index with esteemed accidents	Index with observed accidents (South direction)	Index with observed accidents (North direction)	Index with esteemed accidents	Index with observed accidents (South direction)	Index with observed accidents (North direction)	Index with esteemed accidents
1	36	56	40	144	159	174	21	14	28
2	29	35	20	49	35	31	34	13	27
3	67	56	63	93	127	144	20	7	7
4	30	17	23	90	71	109	12	6	0
5	31	34	34	20	16	0	12	18	0
6	38	58	76	25	20	20	6	23	0
7	68	78	110	23	23	28	13	19	0
8	84	87	126	-	-	-	-	-	-
Sum Dangerousness Index	**382**	**419**	**491**	**445**	**452**	**507**	**117**	**100**	**61**

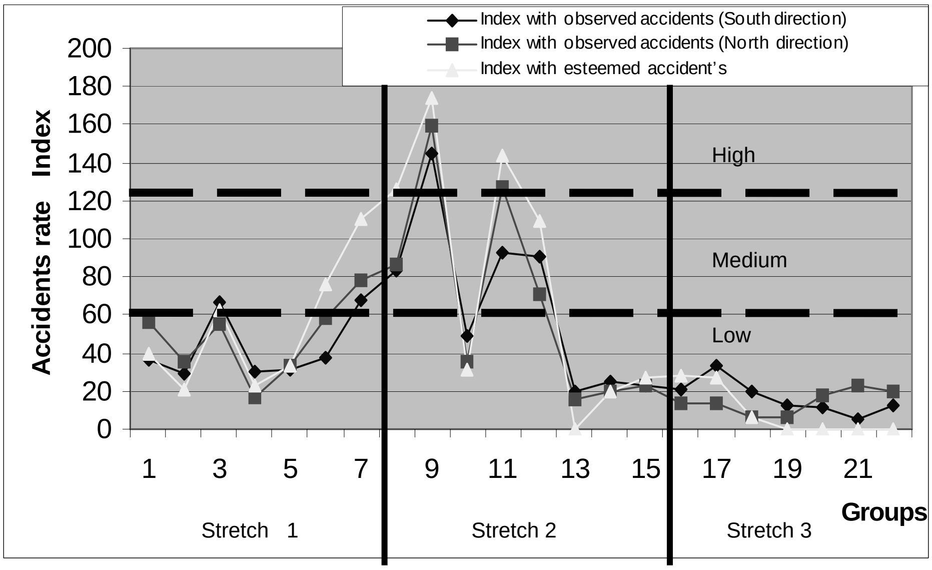

Figure 8 -

CONCLUSION

The model illustrated for the project phase forecast of the accident rates on dual carriageways highlights the importance of risk scenarios whose evaluation avoids checks required by DM 5/11/2001. This occurs where there is imperfect coordination between successive trunks (compound elements, characterised by a substantial constant of $V_{85average}$) and not among single planimetric elements. The results obtained are very interesting I for further development of the experimental field, with the aim of implementing an innovative protocol for preventative and fast identification, based on simple geometrical information of possible stretch reading anomalies. Moreover, the method consents the establishment of a grade of danger, according to prefixed risk thresholds, for the tracts which follow in an infrastructure in exercise, for planning of structural works for the flow safety control.

ENDNOTE [1]

[1] For the Meaning of symbol adopted in table 2, 3 and 4, column six (S, Sum angle= Sai), look figure 9.

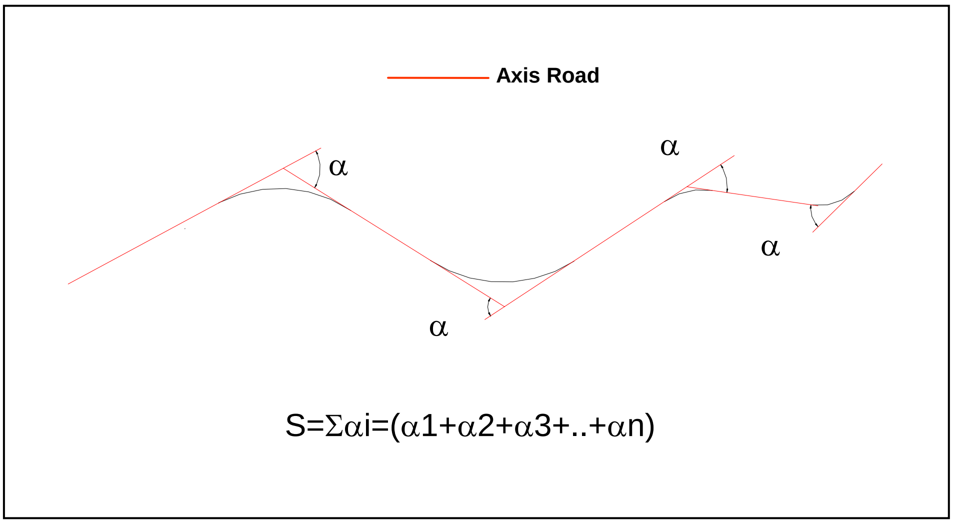

Figure 9

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